2015 Cayuga Lake Watershed Hydrilla Management Plan

Background

The highly invasive aquatic plant *Hydrilla verticillata*, known commonly as 'hydrilla' or 'water thyme', was first detected in August 2011 in the Cayuga Inlet by staff from the Floating Classroom. A follow-up survey located several areas of the Inlet with extensive populations of hydrilla. Racine-Johnson Aquatic Ecologists, the NYS DEC, and researchers from the University of Florida and the US Army Corps of Engineers verified the plant identification.

This was the first detection of hydrilla in upstate New York waters. Hydrilla has since been found in the lower section of Fall Creek and in isolated patches in the southeast corner of Cayuga Lake. Elsewhere in the state, hydrilla has been found in Tonawanda Creek in Niagara County, small ponds in Broome County, and in the Croton River system (tributary to the Hudson River). Management efforts were organized and implemented for Tonawanda Creek in 2014, and will continue in 2015.

The risk of hydrilla spreading to regional and statewide water bodies is substantial. Fragments of the plant, which are easily caught and transported by boats, trailers and equipment, can sprout roots and establish new populations. Fragments also float and are capable of dispersing via water currents. Hydrilla grows aggressively, up to a foot per day. Early in the season, it grows mostly horizontally along the bottom of the waterbody. Side shoots and new tubers can develop at the nodes as the plant grows. As water temperatures increase, the stems elongate, sending the shoot tips, which can themselves grow an inch a day, toward the water's surface.

Hydrilla creates thick mats of vegetation when it reaches the water's surface. It quickly shades out other aquatic plants, displacing native species like pondweeds and wild celery. Hydrilla has long slender stems that can grow underwater to lengths up to 25-30 feet. Hydrilla can set seed, but primarily reproduces vegetatively via floating pieces that set roots, buds produced along the stems (called turions), or overwintering tubers.

Problem Statement

The overall goal of the Cayuga Lake Watershed Hydrilla Project (Project) is to eradicate hydrilla from the Cayuga Inlet, Fall Creek, and adjacent infested waters, and to prevent its establishment in Cayuga Lake, neighboring Finger Lakes, and the Great Lakes. Eradication of hydrilla will prevent native species decline, habitat loss, negative impacts to fisheries, waterfowl and birds of prey, and protect recreational and economic interests on the waterways.

The objectives of the 2015 components of the Project are to:

- Continue reducing hydrilla biomass and prevent tuber production in ~100 acres of the Cayuga Inlet and adjacent tributaries AND ~25 acres of Fall Creek
- Reduce hydrilla biomass and tuber density in areas where hydrilla has been discovered in the southeast corner of Cayuga Lake
- Contain and prevent movement of hydrilla out of the Cayuga Inlet and Fall Creek AND contain and prevent movement of hydrilla within Cayuga Lake
- Monitor for hydrilla and plant community growth, re-growth, treatment efficacy, and spread
- Educate the community and stakeholders regarding ongoing Project efforts, hydrilla (specifically) and invasive species (generally)

Funding from the federal government, New York State, and local sources aimed at these objectives will facilitate the goal of eradication within 8-10 years. While there are direct costs to fight and eradicate hydrilla on an annual basis, it is important to note that the long-term costs of doing nothing, or waiting too long to act,

greatly exceed the costs of Project implementation. For example, the state of Florida spends approximately $20 to $30 million annually for localized management of hydrilla. Population levels within the state have reached a point where eradication is no longer feasible, and only localized management options are possible. Based on the abundance and interconnectivity of freshwater bodies in NYS, if the worst case scenario observed in Florida were transposed to NY, then NY would certainly be looking at annual hydrilla management expenses comparable (if not greater) than those observed in Florida.

Cayuga Inlet Plant Growth

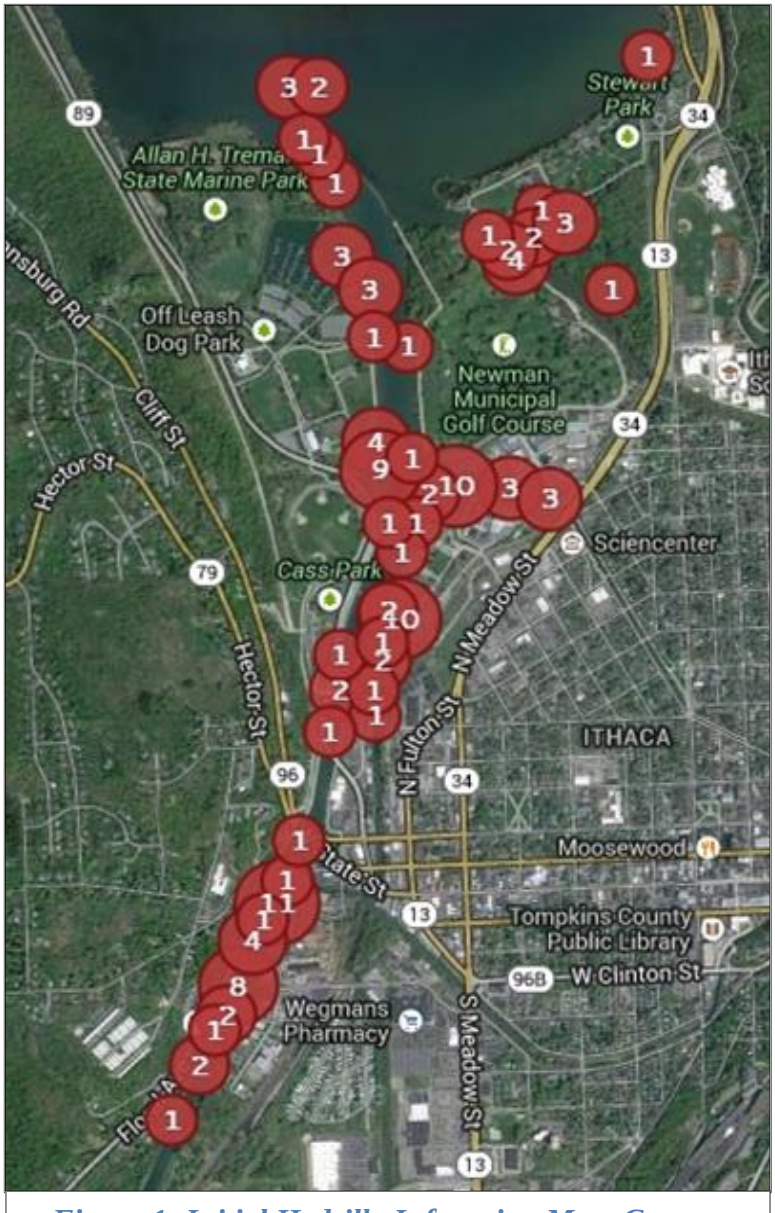

Figure 1: Initial Hydrilla Infestation Map. Cayuga Inlet, Fall Creek, and Surrounding Waterways

Figure 1 shows the initial infestation areas within Cayuga Inlet, Fall Creek, and the surrounding waterways (as of Fall 2013). Extensive survey work was conducted in the fall of 2011 by the Local Task Force (including Racine-Johnson Aquatic Ecologists, the City of Ithaca, Cornell University, NYS DEC, and others) and was overseen by Racine-Johnson Aquatic Ecologists. These surveys included Cayuga Inlet, Cascadilla Creek, Six Mile Creek, Fall Creek, and several connected unnamed waterways within the Cayuga Inlet system. Surveying also included many locations within Cayuga Lake, including more than 400 sites on the south shelf and boat launch sites along the eastern shore of the lake.

The results of the 2011 survey showed hydrilla infestations ranging from trace (single stem) populations to dense beds within Cayuga Inlet, Cascadilla Creek, and connected waterways. Rooted hydrilla was not found initially in Fall Creek, Six Mile Creek or Cayuga Lake in 2011. It was not until August of 2013 that isolated hydrilla patches were discovered growing in Fall Creek and the southeast corner of Cayuga Lake (as shown in **Figure 1**). The Cayuga Inlet infestation zone was considered to comprise an area of about 75 acres in 2011, based on initial monitoring data at the time of the aquatic herbicide permit application in mid-September of 2011. It was expanded in 2012 to comprise an area of about 166 acres, based on additional monitoring conducted between the fall of 2011 and early summer of 2012. However, it is likely that the actual infestation zone was similar in both years.

Identification of Aquatic Plants

Figure 1 shows locations of hydrilla within the infestation zones (2011-2013), as displayed in the iMapInvasives mapping program. The cited location numbers correspond to the documented occurrences at that location at the scale displayed on the map. The specific hydrilla locations within the infestation zones have shifted since Project implementation in 2011 through 2014, and only trace amounts of hydrilla biomass remain within the Cayuga Inlet as a direct result of these ongoing treatments.

History of Invasive Weed Growth-

Aquatic plant communities in Cayuga Inlet were not well documented prior to the hydrilla discovery in 2011. Due to high flow and turbidity within the Inlet, aquatic plant growth has historically been sparse, with both native and exotic plants found within the aquatic plant community. The following exotic plants have been found in Cayuga Inlet and surrounding waterways:

- Eurasian water milfoil (*Myriophyllum spicatum*)- Cayuga Inlet, Fall Creek
- Curly-leafed pondweed (*Potamogeton crispus*)- Cayuga Inlet, Fall Creek
- Brittle naiad (*Najas minor*)- Fall Creek
- European four leaf clover (*Marsilea quadrifolia*)- Fall Creek

Prior to the introduction and spread of hydrilla, none of these exotic plants were reported to be growing invasively in the Inlet, and there were also no reports of nuisance plant growth in association with any of the native plant species found within Cayuga Inlet, Fall Creek, or any of the connected inlet waterways.

There is a long history of aquatic plant survey work in Cayuga Lake, starting with surveys conducted by W.R. Dudley (1886), Weigand and Eames (1925), and the seminal work by W. C. Muenscher in 1927. Eurasian water milfoil was first documented in Cayuga Lake in the 1960s, and has grown invasively in the lake for many years. Its invasive growth has been substantially reduced by aquatic moth herbivory, which was first documented in the north end of the lake in the 1990s. The most recent survey work was conducted by Cornell University from 1987 to 2000, which documented the Eurasian water milfoil herbivory at the Southern end of the lake. The sites sampled in this survey work are shown in **Figure 2** (Below); these data were collected too long ago to be considered a viable estimate of "pre" conditions in the south end of the lake. Habitat assessment, including a listing of prominent aquatic plant species, was conducted in 2008 by Ecologic, LLC in preparation for future dredging of the Inlet.

Curly leafed pondweed (*Potamogeton crispus*) has been in Cayuga Lake since at least 1978. Variable leaf water milfoil (*Myriophyllum heterophyllum*) was reported in the lake in 1928 by Muenscher, although the Dudley study of the lake in 1886 also references variable leaf water milfoil at Union Springs, and *Potamogeton crispus* growing "abundant in the deeper water of inlet and lake…fertile in shallower channels and ditches", also noting that it is rarely fertile by early summer. The same publication also cites *Myriophyllum spicatum* growing throughout the Inlet, Fall Creek, and the lake proper, but there is little evidence that this plant was found in North America prior to the 1940s. It is more likely that this reference represents extensive growth of northern water milfoil (*Myriophyllum sibericum*), which was commonly misidentified as Eurasian water milfoil from the 1800s through at least the 1990s.

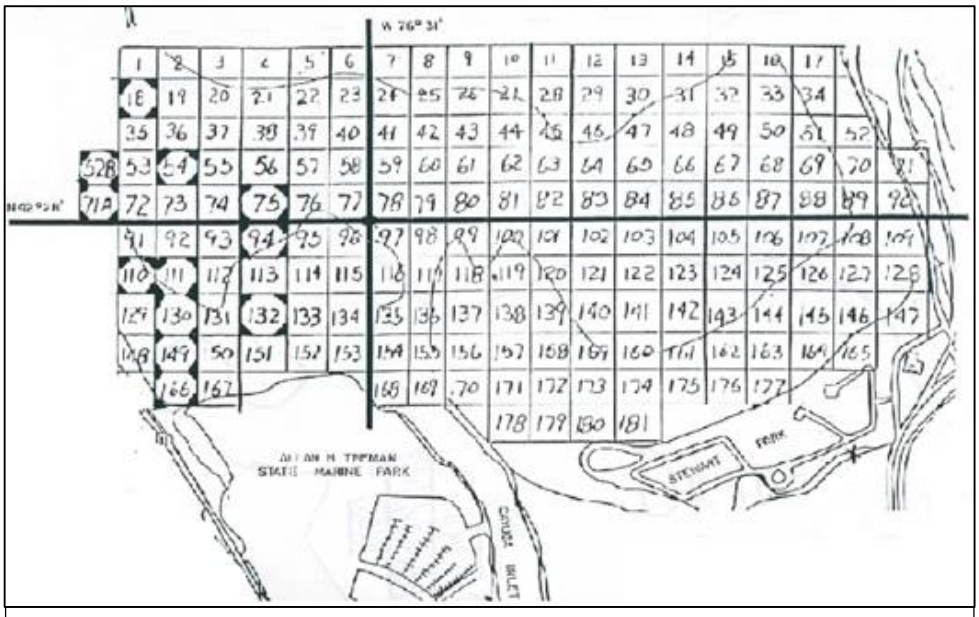

Figure 2: 1998 South Lake Plant Sampling Sites.
(http://www.ecologicllc.com/pdf/DEIS/AppendixK.pdf)

Known Occurrences of Rare/Endangered Species
The black shiner (*Notropis heterodon*) was observed in Fall Creek in 1926, but not in a 1993-1997 fish survey. It is considered an "unlisted" species. Hills pondweed (*Potamogeton hillii*) is a threatened species reported in an 1886 survey of Cayuga Lake and 1924 survey of Cayuga Inlet, but this plant was not found in a 1999 survey of the Inlet. The Natural Heritage reports in recent years have not identified any of these species or any additional protected species in Cayuga Inlet or the surrounding waterways.

Uses Impaired-

There are no use impairments in the Cayuga Inlet. It is used primarily for boating and in support of aquatic life, with the upper portion of the Inlet being a major spawning tributary for rainbow trout. The waterways effect the local economy in three primary ways: through flood protection, property tax revenues, and tourism spending, particularly spending associated with recreational boating and water-dependent businesses.

Recreation: Boating

Ithaca is a boating destination. Because of its connection to the Erie Canal, an avid boater could travel from Ithaca to the Atlantic Ocean via the Saint Lawrence Seaway or to the Gulf of Mexico via Lake Erie and the Mississippi River.

Property values in the waterfront are high; although nearly 97% of waterfront properties are tax exempt, annual tax revenues from the remaining 3% are over $2 million. Finally, water-dependent businesses generated over $2 million in sales (nearly $700,000 of which came from docking fees) in 2008. Revenues from facilities specializing in non-motorized boats are not included. The Inlet has four primary facilities catering to non-motorized boaters: Cornell University and Ithaca College Crew boathouses, a business that rents and sells canoes and kayaks, and the Cascadilla Boat Club, which has approximately 175 members paying annual membership and training fees totaling $60,000 a year.

Land use surrounding the Cayuga Inlet includes the following:

- 347 acres (84%) of waterfront properties within the City are publicly owned parkland and open space.
- 6 restaurants and bars, a spa and health club
- Ithaca Farmer's Market, with 125 vendors and over 5,000 visitors a day - by foot, bike, car and boat access (motorized and paddle boat docks/launches on-site)

- Cornell University & Ithaca College crew teams - during their season 30+ boats share training space daily
- Ithaca Dragonboat Club
- Large Educational and Commercial touring vessels (such as the Cayuga Lake Floating Classroom)
- Allan H. Treman Marine State Park has 370 seasonal boat slips and an 8-lane boat launch ramp
- Two other boatyards and a sailing center
- Water Music, Rhiner Festival, Dragonboat Festival, and other local events incorporate Inlet usage

Flood Control

The current Flood Control Channel capacity is only 38% of the US Army Corps of Engineers (ACOE) design dimensions, based on 2008 bathymetric data - this estimate does not account for aquatic vegetation impeding flows. Sedimentation and a lack of maintenance in the Inlet has caused this loss of capacity. The ACOE recently failed the flood control channel as an effective structure. Hydrilla's ability to clog flood control structures and impede water flow will only exacerbate the current situation.

The economic value of the waterways is derived from their function as flood mitigation and their role as a navigable waterway. The vitality of the waterfront evolved based partially on a navigable waterway. Any impact that reduces the use, enjoyment or function of the waterway can be assumed to diminish its current and future economic value.

Aquatic life and ecological Impacts

Hydrilla is uniquely adapted to grow under low-light/low-nutrient conditions, which allows it to colonize water that is deeper than most native submersed species can tolerate. For example, native submersed plants typically colonize the margins of shallow lakes where water depth is 6 to 8 feet. Hydrilla competes with native plants in these shallow areas, but also grows in much deeper water (up to 25-30 feet deep) with no competition. This greatly extends its capability of spreading in the vegetated littoral zone outward from the shoreline. The surface canopy or mat formed by hydrilla in the upper 1 to 2 feet of the water column comprises as much as 80% of the biomass of the plant. Dense mats of hydrilla growth significantly reduce light availability to lower-growing native submersed plants, which reduces species diversity over time (Haller and Sutton, 1975). The ecological effects of this dense growth on the water surface include significant changes in water temperature, wave action, oxygen production, pH and other parameters, which reduce the suitability of infested waterways for use by aquatic fauna (Haller, 2009).

Invasive plants reduce native plant growth and impede human uses of waters by forming dense surface canopies that shade out lower growing native plants and interfere with water flow, boat traffic, fishing, and recreation. Dense surface canopies also radically change the habitat quality for fish. Dense plant beds provide a place for small forage fish to hide and reduce the ability of predatory fish such as bass and northern pike to see their prey. This tends to lead to a large number of small, stunted forage fishes and poor production of game fishes (Dibble, 2009).

Invasive plants also reduce water quality. While the increased biomass and dense canopies formed by invasive species tend to increase water clarity, they also lead to increased organic sedimentation. The fate of lakes over geological time is to progress from lakes to wetlands to marshes to upland areas as lakes fill with sediments due to erosion and accumulation of organic matter. Invasive species act to hasten this natural process, contributing large quantities of accumulating organic matter to a water body. For infested streams and flowing waterways, this accumulation can also significantly alter flow and habitat. Water becomes stagnant under dense plant canopies and suppresses or prevents oxygen recirculation. In addition, the amount of dissolved oxygen under dense plant canopies may be insufficient to support desirable fish species and may result in fish kills (Madsen, 2009a).

Many animal species are linked to specific native plant communities and the diversity of native communities provides a variety of habitats for aquatic insects and other fauna. Invasive plants reduce the diversity of native

plant communities, which leads to a reduction in the diversity of both fish and aquatic insects. Therefore, invasive plants are harmful to the diversity and function of aquatic ecosystems, and can have significant adverse impacts on water resources. (Madsen, 2009a).

Fall Creek

Similar to the Cayuga Inlet, there are no use impairments in Fall Creek. It is used primarily for boating, non-contact recreation, in support of aquatic life, and as an upstream water supply. Hydrilla growth was discovered in Fall Creek in August of 2013. The Task Force implemented a late season endothall treatment in Fall Creek to address this hydrilla growth on September 26, 2013. This response effort was successful, but hydrilla regrowth was observed in Fall Creek following treatment. As Fall Creek is a major tributary to Cayuga Lake, the Fall Creek treatment zone has been fully incorporated into the comprehensive Cayuga Lake Watershed Hydrilla Management Plan moving forward, with subsequent treatments to address hydrilla growth being implemented in 2014 and beyond.

Cayuga Lake

One of the primary objectives of the hydrilla eradication project is to avoid use impairments in both the Cayuga Inlet and surrounding waterways, including Cayuga Lake. Cayuga Lake supports contact and non-contact recreation, aquatic life, and potable water uses. Isolated hydrilla patches were found in the southeast corner of Cayuga Lake in August of 2013. The Task Force responded quickly to remove these patches and install benthic barriers shortly after the discovery. These response efforts were successful, and at present, none of the above best-uses have been impaired in the lake. However, the threat does exist for these uses to be seriously impaired if hydrilla is allowed to establish and spread further within Cayuga Lake. Therefore, the Hydrilla Task Force will continue to manage and eradicate current hydrilla infestations in the Cayuga Inlet, Fall Creek, and the southeast corner of Cayuga Lake to ensure hydrilla does not spread/establish further in the Cayuga Lake Watershed.

Management History

Do Overall Management Plans Exist?

An overall management plan does not exist for Cayuga Inlet or Fall Creek, and a specific aquatic plant management plan for Cayuga Lake has not been developed. A management plan does exist for the Cayuga Lake watershed, the Cayuga Lake Watershed Restoration and Protection Plan (RPP), which includes the Inlet and Fall Creek. The RPP does not include a detailed plan for aquatic plant management. Funds were secured in 2009 to update the RPP; however, that effort has stalled due to a lack of staff. Other management actions, including dredging of the Inlet and possible total maximum daily load (TMDL) development for the south end of the lake (the latter in support of federal requirements), may eventually be combined into the update of the RPP. In lieu of a plan that targets invasive species in the waterways, this separate management structure has been developed.

Management Team-

The Hydrilla Task Force of the Cayuga Lake Watershed has undertaken the management of the hydrilla infestation in Cayuga Inlet, Fall Creek, and Cayuga Lake. A Hydrilla Program Manager was hired in 2013 to provide project coordination and reduce the workload for both State and Local partners. The Task Force is comprised of four groups who work together in a coordinated fashion to learn the science, seek out possible management options, understand the regulatory options and constraints, share information and implement the management measures most likely to result in eradication of hydrilla. These groups include:

Statewide Task Force:
This overarching coordination group is led by the NYSDEC Invasive Species Coordination Unit (ISCU) in the NYSDEC Division of Lands and Forests, and the Hydrilla Program Manager. This group provides updates from

DEC ISCU, particularly regarding funding or State level efforts, and provides updates on general progress. The statewide Task Force also coordinates updates from the other associated groups.

Management:
Led by the Hydrilla Task Force of the Cayuga Lake Watershed, the management subgroup includes representatives from the City of Ithaca, Tompkins County, Soil and Water Conservation District, Health Department, NYS Parks, Racine-Johnson Aquatic Ecologists, the Education and Outreach subgroup, and consulting scientists. The management subgroup determines the necessary steps to formulate management plans, and contacts and consults with scientists (including an external peer review group) for input on chemicals, alternative methods, monitoring, and plant growth specifics. This group also works closely with contractors who treat invasive aquatic plants to develop treatment proposals and budgets, oversee survey and monitoring work, and prepare base information for technical papers and outreach materials.

Outreach and Education:
Led by Cornell Cooperative Extension of Tompkins County (CCE-Tompkins), this subgroup includes the Hydrilla Program Manager, representatives from the City of Ithaca, the Tompkins County Water Resources Council, NYS Parks, Cayuga Lake Watershed Network, Floating Classroom, West Shore Homeowners Association, and other community stakeholders. The Outreach Committee receives and sends out updates from the other subgroups, develops and distributes outreach materials, including brochures, handouts, presentations and press releases to the public; maintains the hydrilla website (hosted by CCE-Tompkins), organizes hydrilla ID training workshops and public meetings, and provides speakers for community groups wanting updates on management plans and eradication efforts.

Local Task Force:
The Local Task Force is comprised of the Hydrilla Program Manager and representatives from the City of Ithaca, Tompkins County Health Department, Tompkins County Soil & Water Conservation District, Racine-Johnson Aquatic Ecologists, Tompkins County SWCD, Sheriff, NYS Parks, Southern Cayuga Lake Intermunicipal Water Commission (Bolton Point drinking water plant) and consulting scientists. This subgroup works with the Management Sub-Group and the State Task Force to make final decisions about the management of the hydrilla infestation, provides local implementation of the management actions, communicates directly with concerned citizens and stakeholders, and participates in outreach efforts. The Local Task Force also provides official communication to public regarding management implementation aspects that may involve public notice or have impacts on stakeholders, and provides a safety net when unexpected needs arise that must be addressed immediately. Statewide conference calls, initiated by the Local Task Force on a monthly basis (or as needed), provide opportunities for all stakeholders to receive updates.

Description of 2011 Management Efforts

Background
Upon discovery of the hydrilla infestation in the Cayuga Inlet in late summer of 2011, the Hydrilla Task Force was formed to:

a) Research the risks posed by hydrilla and the possible responses,
b) Collaborate with agencies at all levels of government and other interested parties
c) Provide recommendations to the entities that could carry out actions and
d) Conduct extensive outreach and education in the Cayuga Lake Watershed.

Herbicides
The Hydrilla Task Force recommended that the quick-acting herbicide endothall (trade name Aquathol-K) be used in the inlet to stop or slow the growth of hydrilla turions (vegetative buds). The Tompkins County Soil & Water Conservation District applied for a DEC permit to apply the herbicide. Formal notification of landowners within treatment zone occurred on September 14, 2011.

The City of Ithaca declared an emergency, which allowed the Tompkins County Sheriff to close the Inlet for a period of ten days (October 5 – October 14, 2011) to prevent the spread of hydrilla and allow herbicide application to occur.

The herbicide was applied by licensed applicators from Allied Biological, Inc. Use of the water in the Inlet for drinking (including by animals or homeless residents of the "Jungle", a campsite community along the southern end of the Inlet) was restricted for 14 days. The restrictions on water use applied within 600 feet of the site of application. The Bolton Point water intake (2.5 miles north of the Cayuga Inlet) was monitored carefully, even though it was considered well outside the affected area. Some lake house owners who draw their water from the lake were notified, although none of the lake houses were within 600 feet of the site of application, and all had access to municipal water lines. Signs and other outreach materials notified dog walkers, homeless residents of the Jungle, and others of the restrictions. Although swimming and bathing in the Cayuga Inlet is prohibited, there was a one-day restriction on swimming and bathing in Cayuga Inlet (per herbicide label restrictions).

The Tompkins County Health Department, in cooperation with the City of Ithaca, monitored endothall levels in the Inlet the day of application, again after 3 days, again after 7 days, and then every 7 days after until endothall concentrations were undetectable.

Hand harvesting

Additional growth (dense patches and isolated plants) of hydrilla was discovered in the Inlet south of the Route 79 Bridge after the herbicide permit application had been submitted to the NYSDEC in September 2011, and therefore could not be included in the herbicide treatment area. Those areas of the Inlet remained closed after other Inlet sections re-opened, due to the risk of hydrilla fragmentation and spread. Reproductive vegetative turions were found to be developing in late October on the untreated hydrilla plants. Canada geese removed plant biomass reachable from the surface via feeding. Consultation with John McPhedran (Maine DEP) indicated that late fall efforts to remove tubers could be successful. The Hydrilla Task Force was hopeful that complete removal of all plants and reproductive structures could be achieved from the dense bed of hydrilla along the west shore of the southern Inlet.

The Task Force management group discussed possible removal options. Diver Assisted Suction Harvesting (DASH) and hand raking were determined to be possible options since they would address fragmentation concerns, halt development of turions, and stop possible bird dispersal. The management group determined a pilot DASH would be conducted. The effectiveness of DASH to remove tubers was tested on October 25th. Comparison of the materials collected by divers versus sediment cores collected to estimate tuber density revealed that diver efforts removed approximately 1% of hydrilla tubers from the sediment. DEC's OISC funded hand-removal efforts targeting above-sediment vegetation only because the objective was to prevent turions from being released. Aquatic Invasives Inc. was awarded the project and completed work between November 29th and December 5th of 2011. Overall, DASH removal was not considered effective for hydrilla management. DASH efforts resulted in considerable hydrilla fragmentation and increased turbidity, increasing the risk of hydrilla spread and creating difficult working conditions for the diver crew.

Dredging

Navigational dredging of Cayuga Inlet has taken place since the 1860s and has resulted in significant alteration of the Inlet and connected waterways over the intervening 150 years, including construction of the Flood Control Works in the 1960s. Proposed dredging of Cayuga Inlet and lower Cascadilla Creek, likely to be conducted by the State Canal Corporation and the City of Ithaca, was originally slated for 2013. No dredging of the inlet or its tributaries occurred in 2013, but preliminary planning and coordination efforts resumed in 2015. The proposed dredging project has significant implications for the long-term control of hydrilla, both due to the potential removal of hydrilla tubers and biomass within the dredged channel, and the potential risk of spreading hydrilla through dredged spoils disposal and dislodged hydrilla reproductive structures during the dredging operation. The Hydrilla Task Force will actively participate in all dredging discussions to avoid possible negative impacts.

Prevention and Outreach
The City of Ithaca strongly discouraged the use of boats of any kind in the Inlet during the 2011 treatment period. Crew teams from Cornell University and Ithaca College relocated their base of operations outside the Inlet, as did the Floating Classroom. A local tour boat, the MV Columbia hired a diver to periodically check the boat and docking area for hydrilla. The City's paddle boat docks, the Farmers' Market dock, informal launches and the Allan H. Treman Boat Launch were all closed prior to and during the herbicide treatment for a period of ten days (October 5th – October 14th). The entire Inlet was also closed during this period, and the Tompkins County Sheriff controlled boat traffic. The upper Inlet remained closed for several more weeks until the DASH removal initiative could be completed.

Public Outreach (Continuous): Various public meetings and education and outreach activities were conducted. These activities are viewed as a component of "prevention" which will further reduce the ecological threat from hydrilla by educating the public on hydrilla and how to prevent its spread. Three groups are involved in education and outreach efforts.

- **Cornell Cooperative Extension of Tompkins County (CCE)**: CCE has been contracted to provide DEC with services related to coordination, development, and delivery of a statewide invasive species education and outreach program. State Cooperative Extension served as the initial contact for outreach and created the 'Not Wanted' handout on hydrilla. State personnel realized the local need was greater than they could meet early on and passed the lead role to the local Extension offices. Tompkins County CCE serves as the lead in education/outreach efforts. This included development and updating of the StopHydrilla.org website, leading public outreach meetings, and serving as the point of contact for hydrilla questions.
- **Cayuga Lake Watershed Network (CLWN)**: The Cayuga Lake Watershed Network (CLWN) provided public workshops that led to widespread public understanding of and participation in the hydrilla eradication plan proposed by the Task Force. In addition to the workshops, CLWN conducted additional publicity, outreach and education work as needed, in cooperation with the Task Force and Tompkins County Cornell Cooperative Extension.
- **Floating Classroom (FC)**: Public cruises provided a venue for updates on the eradication effort and hydrilla/invasive species in general.
- **Other**: The Hydrilla Task Force of the Cayuga Inlet Watershed (HTF) sponsored public education through plant identification and training workshops, in cooperation with CCE, CLWN and FC. Members of the Task Force also gave numerous media interviews (print, radio and TV), prepared press releases, responded to individual stakeholder concerns, and prepared both position statements for regulatory/agency staff and articles for news outlets. Dr. Holly Menninger (former NY Invasive Species Research Coordinator) organized volunteers to staff information booths at the Ithaca Farmer's Market every weekend from the beginning of September to the end of treatment in mid-October.

Description of Public Involvement in 2011

Providing public access to the eradication effort was a high priority for the Hydrilla Task Force. Public support was needed to allow the chosen treatment to move forward at an accelerated pace. Public awareness of the dangers posed by hydrilla provided the support needed to close the Inlet, cancel water portions of local festivals, and gain the cooperation of local schools, businesses and clubs who temporarily moved their operations out of the Inlet during the height of the boating season.

Public access was provided via training workshops, presentations, media interviews and public meetings. Contact information was shared with the public. Task force members were supported by an expert in crisis communications, and guided in how to maintain transparency and build trust during a fast moving situation where the information was often incomplete.

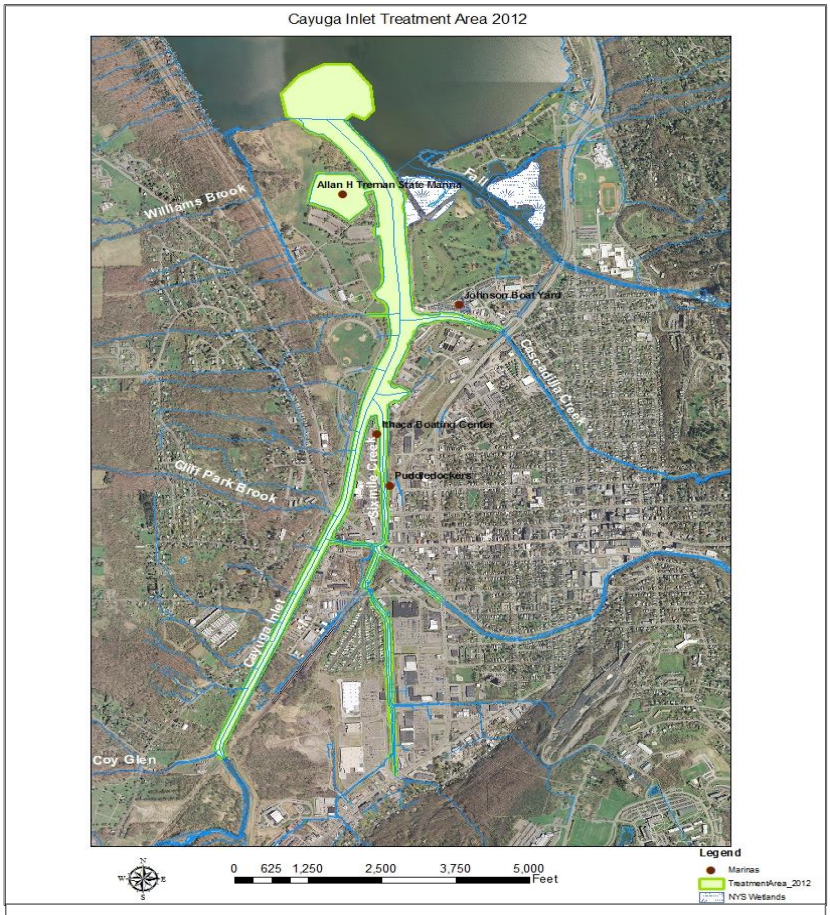

Figure 3: Map of Cayuga Inlet Treatment Areas in 2012 (Aquathol-K and Sonar).

The effort was considered an unqualified success. There was broad based support for the management actions that were taken in 2011, despite the fact that they were both highly disruptive of normal Inlet activities and that the use of herbicides runs counter to the general community sentiments.

Description of 2012 Management Efforts

Background

External aquatic plant experts were consulted over the winter preceding the 2012 growing season to develop a treatment plan. The experts represented researchers and resource managers from across the country with extensive knowledge on hydrilla. Two of the larger aquatic herbicide companies were also invited to submit proposals and information for consideration. Local input regarding site conditions (flow, temperatures, light, water quality, etc.) was distributed to assist in plan development. A dual herbicide approach was the final recommendation.

Herbicides

Herbicides were applied to approximately 166 acres of the Inlet. Aquathol-K was applied on June 26th. The application date was determined by emergence of hydrilla shoots. Sonar Genesis (liquid) and Sonar One (pellet) application began on July 12th. The dual herbicide application provided treatment across asynchronous hydrilla tuber growth patterns. Using two different chemicals also reduced the likelihood of the hydrilla plants developing chemical resistance. The Sonar liquid formulation was applied in staged drip applications to maintain steady fluridone exposure of 3-5 parts per billion (ppb) throughout the infestation zone, while minimizing dosage and transport to uninfected areas, including the south end of Cayuga Lake.

Sonar pellet formulations were applied to areas within the infestation zone where sufficient liquid Sonar contact could not be assured, included shallow and backwater areas and within the Allan H. Treman State Park marina. Chemical concentration monitoring determined the timing for bump treatments of Sonar pellets. A total of four (4) Sonar One treatments occurred. The areas that were treated multiple times included the Allan H. Treman Marina, the upper portion of the Inlet and "donut" area, the flood relief channel behind Wegmans, and downstream portions of Cascadilla Creek. **Figure 4** shows the 2012 fluridone pellet treatment areas.

There were some regulatory concerns regarding the use of the chemicals- the use of fluridone pellets in shallow water, potential swimming restrictions associated with continuous fluridone drip treatments- that the Hydrilla Task Force addressed with NYSDEC. The resolution of these issues included the issuance of an emergency rule allowing shallow water fluridone pellets due to rapid breakdown of the pellets and lack of public access to the treatment zone, local determinations about the lack of any swimming within the treatment area, and state DOH clarification of the differences between water contact and swimming.

Water quality monitoring was conducted both pre- and post-herbicide treatment. Monitoring during herbicide treatment determined chemical concentrations within the treatment area. The Task Force, Allied Biological, and SePRO used this data and to ensure proper chemical concentrations and to alter dosing as needed. Post-

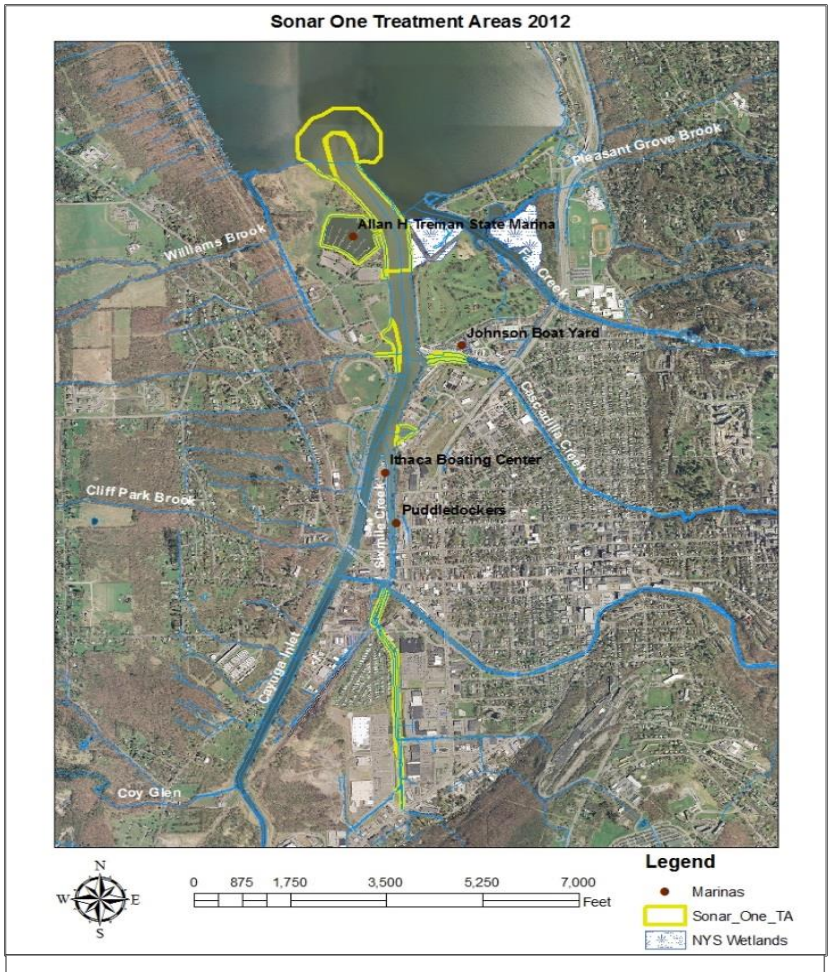

Figure 4: Map of Sonar One (pellet) Treatment Areas in 2012.

treatment monitoring was used to determine spread of the chemical outside the treatment area, degradation of the chemical, and compliance with public notification requirements. Minimal movement of any of the chemicals outside of the treatment area was observed.

Detailed water quality monitoring information and the annual Plant Community and Tuber Monitoring Reports (produced by Racine-Johnson Aquatic Ecologists) are posted at StopHydrilla.org.

Prevention and Outreach

Contingency plans and funding were in place for the use of benthic mats at boat docks if accelerated plant growth in the spring resulted in the potential to spread hydrilla. Inlet users were told to anticipate the possibility of a closure that could last up to 4 days to give the chemical applicators ample time in case of equipment failure, weather delays or other unexpected events. In the end, treatment of the Inlet began shortly after plant emergence, eliminating the need for extended Inlet closure or disruption of boating activities.

Public Outreach (Continuous): Initial efforts were continued and expanded upon in 2012.

- **Cornell Cooperative Extension of Tompkins County (CCE)**: Led education/outreach efforts. This included maintenance of the StopHydrilla.org website, leading public outreach meetings, and serving as the point of contact for public questions. CCE also worked with two Cornell University Communications classes to develop an Outreach and Communication Plan.
- **Cayuga Lake Watershed Network (CLWN)**: The CLWN expanded the number of public workshops around Cayuga Lake in 2012. Three 3-hour training events for the public and professionals were held in May, reaching well over 100 people. The CLWN Steward also gave six presentations reaching another 100 people directly. Most attendees of the training events were community members from Tompkins County municipalities, including Caroline, Dryden, Ithaca, Ulysses, and Lansing; Cayuga County municipalities, including Union Springs, Aurora, and Auburn; and in Seneca County, Fayette and Seneca Falls. CLWN also worked directly with the Cayuga Lake's West Shore Homeowners Association, which has several hundred members. Several members from this organization attended the training events as well. As in 2011, the CLWN conducted additional publicity, outreach and education work as needed, in cooperation with the Task Force and Tompkins County CCE. The CLWN also took the lead in coordinating volunteers to staff an information booth at the Ithaca Farmer's Market every weekend from June through October.
- **Floating Classroom (FC)**: Cruises were offered to the public to assist in plant monitoring in the lake. The FC also printed and distributed educational materials to the public. The FC and other volunteers created a float for the Ithaca Festival Parade depicting the eradication effort and the importance of clean boating practices.

- **Other**: Funding for the Finger Lakes Institute Watercraft Steward Program was awarded through the Great Lakes Restoration Initiative from the US Fish and Wildlife Service, and was coordinated by the NY Department of Environmental Conservation, Cayuga County, and the Finger Lakes-Lake Ontario Watershed Protection Alliance to provide Boat Launch Stewards on the seven easternmost Finger Lakes. NYSDEC, NYS Parks, and various municipalities authorized this Steward program at the launches under their authority. One Steward was stationed at Allan Treman Marina (Ithaca, NY) throughout the height of the boating season. Stewards provided guidance to boaters on clean boating practices. By season end, the Stewards were noticing a clear change in behavior of regular boaters who now sought out stewards before and after boating for assistance in checking for invasives. As in 2011, the HTF sponsored public education through plant identification and training workshops, in cooperation with CCE, CLWN and FC. The HTF also continued to give interviews (print, radio and TV), prepared press releases, responded to individual stakeholders concerns and prepared both position statements for regulatory/agency staff and articles for news outlets. The crews conducting mechanical harvesting in both Seneca and Cayuga counties in the northern part of Cayuga Lake attended ID workshops. They have committed to ceasing their operations to limit spread of hydrilla if it is found during a harvesting run.

Description of Public Involvement in 2012-

Providing public access to the eradication effort remains a priority for the Hydrilla Task Force. Public support for the eradication effort is high. Public awareness of the danger posed by hydrilla translated into support for local legislation in Tompkins and Schuyler counties on clean boating practices, a positive response to boat stewards at launches and at least one home owners association began their own training workshops enlisting volunteer plant 'spotters'.

Public access was provided in the same manner as 2011, with the addition of 'Hydrilla Happy Hours' in 2012– informal presentations made by various HTF members at local restaurants/bars on the Inlet. Project efforts remained successful, but were taxing on HTF members. The Outreach Committee reviewed 2011-2012 efforts to determine if there were opportunities for increased efficiency. The Outreach Committee also used the newly developed Communication Plan to guide future efforts.

Description of 2013 Management Efforts

Background

Experience and knowledge gained from the 2011 and 2012 herbicide treatments and plant monitoring, as well as knowledge and advice from aquatic plant experts, was used to develop the treatment plan for 2013. The experts represent researchers and resource managers from across the country with extensive knowledge about hydrilla. Allied Biological (herbicide applicators) and SePRO (producer of Sonar) submitted proposals for 2013 treatment activities and technical oversight, and final contracts were established between the HTF (via Tompkins County Soil & Water Conservation District), Allied Biological, and SePRO. As in 2012, a dual herbicide approach was the final treatment decision for the Cayuga Inlet.

Herbicides

Herbicide was applied to approximately 135 acres of the Cayuga Inlet. The initial endothall (Aquathol-K) treatment was applied on July 16th in the Cayuga Inlet treatment zone. This application date was determined by emergence of hydrilla shoots. A single, late season endothall treatment was also applied to approximately 25

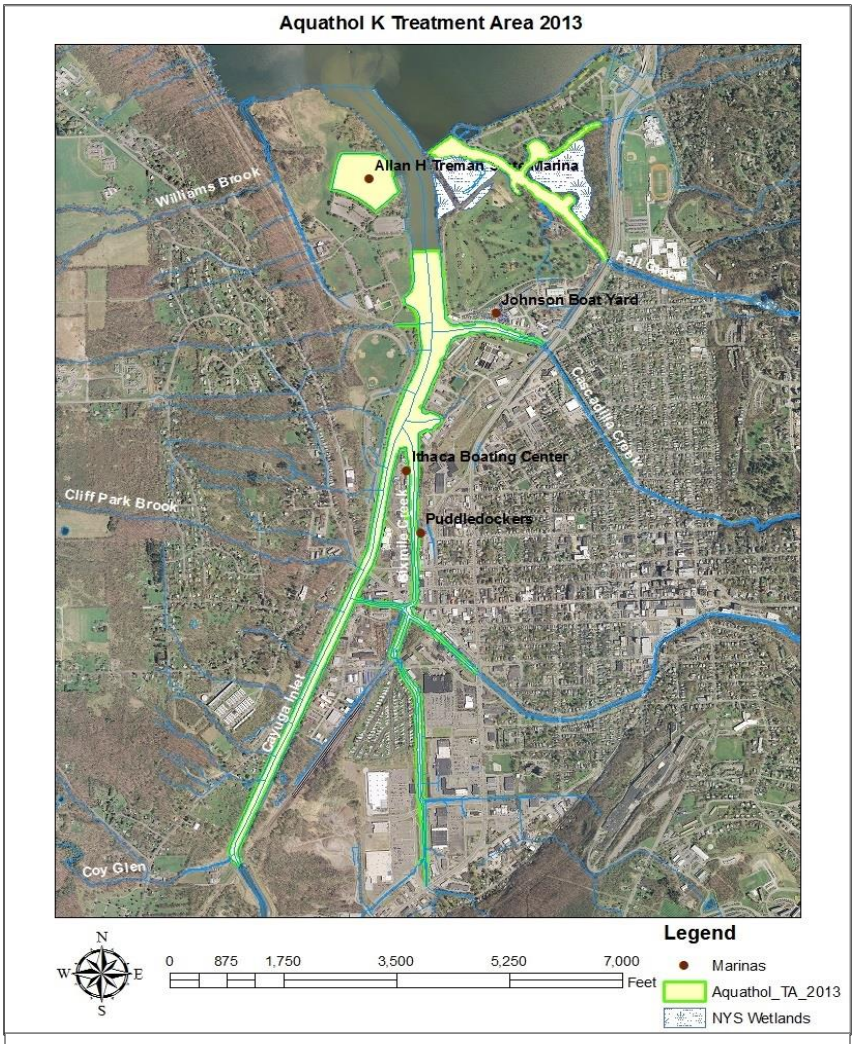

Figure 5: Map of Cayuga Inlet and Fall Creek Endothall Treatment Areas in 2013.

acres of Fall Creek on September 26, 2013, following the discovery of isolated hydrilla patches rooted/growing in Fall Creek (including the Stewart Park Pond and the golf course backwater area) in August. **Figure 5** shows the Cayuga Inlet and Fall Creek endothall treatment areas for 2013. The HTF determined that a single endothall treatment would be the most effective response measure for Fall Creek, based on input from stakeholders and peer reviewers, flow rates in Fall Creek, overall treatment area, and the need for a rapid response.

Sonar Genesis (liquid) and Sonar One (pellet) application began on August 14th. The dual chemical application provided treatment across asynchronous hydrilla tuber growth patterns. Using two different chemicals also reduced the likelihood of the hydrilla plants developing chemical resistance. The Sonar Genesis (liquid) formulation was applied in staged drip applications to maintain a steady fluridone exposure of 4-6 parts per billion (ppb) throughout the infestation zone, while minimizing dosage of and transport to uninfected areas, including the south end of Cayuga Lake

Sonar One (pellets) was applied to areas within the infestation zone where sufficient liquid Sonar contact could not be assured, including shallow/backwater areas, and within the Allan Treman State Park marina. Chemical concentration monitoring determined the timing for re-application of Sonar pellet formulations. A total of two (2) Sonar One treatments occurred. The initial Sonar One pellet application occurred on August 14th in conjunction with the start of fluridone (Sonar Genesis) drip application. The second Sonar pellet "bump" treatment occurred on September 16th. The areas that were treated multiple times with Sonar One included the Allan Treman marina, the flood relief channel behind Wegmans, downstream portions of Cascadilla Creek, the Cornell boatyard bay, and mouth of Linderman Creek. **Figure 6** shows the 2013 Sonar pellet treatment areas.

Water quality monitoring was conducted both pre- and post-herbicide treatment. Monitoring during herbicide treatment determined chemical concentrations within the treatment area. The Task Force, Allied Biological, and SePRO used this data and to ensure proper chemical concentrations and to alter dosing as needed. Post-treatment monitoring was used to determine spread of the chemical within and outside the treatment area, degradation of the chemical, and compliance with public notification requirements. Movement of any of the chemicals outside of the treatment area was minimal.

Detailed water quality monitoring information and the annual Plant Community Report (compiled by Racine-Johnson Aquatic Ecologists) is posted at StopHydrilla.org.

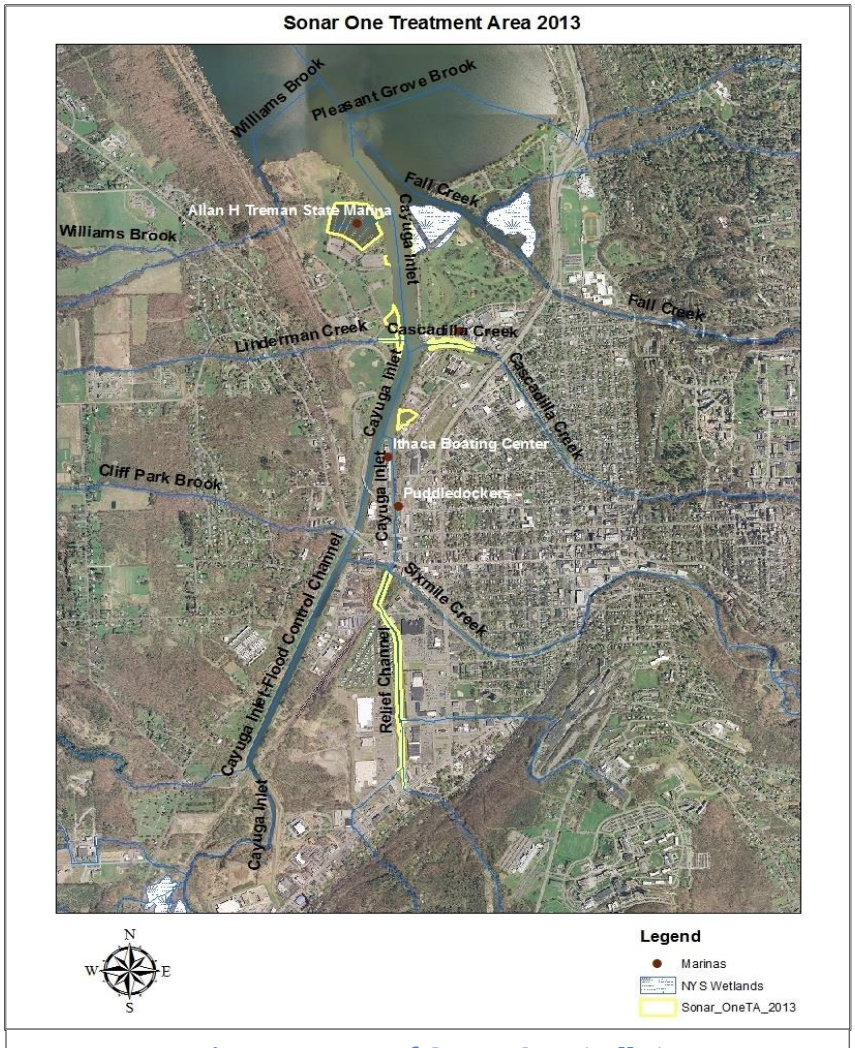

Figure 6: Map of Sonar One (pellet) Treatment Areas in 2013.

Prevention and Outreach

The community was informed of impending treatment through 24 hour notices in the Ithaca Journal and on the Stophydrilla.org website, as well as through the posted herbicide warning signage within/beyond the treatment zone (as required by NYSDEC). The community and inlet users were notified that the inlet would be closed for a 24-hour period to allow for optimal conditions for herbicide applicators. The Tompkins County Sheriff and USCG Auxiliary assisted the Task Force in closing the inlet to boat traffic. Closure of the inlet could be extended beyond 24 hours based on unfavorable weather/water conditions (flow) or unforeseen mechanical issues. In the end, endothall treatment in the Cayuga Inlet was initiated and completed on July 16, 2013.

Public Outreach (Continuous): Efforts from 2012 were continued and expanded upon in 2013.

- **Cornell Cooperative Extension of Tompkins County (CCE)**: Led education and outreach efforts. This included maintenance and updating of the StopHydrilla.org website, leading outreach meetings, and serving as the point of contact for hydrilla questions. Collaborated with CLWN to host trainings and public meetings.
- **Cayuga Lake Watershed Network (CLWN)**: The Cayuga Lake Watershed Network expanded the number of public workshops around Cayuga Lake in 2013. The Network continued working directly with the local shoreline homeowner organizations (such as the West Shore Homeowners Association), which has several hundred members. CLWN also greatly expanded the "Hydrilla Hunters" volunteer initiative in 2013, providing for greater lakeside monitoring of private shorelines for invasive species. As in 2012, the CLWN conducted additional publicity, outreach and education work as needed, in cooperation with the Task Force and Tompkins County CCE. The CLWN coordinated volunteers to staff an information booth at the Ithaca Farmer's Market on Sundays from June through October. Monthly North/South Cayuga Lake conference calls were organized and hosted by the CLWN, which continued through the 2013 treatment season.
- **Floating Classroom (FC)**: Cruises were offered to the public to assist in plant monitoring in the lake. Hydrilla monitoring cruises provided hands on sampling experience to attendees/volunteers, and provided information regarding the native and invasive plant population. General cruises incorporated hydrilla and invasive species information into normal outreach to the public.
- **Other**: Funding for the Finger Lakes Institute Watercraft Steward Program was awarded through the Great Lakes Restoration Initiative from the US Fish and Wildlife Service, and was coordinated by the Finger Lakes Institute to provide Boat Launch Stewards throughout the Finger Lakes region and on Lake Ontario. One Steward was stationed at Allan H. Treman Marina throughout the height of the boating season. Stewards provided guidance to boaters on clean boating practices. As in 2012, the

Stewards observed a clear change in behavior of regular boaters who now sought out stewards before and after boating for assistance in checking for invasives. The HTF also continued to give interviews (print, radio and TV), prepare press releases, responded to individual stakeholders concerns and prepared both position statements for regulatory/agency staff and articles for news outlets.

Description of Public Involvement in 2013

Public access was provided in the same manner as 2012, with formal and informal presentations made by various Task Force members at local venues. As in 2012, the HTF conducted public education and outreach at local venues and community events by providing outreach and education, plant identification, and trainings in cooperation with CCE, CLWN and FC. The "Hydrilla Hunter" program (managed by the CLWN) expanded greatly during the 2013 season, with members of the West Shore Homeowners Association attending workshops and enlisting volunteer plant 'spotters'.

Overall, there was a lack of funding for 2013 outreach efforts, which led to a more targeted approach for community events (such as Sundays at the Ithaca Farmers' Market), a bigger focus on fishing tournaments, and the creation of high quality hydrilla identification transparencies. The Outreach group reviewed 2011 and 2012 efforts to determine opportunities for greater efficiency. This review allowed for greater outreach focus and more streamlined collaboration, while targeting outreach to areas of greatest concern. The outreach efforts remain a success and are a vital component of the overall Project. The HTF Outreach Committee will review and assess 2013 outreach activities to develop an action plan for 2014.

Description of 2014 Management Efforts

Background

Experience gained from the 2011 through 2013 in-field herbicide treatments and plant monitoring, as well as knowledge and advice from external peer reviewers/experts, was used to develop the treatment plan for 2014. The external peer reviewers represent a collection of experts and scientists from across the country, all of whom have direct experience with control of invasive species (generally) and hydrilla (specifically). Reviewer affiliations include: NYSDEC, US Army Corps of Engineers, USDA at Davis California, University of Florida, North Carolina State University, and US Fish & Wildlife Service. Allied Biological (herbicide applicators), SePRO (Sonar producer), and UPI (Aquathol producer) submitted proposals for 2014 treatment activities and technical oversight. Final contracts were established between the Hydrilla Task Force (via Tompkins County Soil and Water Conservation District), Allied Biological, SePRO, and UPI. Similar to the 2013 management efforts, a dual herbicide approach was proposed and supported for the Cayuga Inlet and Fall Creek in 2014.

Herbicides

Fall Creek: Initial application of the contact herbicide Aquathol-K (endothall) occurred on July 17, 2015 in Fall Creek. Applicators from Allied Biological conducted Aquathol-K application via subsurface injection using equipment installed on airboat, johnboat, and via backpack application. The Tompkins County Sheriff assisted the Task Force in closing Fall Creek to boat traffic for a 24hr period in conjunction with the Aquathol-K application. Application was completed in one day.

Follow-up Sonar (fluridone) treatments in Fall Creek began on August 14, 2015. Sonar One (pellet) applications were conducted in the shallow/backwater areas of Fall Creek, and included: Stewart Park Pond, the golf course lagoon, and Fall Creek cove. Sonar pellet bump treatments in Fall Creek occurred on September 2, 12, 23, and 30.

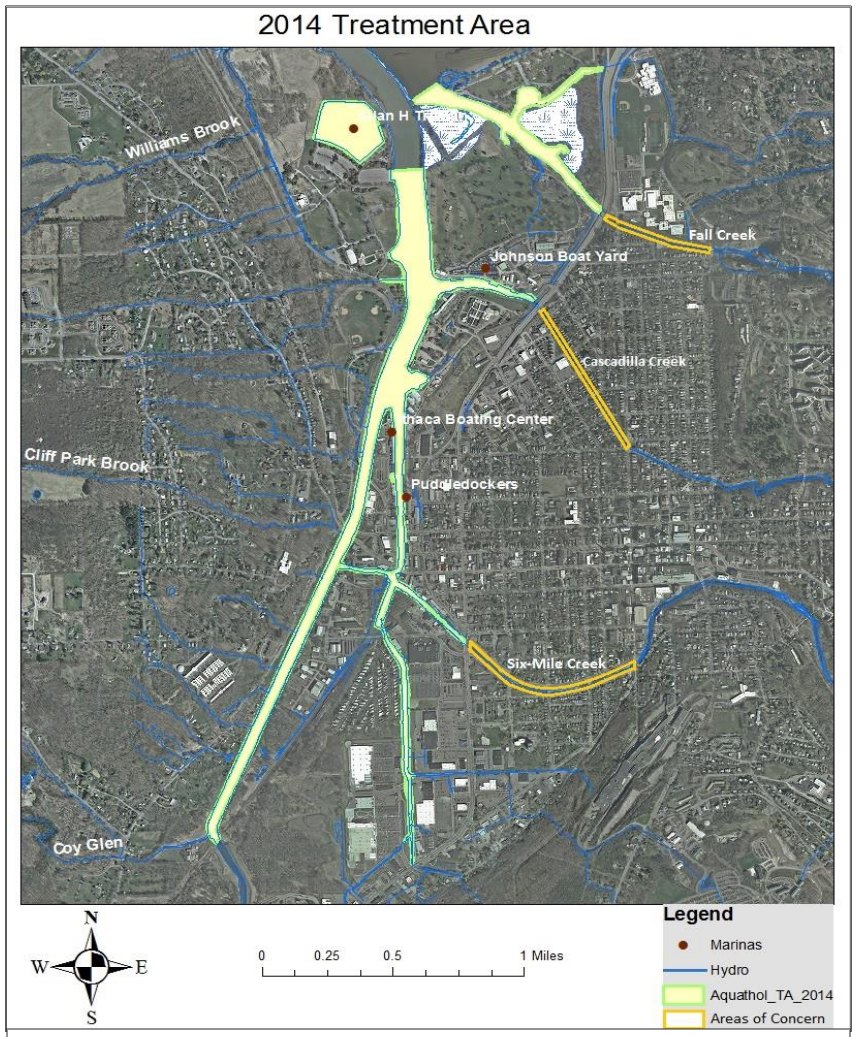

Figure 7: Map of 2014 Aquathol-K Treatment Areas in Cayuga Inlet and Fall Creek.

Cayuga Inlet: Initial application of the contact herbicide Aquathol-K (endothall) occurred on July 29, 2015 in the Cayuga Inlet. Applicators from Allied Biological conducted Aquathol-K application via subsurface injection using equipment installed on airboat, johnboat, and via backpack application. The Tompkins County Sheriff and USCG Auxiliary (Flotilla 2-2) assisted the Task Force in closing the Inlet for a 24hr period in conjunction with the Aquathol-K application. Application was completed in one day. **Figure 7** depicts the 2014 Aquathol-K treatment areas within Cayuga Inlet and Fall Creek.

Initiation of follow-up Sonar (fluridone) treatments in Cayuga Inlet began on August 26, 2015. Sonar Genesis (liquid) injection units were turned on for the season, and continued application through October 8, 2015. These units allowed for the steady application of 5-8ppb of Sonar for the season; maintaining target concentrations and contact time throughout the season. Sonar One (pellet) treatments occurred on August 26th and September 30th in the Allan Treman Marina and Linderman Creek. **Figure 8** depicts the 2014 Sonar One (pellet) treatment areas within Cayuga Inlet and Fall Creek.

Post-treatment water quality monitoring was conducted by the HTF and Stakeholders, including: Tompkins Co. Health Dept., City of Ithaca, Community Science Institute, Allied Biological, and SePRO. This monitoring was conducted to:

1. Ensure herbicide concentrations did not exceed the 50ppb Maximum Contaminant Level (MCL) for drinking water safety at the Bolton Point water intake
2. Determine drift/loss of herbicide within/outside of the treatment zones
3. Ensure herbicide concentrations remain at target levels for effective treatment
4. Assist the HTF in making necessary adjustments to treatment protocols

All monitoring results were provided to the public via the Tompkins Co. Health Department and Stophydrilla.org websites.

Other Control Measures:

In addition to the dual herbicide applications in Cayuga Inlet and Fall Creek, physical control measures and benthic barriers were used to address hydrilla growth in Fall Creek cove and the southeast corner of Cayuga Lake.

With assistance from the City of Ithaca, the HTF secured forty (40) new benthic barriers for emergency use in the Cayuga Lake Watershed. A small number of benthic barriers were installed in the southeast corner of Cayuga Lake to address isolated hydrilla patches discovered during routine monitoring activities in 2014. As in

2013, the benthic barriers were used to cover hydrilla patches outside of the permitted herbicide treatment zone. Benthic barriers block sunlight and prevent plant growth. This effort was considered successful, and will be utilized in the future if deemed appropriate.

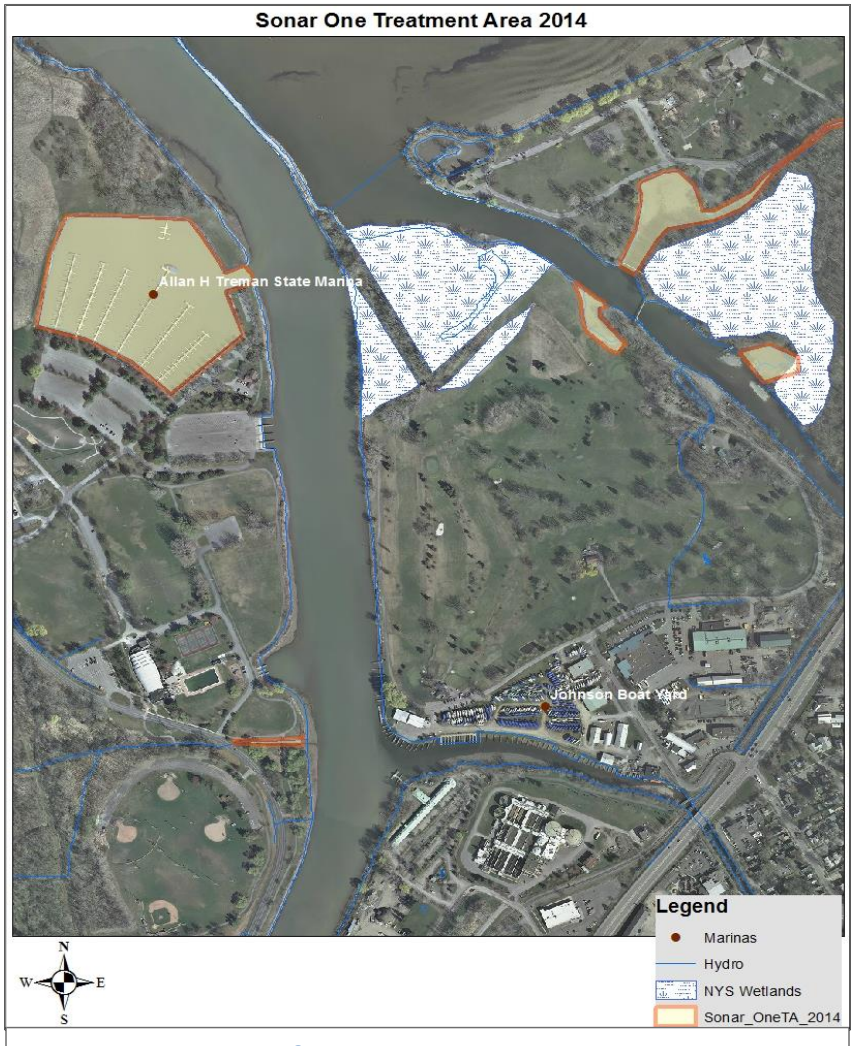

Figure 8: Map of 2014 Sonar One Treatment Areas in Cayuga Inlet and Fall Creek.

A physical removal effort was also conducted in Fall Creek cove on September 23 and 24, 2014. Sonar concentration levels within the Fall Creek cove were below target levels for most of the season, due to flow rates and rapid dilution in the Fall Creek system. In order to address hydrilla patches within the Fall Creek cove, members of the Hydrilla Task Force (City of Ithaca, NYS Parks, and HTF Program Manager) conducted a physical removal effort using small watercraft. After accessing the shallow Fall Creek cove, the HTF crew removed visible hydrilla patches by hand, and used small nets to capture any hydrilla fragments created during the removal process. Removed hydrilla material was disposed of properly back on land. The goal of this effort was to remove hydrilla biomass above the sediment. This effort was considered highly successful, and may be utilized again in future management efforts (if necessary).

Prevention and Outreach

The community was informed of impending treatment through 24 hour notices in the Ithaca Journal and on the Stophydrilla.org website, as well as through the posted herbicide warning signage within/beyond the treatment zone (as required by NYSDEC). In addition, the Outreach Committee created treatment notification mailing lists for the 2014 season. These mailing lists targeted inlet/waterfront businesses, and provided advanced notification for upcoming treatments. This advanced notice allowed inlet businesses additional time to plan for the 24hr Inlet closure associated with Aquathol-K treatment. The Tompkins County Sheriff and USCG Auxiliary assisted the Task Force in closing the inlet to boat traffic.

Public Outreach (Continuous): Efforts from 2013 were continued and expanded upon in 2014.

- **Cornell Cooperative Extension of Tompkins County (CCE)**: Led education and outreach efforts. This included maintenance and updating of the StopHydrilla.org website, leading outreach meetings, and serving as the point of contact for hydrilla questions. Collaborated with CLWN to host trainings and public meetings. Also managed newly created treatment notification mailing lists, and sent out treatment updates to Inlet business owners and the community.
- **Cayuga Lake Watershed Network (CLWN)**: The Cayuga Lake Watershed Network expanded hydrilla outreach efforts and Hydrilla Hunter program to the northern end of Cayuga Lake. CLWN continued working directly with the local shoreline homeowner organizations to monitor shoreline for suspicious plant growth. As in 2013, the CLWN conducted additional publicity, outreach and

education work as needed, in cooperation with the Task Force and Tompkins County CCE. The CLWN coordinated volunteers to staff an information booth at the Ithaca Farmer's Market on Sundays from June through October. Monthly North/South Cayuga Lake conference calls were organized and hosted by the CLWN, which continued through the 2014 treatment season.

- **Floating Classroom (FC)**: Hydrilla Survey Cruises were offered to the public to assist in plant monitoring in the lake. These cruises provided hands on sampling experience to attendees/volunteers, and provided information regarding the native and invasive plant population. General cruises incorporated hydrilla and invasive species information into normal outreach to the public.
- **Other**: The HTF continued to give interviews (print, radio and TV), prepare press releases, responded to individual stakeholders concerns and prepared both position statements for regulatory/agency staff and articles for news outlets.

Description of Planned 2015 Management Efforts

Background

The external peer review process was conducted on March 27, 2015. Input from external peer reviewers/experts, as well as extensive plant community monitoring data from 2014, was used to develop the treatment plan for 2015.

An overarching message from peer reviewers was that a more proactive management strategy needed to be implemented in the southeast corner of Cayuga Lake to address the isolated hydrilla patches discovered in 2013 and 2014. With management and eradication efforts in Cayuga Inlet and Fall Creek being highly successful, these areas are not actively contributing to the spread of hydrilla beyond the treatment zones. Moving forward, it will be the isolated patches in the southeast corner of Cayuga Lake that pose the greatest threat for hydrilla spread. As such, the HTF assessed available management options and ultimately decided that proactive herbicide treatment in the southeast corner of Cayuga Lake would provide the best opportunity for success.

Herbicides

Cayuga Inlet and Fall Creek: Similar to the 2014 season, a dual herbicide approach will be used in the Cayuga Inlet and Fall Creek again in 2015. Initial contact herbicide applications (Aquathol-K) will be made in both the Inlet and Fall Creek, as determined by the presence of growing hydrilla vegetation. Sub-surface injection equipment will be used from airboat, johnboat, and backpack application equipment.

One difference for 2015 is the Aquathol-K application protocol that will be followed in Fall Creek. Based on the rapid dilution and partial effectiveness observed in the 2014 Fall Creek application, Aquathol-K will be applied via sub-surface injection unit over a 36hr period in Fall Creek. The goal of this updated application protocol will be to increase Aquathol-K retention time and to maintain target concentrations over a longer period. This should greatly improve treatment efficacy.

Following initial applications of Aquathol-K in Cayuga Inlet and Fall Creek, follow-up, low-dose applications of Sonar will occur. Sonar Genesis (liquid) injection units will once again be used in the larger Cayuga Inlet treatment zone. This will allow for sustained target concentration levels and retention time, greatly improving hydrilla treatment efficacy. Sonar One (pellets) will be utilized in backwater areas (Allan Treman Marina and Linderman Creek), which receive less direct flow throughout the season.

Sonar One will also be used in the shallow backwater areas of Fall Creek (Stewart Park Pond and feeder stream, Golf Course lagoon, Fall Creek cove, and wetland area north of Golf Course). Routine bump treatments will be required to maintain Sonar concentrations in Fall Creek throughout the season. Sonar Genesis will not be used in Fall Creek.

Post-treatment water quality monitoring will be conducted by the HTF and Stakeholders, including: Tompkins Co. Health Dept., City of Ithaca, Community Science Institute, Allied Biological, and SePRO. This monitoring will be conducted to:

1. Ensure herbicide concentrations did not exceed the 50ppb Maximum Contaminant Level (MCL) for drinking water safety at the Bolton Point water intake
2. Determine drift/loss of herbicide within/outside of the treatment zones
3. Ensure herbicide concentrations remain at target levels for effective treatment
4. Assist the HTF in making necessary adjustments to treatment protocols

All monitoring results will be provided to the public via the Tompkins Co. Health Department and Stophydrilla.org websites.

In addition, extensive plant community and tuber monitoring will be conducted in conjunction with ongoing herbicide treatments. A crew from Racine-Johnson Aquatic Ecologists will conduct rake-toss sampling to assess overall plant community composition and health, while also monitoring for potential hydrilla spread. Hydrilla tuber (seedbank) monitoring within the treatment zones will allow the HTF to strategically time herbicide treatments based on tuber germination and growth, while also monitoring tuber population decrease to assess overall management efficacy.

Evaluation of Successes and Failures, and Lessons Learned

The success of the hydrilla eradication efforts from 2011 to the present are continuously evaluated by the Hydrilla Task Force through a combination of plant and tuber surveys, chemical residual data, public outreach efforts, and evaluation of hydrilla treatment results in and outside the treatment zone.

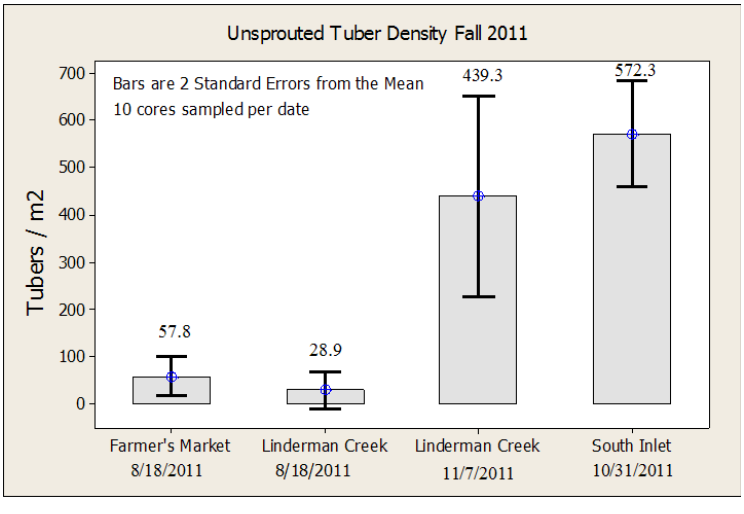

Figure 9: 2011 Hydrilla Tuber Densities, Cayuga Inlet

Evaluation of 2011 Eradication Efforts:

Plant and tuber survey results:

The application of endothall in 2011 killed approximately 95% of the hydrilla biomass above the soil level, but the remaining hydrilla had strong re-growth, probably due in part to the unusually warm fall and the late timetable for the treatment. The 2011hydrilla locations in the inlet found by rake-toss survey are listed on the IMAP invasive database and shown in **Figure 1**. A large rake toss survey of the south end of Cayuga Lake occurred over the Labor Day Holiday in 2011 and no hydrilla was found rooted in the lake. In the survey, hydrilla was found at seven locations in the Cayuga Inlet south of the Red Light House (entrance into the lake). Tuber densities were estimated through the fall of 2011 with **Figure 9** showing three locations in Inlet. Linderman Creek shows a dramatic increase in tubers from 8/18/2011 to 11/7/2011, suggesting that tuber growth in the Cayuga Inlet occurs primarily in the fall.

Chemical residual results:

The Tompkins County Soil and Water Conservation District collected water samples from the shore at six locations upstream and downstream of treatment areas as well as upstream of Cascadilla and Six Mile Creek. The Ithaca Area Waste Water Treatment Facility (IAWWTF) provided a boat for grab samples from six in-lake locations. Water samples required for DEC were taken 24, 48 and 72 hours after the first and second endothall applications. Endothall was still present at detectable levels after 72 hours, so sampling continued every seven days until there was “no detection”. This was achieved on Oct. 26, 2011. Water samples were also taken at the

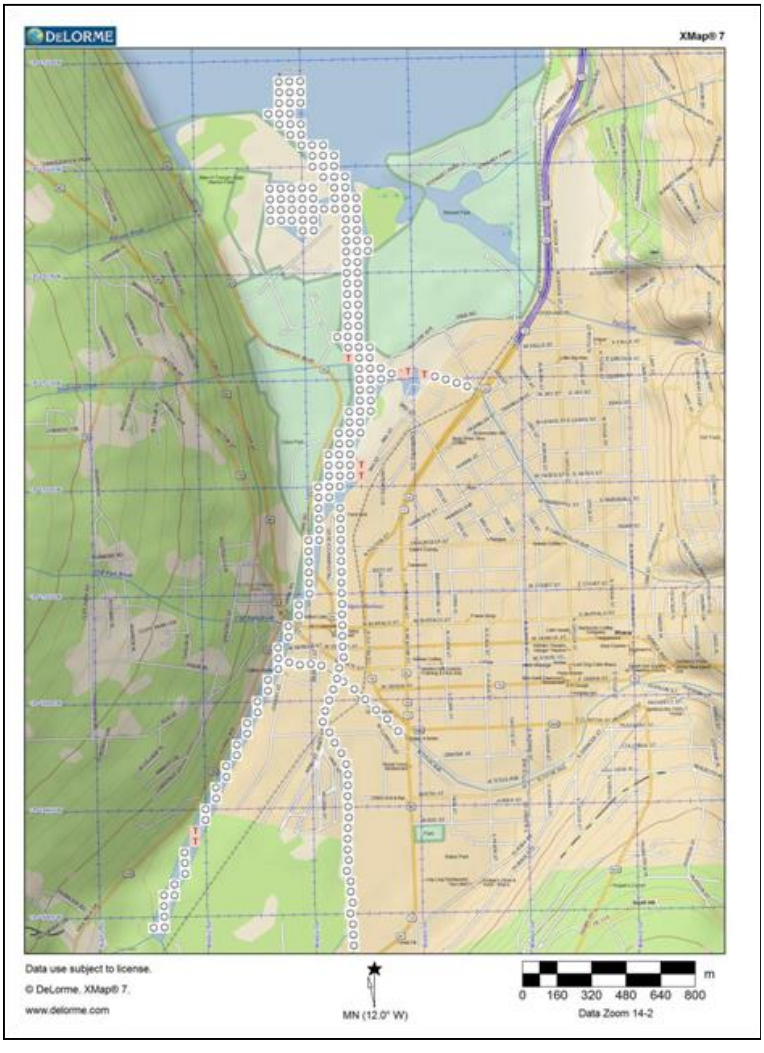

Figure 10: Distribution of 2012 Hydrilla densities, Cayuga Inlet

Bolton Point water intake on October 13th, 17th, 24th, and November 18th. There were positive detections on October 17th and the 24th at the minimum detection level of 9 ppb. This was not a concern as the maximum contaminate level for endothall is 50 ppb. More information is available at **Stophydrilla.org**

Alternative methods results:
It was determined from the pilot study that removal of visible biomass by Diver Assisted Suction Harvesting (DASH) was unsuccessful. Environmental conditions at the site and the specific characteristics of the hydrilla hampered the removal effort. Suspension of silt and clay particles by suction harvesting created zero-visibility work conditions, and cold waters required use of heavy neoprene gloves, decreasing the ability to detect plants for removal. The operation requires water pumps to move a large volume of water to maintain adequate suction of materials. Materials placed by the divers into the suction hose, along with the water, is deposited into mesh bags with. The bags must have a large enough 'mesh' size so that silts, clay, leaves and other plant material being collected do not immediately clog the bags and block water movement.

This process resulted in the fragmentation of hydrilla and contributed to washing small plant particles back into the recently cleared area, increasing the potential for spread. The result was inefficient hydrilla removal and fragmentation of plants. Hydrilla is naturally very brittle unlike like Eurasian water milfoil (*Myriophyllum spicatum*) and the common native coontail (*Ceratophyllum demersum*); both latter species do not break up as much in the collection onion bags. Though it is a standard process that is widely used and accepted for removal of other aquatic invasive species, the mechanical removal process was determined to be too 'aggressive' for hydrilla. The use of diver assisted hand harvesting, however, may have some applicability for other sites in the Inlet or in the lake, should hydrilla be found growing in beds within the lake or in locations not manageable by herbicides in the Inlet.

Evaluation of 2012 Eradication Efforts:

Plant and tuber survey results:
The endothall treatment was deemed to be 99% effective at killing hydrilla vegetation within three days in the treatment zone, except for the area by the fish ladder where plant material died within 7 days. Fluridone dosing began on July 11th. The first post-treatment hydrilla growth was observed on July 27th in the form of pink stems near the Farmer's Market. Within 2 weeks, these stems were gone. No other hydrilla growth was found in the main treatment area for the rest of the season, with the exception of one healthy stem fragment located on August 17th on the east side of the west break wall leading to the red lighthouse. Repeated dives and rake toss surveys in that area resulted in no other hydrilla findings.

Figure 11 shows the results of the rake-toss survey from the Cayuga Inlet for 203 locations described as the Inlet, plus 29 locations at the entrance to Cayuga Lake and known at the Lighthouse area. The pie charts show results of plant densities determined by 406 and 58 rake tosses in the Inlet and Lighthouse areas, respectively. Detailed monitoring procedures will be described in the 2012 Cayuga Inlet Monitoring Plan (reference). **Figure 11** shows the percentage of plant density ratings for all plant species combined (native and non-native) for the pre-herbicide survey in late June and the post-herbicide survey in November

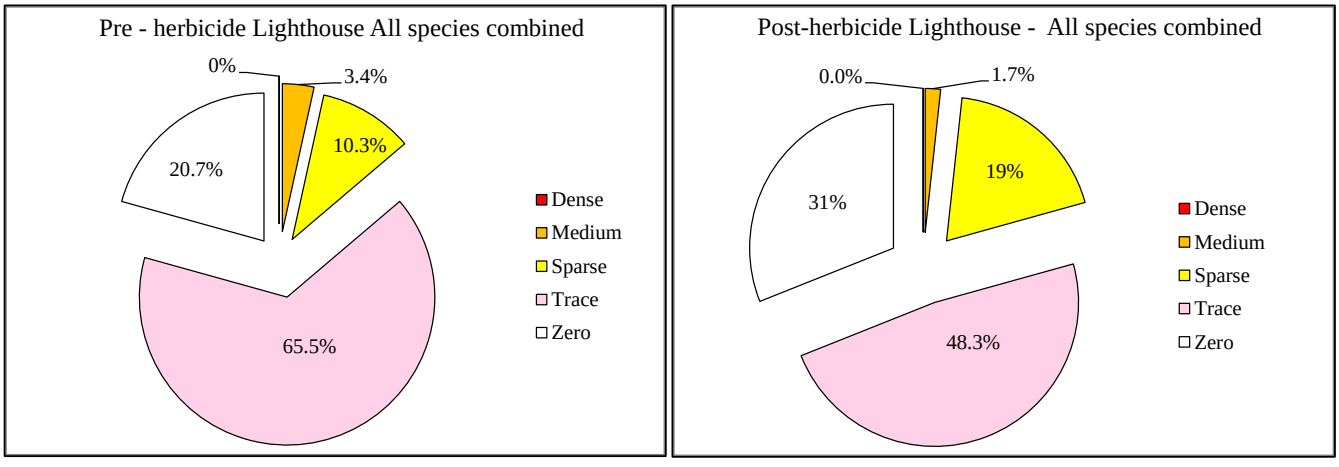

Figure 11: Change in Percentage of Plant Density Ratings for All Plant Species at Lighthouse

Figure 12 shows only the 58 rake tosses for the Lighthouse area of the Inlet, that part at the entrance to Cayuga Lake. This suggests that a greater percentage of the rake toss results with more plant growth in this area. This is likely due to less turbid waters influenced by clear lake water intrusion but may also indicate less herbicide effect of the Inlet treatment. Additionally, it is likely that the late fall survey (post-herbicide evaluation) is missing native plants that naturally die back in mid-summer and would not be found in fall. One example is *Potamogeton pusillus* that grows in the inlet in the spring but not in fall. Another positive influence on these graphs is the loss of the target plant species, *Hydrilla verticillata*, which was present on 15 of the rake-tosses of the Inlet pre-herbicide survey but was not found in the November survey due to the 2012 herbicide treatments.

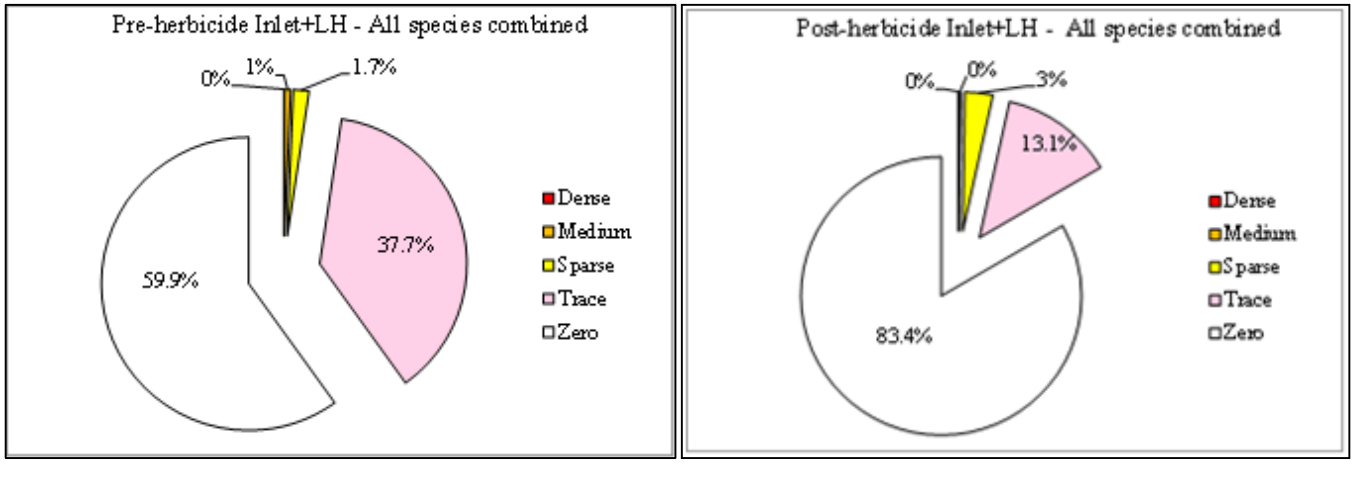

Figure 12: Change in Percentage of Plant Density Ratings for All Plant Species in Inlet

Figure 11 and **Figure 12** show that other plant communities, comprised of both native and non-native plants (the latter comprised of Eurasian water milfoil, curly leafed pondweed, and starry stonewort) survived the treatment throughout the treated area, even though some of these plants can be susceptible to both fluridone and endothall.

The high turbidity and seasonal flow variability associated with the Inlet may suppress all plant growth, so the presence of at least trace plant growth throughout much of the monitored sites suggests minimal impacts to the native plant communities

Figure 13 depicts extensive habitat and adequate conditions in support of macrophyte growth in the south end of Cayuga Lake. No hydrilla was found in any of the 1090 surveyed locations in 2012 at the southern end and along the southeastern and southwestern shores of Cayuga Lake. **Figure 11** and **Figure 12** also suggest that any diluted migration of fluridone or endothall into the south end of the lake did not appear to substantially affect aquatic plant growth overall or native plants susceptible to fluridone, including common waterweed (*Elodea* sp.) and coontail (*Ceratophyllum demersum*).

Chemical residual results:
To protect public health and to assure adequate dosage/distribution for herbicide efficacy, chemical residual monitoring was conducted to evaluate concentrations and persistence of the applied herbicides. Fluridone residual rates were monitored regularly to determine drip discharge rates and if additional pellet "bump" applications would be needed. Chemical residual sampling results have been posted on the StopHydilla.org web page.

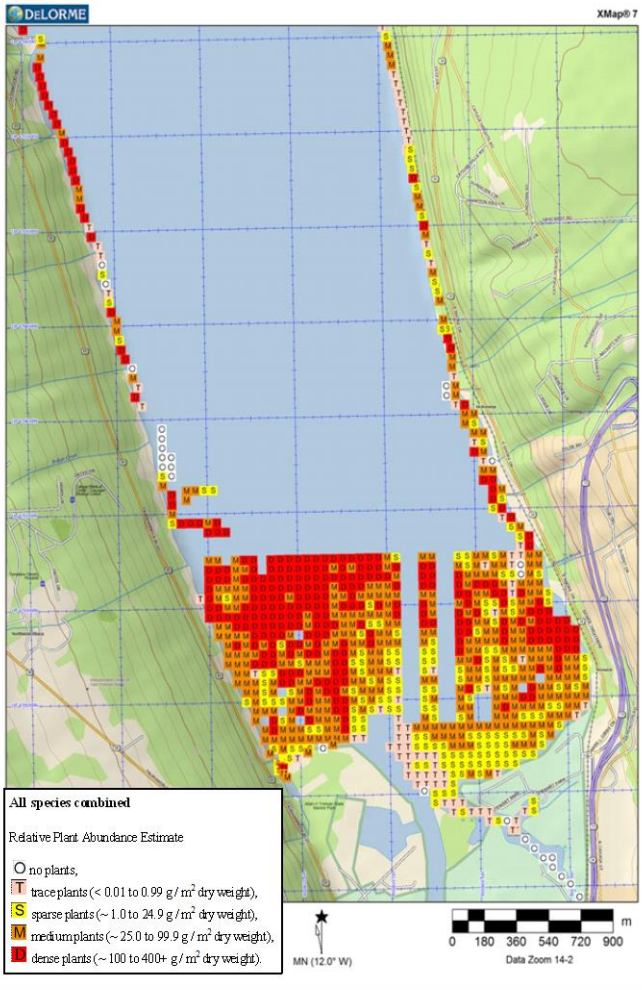

Figure 13: 2012 All species combined densities, southern Cayuga Lake

The endothall monitoring- conducted in 16 locations (DEC, Tompkins County DOH, and Local Task Force chosen sites)- indicated that endothall levels dropped below the MCL (maximum contaminant levels) of 50 ppb within the treatment area sometime between 7 and 14 days after treatment. Endothall levels were not detectable at the Bolton Point water intake at any time during or after the 2012 applications.

Fluridone sampling- conducted in 28 locations (DEC, Tompkins County DOH, and Local Task Force chosen sites)- showed fluridone levels in all locations at all times to be below the allowable application rate of 50 ppb and the labeled maximum allowable rate of 20 ppb in potable water supplies in New York State. For this application, the maximum allowable rate was 8 ppb, with a target rate of 3-5 ppb. The seasonal total was not to exceed 150 ppb.

Alternative methods results:
No alternative methods were used in 2012. The aquatic herbicide treatments were shown to be effective at greatly reducing biomass, and the combination of pellet and metered liquid herbicide treatments were adequate to penetrate all areas of hydrilla growth within the infestation zone. Herbicide levels maintained a high enough concentration to achieve the eradication objectives of the project.

Evaluation of 2013 Eradication Efforts:

Plant and tuber survey results:

Endothall treatments were deemed to be 99% effective at killing hydrilla vegetation within the inlet treatment zone. The initial endothall treatment within the Cayuga Inlet treatment zone occurred on July 16th. Fluridone dosing began on August 14th and continued through October 15th. Following the initial endothall treatment, and through to the end of the fluridone treatment, repeated rake toss surveys and tuber sampling resulted in no further observance of hydrilla regrowth in the inlet treatment area.

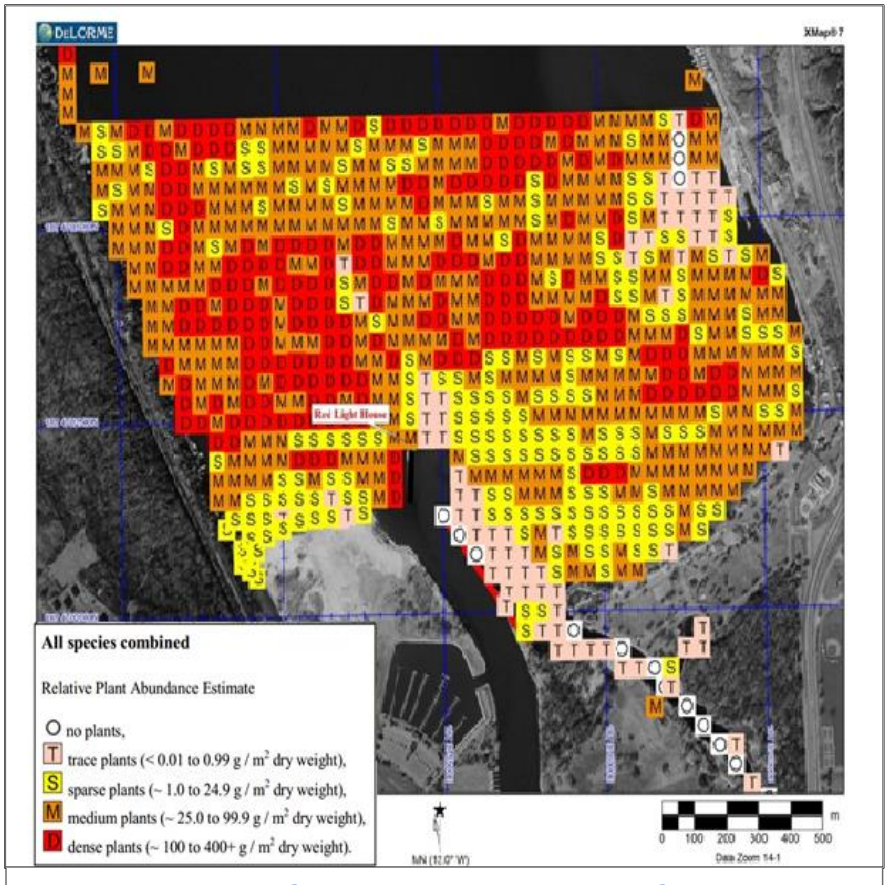

Figure 14: Map of Rake-Toss Survey Results for ALL Plant Species in Fall Creek and southern Cayuga Lake.

Following the discovery of hydrilla patches growing within Fall Creek in August (including the Stewart Park Pond and golf course backwater area), a single endothall treatment was applied in the Fall Creek treatment zone on September 26, 2013. Endothall treatment was deemed to be 95% effective in killing hydrilla vegetation within the Fall Creek treatment zone. Post treatment surveys and monitoring showed evidence of hydrilla regrowth within the Fall Creek treatment area. The Task Force feels that treatment protocols could have been improved in Fall Creek to increase treatment efficacy, and will ensure that those adjustments are made in 2014 as the Fall Creek treatment zone is fully incorporated into the overall Cayuga Lake Watershed Hydrilla Management Plan.

During the 2013 season, 1,537 plant survey locations were sampled in the Cayuga Inlet, Fall Creek, and southern end of Cayuga Lake, comprising a total of 3,074 individual rake-toss samples. **Figure 14** shows the results of the rake-toss surveys from the Fall Creek and southern end of Cayuga Lake for 2013. A detailed monitoring procedure is described in the 2013 Cayuga Inlet Monitoring Plan (reference). Referencing the legend in **Figure 14**, the colored squares depict rake-toss sampling locations and the relative plant abundance/density at each location. Data collected from these sampling points includes plant species presence and abundance.

When compared to the plant community survey map from 2012 (**Figure 13**, above), a similar distribution of relative plant abundances is observed, ranging from trace to dense. Although plant community growth varies from season to season, there has not been a distinct decline in the overall relative plant abundances from 2012 through 2013. **Figure 14** also indicates extensive habitat and adequate growth conditions in support of macrophyte growth in the south end of Cayuga Lake. This would suggest that diluted migration of fluridone or endothall into the south end of the lake did not appear to substantially effect aquatic plant growth or native plants susceptible to fluridone, including common waterweed (*Elodea* sp.) and coontail (*Ceratophyllum demersum*).

Figure 15 through **Figure 18** summarizes tuber sampling data for the four primary tuber monitoring sites within the Cayuga Inlet. As in 2012, the four long-term tuber monitoring locations in 2013 were: the Cornell Boatyard, Ithaca Farmers' Market/Cascadilla Kayak Launch, Mouth of Linderman Creek, and South of the Route 79 Bridge.

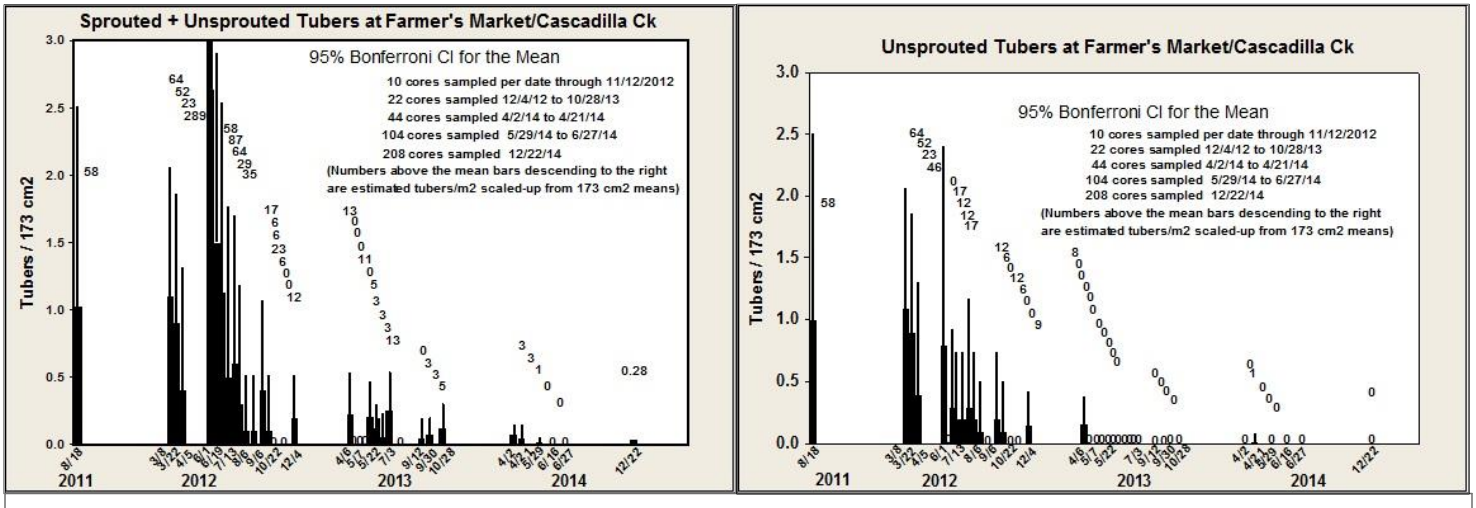

Figure 15: Sprouted and Unsprouted Tuber Densities at the Tuber Sampling Location at the Ithaca Famers' Market/Cascadilla Creek (Cayuga Inlet).

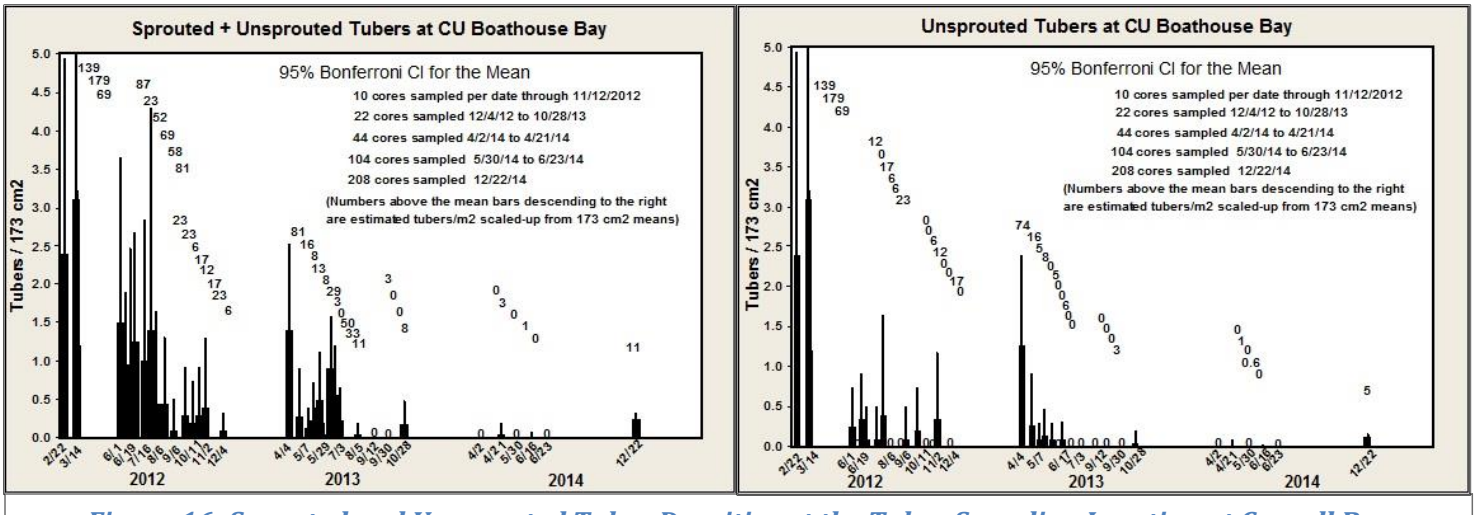

Figure 16: Sprouted and Unsprouted Tuber Densities at the Tuber Sampling Location at Cornell Bay (Cayuga Inlet).

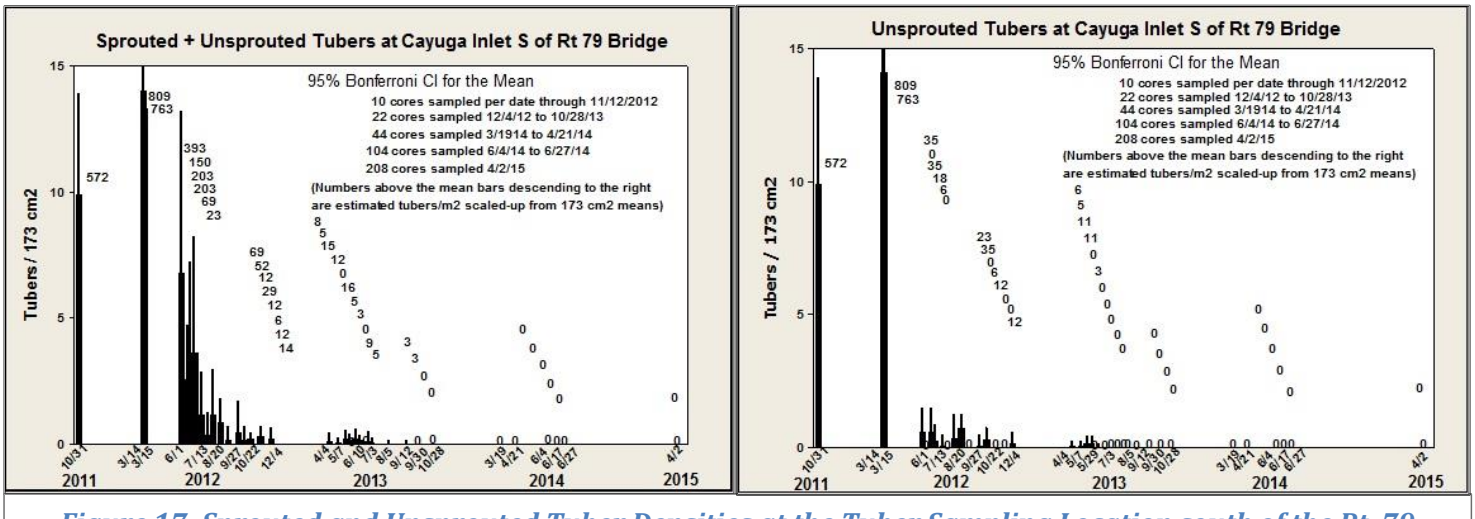

Figure 17: Sprouted and Unsprouted Tuber Densities at the Tuber Sampling Location south of the Rt. 79 Bridge (Cayuga Inlet).

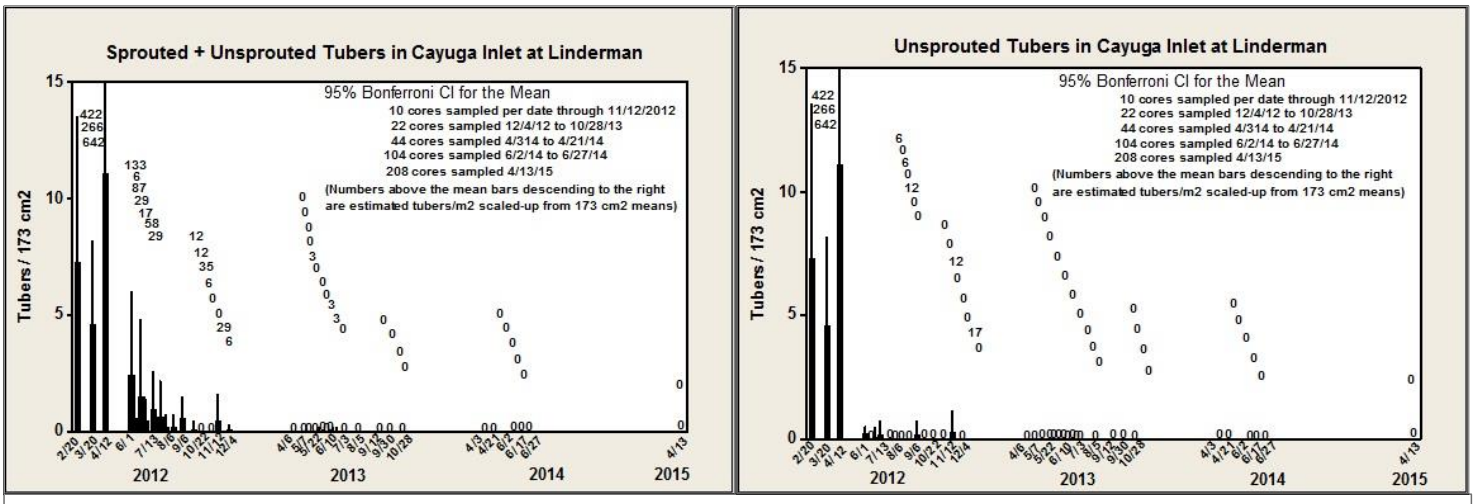

Figure 18: Sprouted and Unsprouted Tuber Densities at the Tuber Sampling Location at the mouth of Linderman Creek (Cayuga Inlet).

Since Project implementation in 2011, the Task Force has observed a marked decline in tuber densities (both sprouted and unsprouted) at all four monitoring locations within the Cayuga Inlet. Compared to the tuber densities observed at all locations in 2011 and early 2012, the current tuber densities have been reduced to less than 1/10th of their original size, with many location samples having "no find" whatsoever. Though the presence of remaining tubers means that treatments will need to continue in 2014, the significant reductions in the overall tuber densities throughout the Cayuga Inlet are a strong, positive indication that the herbicide treatments have been very effective, and progress towards eradication is being achieved.

Chemical Residual Results:

Post-treatment monitoring was conducted to evaluate concentrations and persistence of the applied herbicides in order to protect public health and to assure adequate dosage and distribution for treatment efficacy. Fluridone residual rates were regularly monitored to modify the drip discharge rate and to determine when additional Sonar pellet "bump" applications were needed. Chemical residual sampling results have been posted on the Tompkins Co. Health Department and StopHydilla.org websites.

The endothall monitoring -conducted in 10 locations for the inlet treatment AND 7 locations for the Fall Creek treatment (DEC, Tompkins County DOH, and Local Task Force chosen sites) - indicated that endothall levels dropped below the MCL (maximum contaminant levels) of 50 ppb within the inlet treatment area sometime between 7 and 10 days after treatment AND between 48 and 72hrs for the Fall Creek treatment area. Endothall levels never exceeded the 50ppb MCL at the Bolton Point water intake at any time during or after the 2013 applications.

Fluridone sampling- conducted in 14 locations (DEC, Tompkins County DOH, and Local Task Force chosen sites)- showed fluridone levels in all locations and at all times below the allowable application rate of 50 ppb and the labeled maximum allowable rate of 20 ppb in potable water supplies in New York State. For this application, the maximum allowable rate was 8 ppb, with a target rate being 4-6 ppb. The seasonal total was not to exceed 150 ppb. Water monitoring within the Cayuga Inlet treatment zone (specifically the Allan Treman marina) continued through the first week of December 2013, and was completed after ALL locations showed a fluridone concentrations to be <1.0ppb.

Alternative methods results:

Following the discovery of isolated hydrilla patches in the southeast corner of Cayuga Lake in August 2013, an alternative management method was implemented in this area. Aquatic herbicide treatments were shown to be effective at significantly reducing hydrilla biomass/tuber/turion production within the Cayuga Inlet and Fall Creek treatment zones. However, after reviewing the treatment options for the isolated hydrilla patches in the SE corner of Cayuga Lake, the Task Force determined that the possibility for significant dilution and loss of

chemical product outweighed the possible treatment benefits. Based on the size of the isolated patches, treatment area conditions, and necessity for rapid response, the Task Force determined that physical removal of the patches utilizing divers would be the best option for rapid and effective response.

Between August 28th and 30th, a team of divers (led by Racine-Johnson Aquatic Ecologists) worked to physically remove the isolated hydrilla patches from the SE corner by hand. Divers worked carefully to remove whole hydrilla plants (stems, roots, and tubers) by lifting them from below the sediment. Work was conducted within netted barriers to ensure that any hydrilla fragments were also captured and removed. Following physical removal, benthic barriers were placed over the removal area to block sunlight and prevent potential hydrilla regrowth. Subsequent sampling and monitoring of the removal area showed no signs of hydrilla regrowth following the physical removal in 2013. Further monitoring and sampling of this area will be conducted moving forward to ensure no hydrilla regrowth or spread occurs. This removal effort was determined to be successful; providing for effective removal and control, and allowing for a more rapid response (as compared to applying for and obtaining a new NYS DEC herbicide application permit).

Public Outreach & Inlet Closure:
One of the most important and challenging components of the Cayuga Inlet Hydrilla Project involves the notification of the public regarding upcoming treatments. It is the Task Force's goal to ensure that as many members of the public are notified of impending treatments, including treatment timing, associated water use restrictions, inlet closure, and water quality monitoring results.

In 2013, the area of greatest public concern involved the closure of the inlet for a 24hr period during the initial Aquathol-K treatment. During the time frame associated with the contact herbicide treatment, the Tompkins County Sheriff and USCG Aux. Flotilla 2-2 assisted the Task Force in closing the inlet for a 24hr period. This 24hr closure helped to provide the best possible conditions for the herbicide applicators to ensure a proper and effective treatment. In addition, closure ensured public safety by reducing the risk of accidental exposure to treated waters during the 24hr swimming restriction associated with Aquathol-K application. Lastly, closure helped to ensure the safety of the herbicide applicators by reducing boating/recreation traffic in the treatment zone while they conducted their work.

While the closure greatly increased safety for the community and herbicide applicators, inlet businesses did experience hardship during this 24hr period. Some businesses that depend on boat traffic and tours had to cancel scheduled tours on the treatment day, resulting in lost revenue. While the Task Force makes every effort to notify inlet business owners as soon as possible regarding treatment plans, the variable weather/water conditions, and asynchronous growth/germination of hydrilla tubers, make it difficult to pinpoint an exact treatment date until approximately 1-2 weeks prior. Notification is provided, however in some cases boat tours had been scheduled more than 9 months in advance. This advanced scheduling far exceeds the timeline for Cayuga Inlet hydrilla treatment planning, often by a full season.

The Task Force acknowledges these hardships, and will work diligently to provide possible alternatives to inlet businesses moving forward. It will be difficult to accommodate ALL inlet business needs, but it is the Task Force's hope that a flexible and acceptable arrangement can be made to accommodate those adversely impacted by the inlet closure. For the 2014 season, the Task Force has collaborated with NYS Parks (Taughannock State Park) to provide a suitable satellite business site for inlet boat tour businesses during the 24hr inlet closure period. A mutual standpoint of flexibility and understanding will be necessary from all parties involved, but the option is available to businesses that would like to take advantage.

Evaluation of 2014 Eradication Efforts:

Herbicide Treatments:

Endothall treatments were considered to be effective in the Cayuga Inlet, with a vast majority of hydrilla biomass (95% +) being killed following the initial application. Endothall concentrations and retention time were slightly lower than target levels, but treatment proved to be effective nonetheless.

Follow-up Sonar treatments (Genesis injection and Sonar One pellets) in Cayuga Inlet were considered effective in preventing hydrilla regrowth following initial endothall application. Utilizing multiple Sonar formulations and application methods (injection and pellets), Sonar concentrations and retention time were on target and maintained throughout the 2014 season.

Endothall treatment in Fall Creek was considered only partially effective in 2014. As is the case, the average flow rates through the Fall Creek system are much higher than that of the Cayuga Inlet. These higher flow rates (CFS) make maintaining herbicide concentrations and retention time challenging, as was observed in 2014. Of particular difficulty was maintaining Sonar One (pellet) concentrations and retention time in the Fall Creek cove area. Again, higher flow rates throughout Fall Creek made rapid dilution and short retention time a constant issue. This issue led the HTF to implement alternative control methods in the Fall Creek cove area in late September 2014 (See Alternative Methods, below).

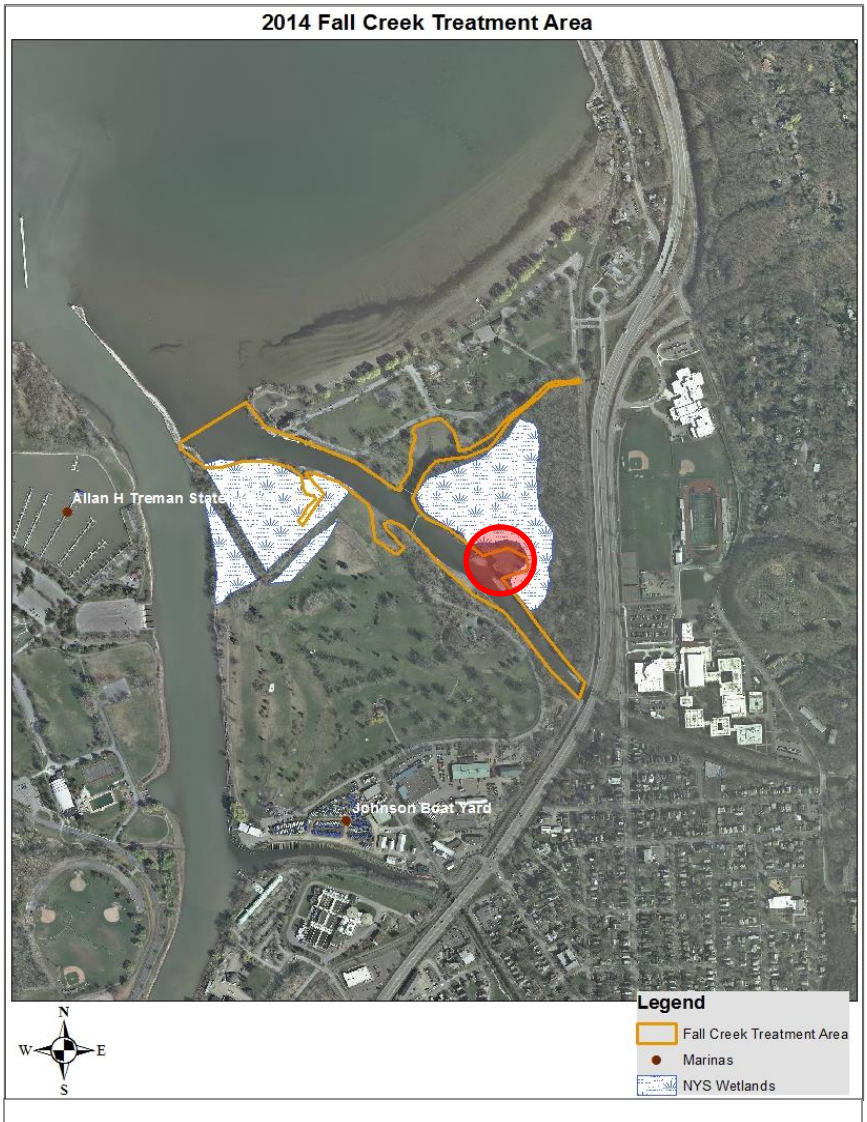

Figure 19: Fall Creek cove physical removal effort location.

Alternative Methods:

With flows in Fall Creek leading to difficulty in maintaining endothall and fluridone concentrations throughout the season, the HTF needed an alternative method to address hydrilla growth in the Fall Creek cove. On September 23 & 24, 2014, members of the HTF (City of Ithaca, NYS Parks, and HTF Program Manager) conducted a physical removal effort of hydrilla biomass in the Fall Creek cove area (**Figure 19**).

Using small johnboats, an 8-person crew accessed the Fall Creek cove area. Hydrilla plants were physical removed by hand, and nets were used to capture any floating fragments created during the process. All hydrilla material was collected and disposed of properly back on land. This effort was conducted over a two-day period, when water flow was slow and clarity was good.

Overall, this alternative management method was considered very successful in targeting and removing isolated hydrilla patches, and the HTF will consider utilizing this approach again in future seasons. The primary goal was to prevent fragmentation and possible spread of

hydrilla. Tubers were not targeted, and regrowth in 2015 is likely.

Benthic mats were also utilized again during the 2014 season. With assistance from the City of Ithaca, the HTF was able to secure additional benthic mats to have on hand for rapid hydrilla response. Isolated hydrilla patches were discovered in the southeast corner of Cayuga Lake in 2014, adjacent to areas where hydrilla patches had been removed and covered with benthic barriers in 2013. Crewmembers from Racine-Johnson Aquatic Ecologists worked quickly to install additional benthic barriers over the newly discovered patches. As in 2013, these efforts were considered a successful alternative for hydrilla management in areas outside of the permitted herbicide treatment zones. Extensive plant community sampling continued through the end of the season to monitor for potential hydrilla regrowth in the benthic barrier area. No hydrilla regrowth was observed.

Plant Community and Hydrilla Tuber Monitoring Results:
Racine-Johnson Aquatic Ecologists conducted extensive plant community and hydrilla tuber monitoring and sampling efforts throughout the 2014 season. Plant community monitoring utilized rake-toss sampling methods (50m x 50m AND 25m x 25m grids) to analyze overall plant community composition (species, presence, abundance, and distribution). The primary goal was to monitor for hydrilla growth and spread, but the HTF is also interested in monitoring for potential herbicide impacts to non-target species (natives). The HTF did not observe adverse impacts of herbicide treatments to the native plant community.

Hydrilla tuber monitoring was conducted within the Cayuga Inlet and Fall Creek treatment zones throughout 2014. Sediment core samples were collected from areas with historically high hydrilla growth, including the Ithaca Farmers' Market, Cornell Boathouse Bay, and Golf Course lagoon (in Fall Creek). As was the trend in 2013, tuber sampling efforts had difficulty finding <u>any</u> tubers within the sampling areas. This can be directly attributed to the drastic decline in hydrilla tuber populations associated with ongoing herbicide treatments, especially in Cayuga Inlet.

A few areas of concern were determined through the 2014 plant community and tuber monitoring efforts, however. These areas include:

1. The Cornell Boathouse bay
2. Southeast corner of Cayuga Lake
3. Fall Creek

The Cornell Boathouse bay proved to be one of the few remaining locations where hydrilla tubers are still being observed. Hydrilla tubers and plant fragments were collected from a deep pocket area adjacent to the Boathouse docks. This area will be monitored closely in 2015 and beyond, and will require a more focused treatment protocol.

Isolated hydrilla patches were observed in the southeast corner of Cayuga Lake, adjacent to areas where hydrilla patches were removed and covered with benthic mats in 2013. Moving forward, it will be these isolated patches in the southeast corner of the lake that post the greatest threat for hydrilla spread. Extensive plant community sampling will be conducted in the southern end of Cayuga Lake, and hydrilla presence, growth, and spread will be monitored closely. The HTF will plan a more aggressive and proactive management strategy to address these isolated patches in 2015.

Certain areas of the Fall Creek received only marginally effective herbicide treatments in 2014. Higher flow rates throughout the Fall Creek system led to difficulties in maintaining herbicide target concentrations and retention time. Moving forward, the HTF will adjust management protocols and treatment timing to ensure greater herbicide efficacy. A major protocol change in 2015 will be the drip application (injection) of Aquathol-K over a 36-hour period, instead of a single "one shot" application. The extended drip application of Aquathol-K will allow for greater retention time and maintenance of target herbicide concentrations.

Context of Aquatic Plant Management

As noted above, a formal aquatic plant management plan for Cayuga Inlet, Fall Creek or Cayuga Lake had not been developed prior to the discovery of hydrilla in the inlet in 2011. Therefore, the eradication of hydrilla from Cayuga Inlet and connected waterways was not explicitly cited as an objective. This was the impetus behind the Task Force creating a Hydrilla Management Plan. The streams and Lake support a variety of uses, and the plan to eradicate hydrilla has explicitly addressed these uses. Aquatic herbicide application will ultimately enhance those uses through the removal of this invasive plant, and ultimately protect the lake's ecology and aesthetic appeal.

Management Objectives

Extent of Preferred Management-

In most cases, the objective of an aquatic plant management plan is to restore uses impacted by nuisance or invasive plant growth, while balancing other potentially conflicting uses. As inferred by the name, Aquatic Plant Management usually does not include eradication. Eradication is considered the removal of an entire population of an invasive species and all its propagules from an area of infestation. It is only feasible if pioneering species are discovered soon after introduction, which rarely happens. In addition, not all invasive species pose equal threats to the local ecosystem. *Hydrilla verticillata* was discovered in the Inlet within the first 1-2 years of introduction, and is one of the most aggressive and damaging invasive species known.

As noted in the Problem Statement articulated in the beginning of this Plan, the primary objective of the Cayuga Lake Watershed Hydrilla Management Plan is to eradicate hydrilla from the Inlet, Fall Creek and surrounding waterways. By necessity, this requires application of management tools throughout the infestation zone, as partial or selective control is not consistent with eradication. The asynchronous nature of hydrilla tuber germination, longevity of the reproductive cycle for tubers and turions, and seasonal nature of both aquatic plant biomass growth and hydrologic transport within the Cayuga Inlet system further necessitates the use of both seasonal (short-term) and extended management tools. However, this need may be re-evaluated in the future as dictated by plant and tuber growth response to eradication efforts. The persistence of tubers and the risk of tuber germination several years after management is initiated, or if management is suspended while tuber banks are still viable, also necessitate the application of eradication tools for many years. The combination of all of these challenges requires the development of a comprehensive, long-term strategy for eradicating hydrilla and preventing its spread outside of the present infestation zones.

Expected Use Benefits

It is anticipated that the successful eradication of hydrilla from local streams will prevent the spread of this highly invasive plant to Cayuga Lake, the surrounding Finger Lakes, and the larger Great Lakes region. Eradication will allow this critically important ecosystem to maintain biological integrity and water-based recreational uses, property values, and otherwise support the ecology and economy of the Great Lakes region. The more immediate and localized benefit will be to restore and enhance the ecological integrity of Cayuga Inlet and surrounding waterways by eliminating surface canopies and submersed beds of hydrilla in heavily trafficked areas, improve aesthetic and recreational quality, and sustain recreationally-driven economic uses of these waterways.

Critical Areas to Protect

The successful eradication of hydrilla will serve to protect a variety of uses of the streams and Cayuga Lake, including water intakes, shoreline areas subject to algae growth, upper waters of boating channels susceptible to propeller clogging and navigational impediments, fisheries habitats, and other ecologically important areas within streams and Cayuga Lake. The proposed eradication actions are intended to minimize potential impacts to areas that warrant special protection.

Management Alternatives

There is a wide variety of aquatic plant management tools available to a water body manager in New York State. Some of these tools require permits from the NYS DEC or other state or local agencies, some require detailed review and approval of proposed actions, and others are largely allowed without the use of a rigid permitting or evaluation program. A summary of these options is available in several publications, including Diet for a Small Lakes: The Expanded Guide to New York State Lake and Watershed Management (http://www.dec.ny.gov/chemical/82123.html). This publication summarizes the physical, mechanical, chemical, and biological control options available in New York State, divided into "local" and "lake-wide" management options. The governing principle, primary advantages and disadvantages, target plants, expected costs, and regulatory issues for each option are discussed at length. The pertinent sections for each of these options are discussed below.

Management Alternatives

The management alternatives identified below can be evaluated in the abstract—based on information in the open literature, through case studies in other states or other regions in New York State for which hydrilla control was the target, through evaluation of proposals from aquatic plant managers, and through feedback from an external peer review team. All of these processes for evaluating hydrilla management alternatives were utilized for this Project. The open literature has very little information about the most appropriate management actions for eradicating monoecious hydrilla. There are limited case studies from California, Maine, New York, and other states with monoecious hydrilla infestations. The primary means for evaluating management alternatives is through the evaluation of proposals provided to the Hydrilla Task Force, and working with a team of external peer reviewers to identify the most appropriate actions to meet the Project objectives.

In 2012, an external peer review team of monoecious hydrilla experts from the University of Florida, the US Army Corps of Engineers (Florida and Vicksburg), Mississippi State University, North Carolina State University, and the University of California, were recruited by the Task Force to review proposals and supporting materials provided by the Task Force. The external peer review team has been consulted in advance of each treatment season.

A monoecious hydrilla literature review, commissioned by the Northeast Aquatic Nuisance Species Panel, was completed in February 2013 and provides important insights for hydrilla eradication in the Inlet in the coming years.

Local Control

The following plant management options are used for "local" control—a small infestation that constitutes only a portion of an infested water body, or the control or eradication of a portion of a larger infestation.

Hand harvesting:

The management option, whether conducted solely by hand or augmented with the use of divers and/or suction harvesting equipment, involves the removal of plant biomass and (ideally) all rooted material and reproductive structures. It is limited in scope to very small infestations, generally less than 1000 square feet by hand. Large-scale operations involving multiple divers and plant transport systems have been deployed at several New York state lakes, most often when large-scale plant management options are not available or not appropriate. This option did not require a permit from the NYSDEC, for the specific infestation zone addressed in this Plan at the time of the infestation.

The diver-assisted suction harvesting operation used for a small hydrilla infestation south of the Rt. 79 Bridge in Cayuga Inlet has been evaluated above. To summarize, the highly fragile nature of the hydrilla plant, "blunt" nature of suction removal operations, high turbidity and clay substrate, poor water visibility and flowing water, and the very high cost of the operation (approx. $16,000 per acre), restricts the use of this tool, at best, to very small infestations not manageable by other techniques (such as very small beds in very shallow water). Given

the persistence of the hydrilla tubers, it is likely that any hand-harvested beds would need to be harvested multiple times per year over the course of several years (or be transitioned into eradication using some other management tool). In addition, in aquatic plant beds with multiple species of plants, including some hydrilla lookalikes common to Cayuga Lake, targeted hydrilla removal can be very challenging.

Benthic Mats

Benthic barriers, sometimes called benthic screens or bottom mats, prevent plant growth by blocking sunlight required for growth. The mats also provide a physical barrier to growth by reducing the space available for expansion and by preventing plants from germinating. Most aquatic plants under these barriers will be controlled if they are deprived of light for at least 30 days. If the mats are not secured to the bottom using sand or other "smothering" materials and are removed within a well-defined timeframe, NYSDEC permits are not required.

However, as with hand harvesting, the use of benthic mats is limited to but can be very effective for small populations. Plant surveys conducted in the fall of 2011 identified more than 9 acres of dense infestations. The use of benthic barriers to eradicate these infestations would be very expensive (on the order of $15,000-20,000 per acre) and would require either permanently sited mats or the logistic challenge of siting and removing these mats at multiple times and sites throughout the Inlet system.

As noted above, benthic mats were used effectively in August of 2013, following the physical removal of isolated hydrilla patches in the southeast corner of Cayuga Lake. After divers had removed the hydrilla patches by hand, benthic mats were installed over the removal areas. Subsequent monitoring and sampling in these removal areas showed no signs of regrowth. The HTF considers benthic mats to be a viable management strategy to address isolated hydrilla patches in the future.

Rotovating or Hydroraking

Rotovating or rototilling is a form of mechanical control for aquatic vegetation. It uses a rototilling machine to cut aquatic plant shoots from the sediment and remove them from the water body. Hydroraking is essentially the same technique, but it uses a mechanical rake to collect and remove some of the cut material.

Given the great risk of spreading hydrilla through fragmentation, the high likelihood of hydrilla re-growing from small fragments, and the primary goal of eradicating rather than managing hydrilla in Cayuga Inlet and surrounding waterways, rotovating and hydroraking are not recommended control strategies.

Lakewide Control

The following options refer to "lake-wide" (or "inlet-wide") infestations. These may not constitute the entirety of a waterbody, but rather represent control or management of most or all of an infestation zone.

Physical and Mechanical Controls

Physical control measures affect the physical growth patterns of the weeds by disturbing the sediment, altering light transmission through the water or to the plants, or water-level manipulation. Mechanical control strategies remove the plants and root systems, such as cutting, harvesting, and rotovating

Drawdown

Drawdown involves off-season manipulation of water levels to expose rooted aquatic vegetation and sediments to the freezing and drying action of cold air. Snow cover may insulate the sediment and prevent freezing in mild winters. Freezing can help control weeds by loosening roots and loose organic material on the exposed sediments. Drawdown usually occurs between December and April in New York State.

The water level in Cayuga Inlet and surrounding waterways is partially controlled by the state Canal Corporation, as part of regulating the state Barge Canal. While there is some latitude in controlling water levels for the purpose of affecting change in hydrilla population levels- water levels in Cayuga Lake were dropped

earlier than usual in 2011- the allowable drop and water level usually achieved in March is dictated by a rule curve established to meet several objectives. Moreover, since hydrilla has been found rooted in the middle of the Inlet channel, the Inlet would have to be completely drained water from tributaries as well as lake water would have to be kept out of the Inlet channel. In practical terms, this is not physically possible.

Shading

Shading involves the use of non-toxic, vegetable dyes that inhibit light penetration throughout the water column. This limits the growth of nuisance aquatic vegetation in water depths greater than two to four feet. The dye absorbs certain wavelengths of light, which further limits plant photosynthesis. The chemicals used do not work as herbicidal agents, as they are not absorbed or otherwise taken in by aquatic plants or animals. Shading is used to treat an entire waterbody, and is most often used in ponds or closed water systems.

However, Shading is rarely used on large water bodies, and would not be a very effective tool for a high flowing system such as Cayuga Inlet, due to rapid and heavy dilution. There is little evidence that shading could effectively control, and certainly not eradicate, hydrilla. Recent research by North Carolina State indicates that hydrilla can grow in complete darkness for at least 56 days, eliminating shading as a tool to remove hydrilla.

Mechanical harvesting

Mechanical harvesting physically removes the upper portion of rooted aquatic plants, using a machine to cut and transport the vegetation to shore for proper disposal. It is often described as underwater lawn mowing. This common method of aquatic vegetation control can be used for clearing boat channels, launch sites, swimming areas, and other high use areas where weeds pose the greatest nuisance. It is often done to improve recreational use, which can be resumed immediately after harvesting. Harvesting also removes the nutrients, primarily phosphorus, stored in the plant structure, thus controlling one contributor that causes excessive rooted vegetation growth.

However, the same risks cited for rototilling and hydroraking apply to mechanical harvesting, due to the prolific generation of fragments and very high risk for spread of reproductive structures. Mechanical harvesting is also not an eradication tool, and thus does not fit with the primary objectives of the hydrilla control efforts to be achieved in Cayuga Lake Watershed.

Dredging

Dredging has been planned in the Cayuga Inlet to restore the navigation channel and the capacity for storage and transport of floodwaters away from downtown Ithaca. The Army Corps of Engineers determined that the Inlet no longer met requirements as a functioning flood control channel (FCC) in August of 2011. Until that function can be restored, the availability of FEMA funds is uncertain in the event of a flood. Maintenance of the navigation channel is the responsibility of the NYS Canal Corporation. The FCC is the responsibility of the NYS Department of Environmental Conservation (DEC).

The City of Ithaca was charged to find a location for dredged materials to be dewatered and did so in July of 2010. The Canal Corporation has sufficient funding to dredge the navigation channel and can begin work as soon as the dewatering facility is operational, possibly as early as the fall of 2013. The DEC does not have this work budgeted and is in discussions with the Army Corps of Engineers regarding the extent of dredging required to restore the FCC. In an effort to control costs, they are hoping that they will not be required to return the FCC to its original design dimensions. As of June 1, 2015, the City of Ithaca and TG Miller have begun planning for the dredging of the Cayuga Inlet, navigational channel, and FCC has begun. The HTF will coordinate directly with the City and TG Miller to provide input on dredging protocols and precautions for contaminated dredge spoils containing hydrilla tubers.

Dredging is considered a viable management tool for hydrilla via tuber removal. Dredging is most applicable to shallow waterways that are enclosed or can be contained. Most areas of the inlet do not meet these conditions, but as dredging is already planned during the same time frame as hydrilla eradication efforts, coordinating the

efforts could result in a more certain removal of the plant and possibly shorten the number of years herbicides have to be used.

Important components of the dredging project that make the difference between it being helpful or harmful to hydrilla eradication efforts are:

- Duration of dredging activities in the inlet
- Extent of dredging
- Coordination of dredging components (navigation channel and FCC)
- Handling and disposal of dredged materials

The optimal blend of the dredging project with hydrilla eradication would include: a shortened duration (<5 years as an initial estimate), bank-to-bank dredging including bays and tributary streams, coordination of Canal Corporation and DEC efforts so that dredging progresses from upstream to downstream, addressing the need for a larger area to hold dredging spoils, and finding ways to inactivate or isolate tubers in the dredged material. $13 million in State funding has been made available. Consultants have been tasked to investigate ways to dredge and enhance the hydrilla eradication effort – and ways to dredge to minimize the threat of further spread.

Biological control

This broad category refers to biological control agents- organisms purposefully stocked into a waterbody to prey on target pests.

Grass Carp

Grass carp (*Ctenopharyngodon idella*), also known as 'white amur,' remove vegetation in a lake by consuming it at a rate of 20 to 100 percent of their body weight each day. This physical removal of vegetation is a type of bio-manipulation, altering the food web in order to change lake conditions or give advantage to a desired species. Use of grass carp is one of the few bio-manipulation tools shown to control excess levels of nuisance aquatic plants. The grass carp is the most extensively studied and most frequently stocked fish used for aquatic plant management in North America. They were originally imported to Arkansas and Alabama from Malaysia in 1962. Only sterile grass carp, called triploid carp, are currently allowed to be stocked in New York State. The fish have been stocked at a rate of about 10 to 40 per vegetated acre of lake surface, with lower rates (usually 6-10 fish) more acceptable in recent years within a NYS DEC permitting program.

Sterile carp have been used to stop hydrilla in water bodies that can be isolated, such as ponds. They eat <u>any</u> submerged vegetation, regardless of whether it is invasive or not. There is strong evidence that grass carp prefer hydrilla over many other aquatic plants, including other plants native to Cayuga Inlet and Cayuga Lake. However, since the Cayuga Inlet cannot be isolated or contained, grass carp applied directly to the Inlet or Fall Creek would likely escape into Cayuga Lake, causing extensive habitat damage. This renders the grass carp an inappropriate hydrilla management option for the Inlet and Fall Creek.

Herbivorous insects

At least 25 herbivorous insect species have been found that feed on aquatic plants. The milfoil moth (*Acentria ephemerella*) and the milfoil weevil (*Euhrychiopsis lecontei)* are the most studied, and perhaps the most promising of these herbivorous insects. Both of these insects have been demonstrated to target Eurasian water milfoil, and the moth has been implicated in significant reductions in Eurasian water milfoil populations in the north and south end of Cayuga Lake for many years. These organisms have been cultivated in the laboratory and introduced into several New York state lakes to evaluate their effectiveness as an augmented biological control agent.

Unfortunately, these insects appear to be limited to control of Eurasian water milfoil (or perhaps other milfoil species), and do not prey on hydrilla. There is some active research on the potential for several species of herbivorous insects—particularly *Hydrellia pakistanae* (Asian hydrilla leaf mining fly), *Hydrellia balciunasi*

(Australian hydrilla leaf mining fly), *Bagous affinis* (hydrilla tuber weevil), and *Bagous hydrillae* (hydrilla stem weevil)—but the present research has not been sufficiently developed for large-scale field trials in the northeast.

Chemical control

Aquatic herbicides are chemicals that kill macrophytes (aquatic plants) or inhibit their normal growth through direct toxic reactions or by hampering their photosynthetic ability. Some chemicals are species-specific and others affect a broad spectrum of plants. Herbicides are usually applied to the water directly above the nuisance weed bed and the plants are left to die and degrade within the waterbody.

Several herbicides can be used to effectively control hydrilla, but one of the most significant problems associated with chemical control of any submersed species is dilution. An acre of water that is 1 foot deep comprises 325,800 gallons of water, which results in tremendous dilution of herbicides. In addition, water flow or movement greatly reduces the amount of time hydrilla is exposed to the herbicide. These factors can make it difficult to control hydrilla using chemical methods, so treatments should be designed to take dilution and water movement into consideration.

Fast-acting contact herbicides – including copper, diquat, and endothall formulations – are taken up quickly by hydrilla and result in rapid plant death and decay. These herbicides are generally used for spot treatments, strip treatments along shorelines, and where water movement would limit use of slower-acting systemic herbicides.

Slow-acting systemic herbicides – including fluridone, imazamox and triclopyr – control hydrilla by inhibiting enzyme activity or otherwise interrupt biological functioning. These herbicides are usually applied as whole-lake treatments, and provide control of hydrilla only when a long period of contact is possible. An advantage to systemic herbicides is that they are effective at low rates – usually concentrations of less than 100 ppb or even less than 10 ppb in the cases of fluridone. These herbicides slowly kill plants by starving them over a long period, but usually provide 1 to 2 years of control. Slow plant decay resulting from systemic herbicide treatments minimizes possible oxygen depletion and reduces the potential for fish mortality. The disadvantage of systemic herbicides is that they generally require a total lake treatment, or at least treatment in coves, bays and other areas where water movement and dilution are reduced and there is little or no water exchange.

The specific evaluation of each of the herbicides available for controlling aquatic plants in New York State is as follows:

Copper Products

Copper products have been used primarily to control nuisance algae, although some copper formulations have been used to control hydrilla singly or as part of a tank mix with other aquatic herbicides. The external peer review team reviewed all potential contact and systemic herbicides and determined that other herbicides would be better choices for eradicating hydrilla in Cayuga Inlet and Fall Creek.

Diquat

Diquat is a contact herbicide that controls emergent species such as cattail; floating species such as duckweed; and submerged species such as coontail, milfoil, nitella and some varieties of pondweed. It must be applied in water less than six feet deep or closer than 200 feet from shore, whichever provides the greater distance from shore. Use may be limited in lakes with stressed bass, walleye, or muskellunge populations. Due to potential risks to fish communities, the availability of more appropriate herbicides, and the expectation that the turbidity of the Inlet due to sediment particles that would inactivate the diquat cation, diquat was not considered for use for eradicating hydrilla in Cayuga Inlet.

Glyphosate

Glyphosate is a systemic herbicide used almost exclusively on emergent and floating plants, notably cattail and water lily. It is not been commonly used for submersed plant control in New York State, and requires significant setbacks from potable water intakes. For these reasons, it was not considered for use for eradicating hydrilla in Cayuga Inlet.

Triclopyr
Triclopyr is a systemic herbicide that targets Eurasian water milfoil and purple loosestrife. It is a selective herbicide that can be applied at higher dosage rates than some of the other registered herbicides. However, hydrilla is not considered highly susceptible to triclopyr, so it was not considered for use for eradicating hydrilla in Cayuga Inlet.

2, 4-D
2, 4-D is a systemic herbicide used for controlling a wide variety of emergent, floating and submerged species, primarily Eurasian water milfoil, water chestnut, coontail, and water hyacinth. It remains in the sediment for several months and cannot be used in waters used for potable water supplies when the concentrations of the chemical exceed 70 ppb. For these reasons, and due to lower susceptibility of hydrilla to 2, 4-D, this herbicide was not considered for use in eradicating hydrilla in Cayuga Inlet.

Imazimox
Imazimox is a newly registered systemic herbicide in New York State, applied to submerged vegetation by broadcast spray or underwater hose application, and to emergent or floating leaf vegetation by broadcast spray or foliar application. This growth inhibitor has demonstrated some success in controlling hydrilla. However, due in part to the lack of data regarding the effectiveness of this herbicide for the control of monoecious hydrilla, it was not considered for use in eradicating hydrilla in Cayuga Inlet, although it may be considered in the future.

Endothall
Endothall is a contact herbicide often used to control coontail, Eurasian milfoil, hydrilla, and most pondweeds. It stays in the water column longer than either Diquat or 2, 4-D, but its breakdown products (carbon, hydrogen and oxygen) are of less concern than those from these other herbicides. The Aquathol-K formulation is preferred in New York state lakes to minimize toxicity. This herbicide has been used to control hydrilla in other states, including those in the northeastern United States (associated with the monoecious variety of hydrilla), and thus is among the preferred herbicides for controlling this plant.

Fluridone
Fluridone is a systemic herbicide, known by the trade name of Sonar. In New York State, it is used extensively for the control of Eurasian water milfoil and curly-leafed pondweed, and has been used extensively in the northeastern United States to control monoecious hydrilla. It has been used at low dosage rates to attempt to manage target plants while preserving non-target plants. This herbicide has been used to control hydrilla previously in New York and in other states, and thus is among the preferred herbicides for controlling this plant.

No Action Alternative
The "no control" option can be appropriate in some circumstances. However, while this option is discussed at length below, it is a less viable option when eradication is the goal, as in Cayuga Inlet and Fall Creek. Factors cited by Madsen (Madsen, 2009b) that should be considered include the following:

- *Plant species* – **Is the plant invasive? Is it a native plant impairing water body uses or is it just unwanted by stakeholders**? In the case of the hydrilla infestation in Cayuga Inlet, the target plant has been well established as invasive, and the impairments (present and future) have been identified.
- *Size of infestation* – **Is this a pioneer infestation consisting of a few plants? Is it an established, but stable, population? Is it an established population or starting to approach problematic thresholds?** For the Cayuga Inlet infestation, the population is established, may be spreading, and has already achieved problematic thresholds (as of 2011).
- *Plant location* – **Is the infestation in an isolated location? Is the location conducive to spreading the pest plant by fragmentation, flow, etc.? Are there important water bodies nearby that are prone to becoming infested?** As discussed above, the primary objective for the Cayuga Inlet hydrilla eradication

project is to prevent infestation of other nearby waterbodies, particularly Cayuga Lake, other Finger Lakes, and the larger Great Lakes ecosystem.

• *Plant biology* – **Is there a likelihood of a rapid population expansion? Would "no control" permit the plant to produce viable seed or vegetative propagules that could make later control efforts more difficult and expensive?** The biological advantages associated with hydrilla- prolific production of several different reproductive structures, persistence and longevity of tubers, etc. - necessitate a management response for a hydrilla introduction, particularly when the other objectives cited above indicate a need for response.

• *Exploitation* – **Is the plant species providing an ecological service (e.g. nutrient uptake, food source for waterfowl, habitat for fisheries, etc.)?** There is no evidence that hydrilla in Cayuga Inlet is serving a valuable ecological service, and some evidence that the introduction and spread of hydrilla into Cayuga Lake would compromise ecological services already provided by the native plant community.

• *Managerial will* – **Managers may be under pressure to not control a plant because it provides benefits (perceived or real) to a user group. Stakeholders may oppose control because they are not familiar with proposed methods.** The need to eradicate the hydrilla populations in Cayuga Inlet have been well articulated to multiple stakeholders, and is a well-defined goal for the state of New York for this site and region. There has been near universal support for the management actions to date and the eradication objectives moving forward.

• *Managerial experience* – **Inexperienced resource managers are often uncomfortable with making aquatic plant management decisions (especially on a large-scale). Until a manager understands the issues and situation, the "no control" option may be viewed as the safest and least controversial.** The Hydrilla Task Force of the Cayuga Lake Watershed, and supporting managing structure, have quickly developed the expertise and external framework to identify appropriate management and eradication actions, articulate these plans, and build public support for these actions. Given that the eradication goal is shared at multiple levels by multiple stakeholders, this concern would likely be addressed even if highly qualified local resource managers were not available.

A careful evaluation of each potential rationale for adopting the "no action alternative" determined that each was inconsistent with the objective of eradicating the hydrilla in Cayuga Inlet and Fall Creek.

Preferred Alternative(s)

Herbicide was chosen as the preferred alternative in 2011 due to the short time frame available to implement action and interrupt tuber formation. A small portion of the Inlet was treated using DASH later in fall 2011 due to permit complications that could not be overcome before the end of the growing season. It was hoped that DASH would be a viable, non-chemical option for future treatments. This method proved to be ineffective at removing hydrilla and caused fragmentation of plant material potentially leading to spread of the plant.

Herbicide was again chosen as the preferred alternative in 2012 after careful consideration of all options, site conditions and permitting requirements. Contingency plans for use of benthic mats were developed in areas where chemical mixing might be inadequate, where asynchronous tuber germination might hamper chemical treatment, and in locations where chemical use might not be feasible, such as in the lake. The above conditions did not materialize so the chemical treatment was all that was required.

A similar, dual-herbicide treatment was again chosen as the preferred alternative in 2013 and 2014 after careful consideration of all options, site conditions and permitting requirements. Contingency plans for use of benthic mats were developed in areas where chemical mixing might be inadequate, where asynchronous tuber germination might hamper chemical treatment, and in locations where chemical use might not be feasible, such as in the lake. The combination of endothall and fluridone was utilized in the Cayuga Inlet treatment zone. A single endothall treatment was applied in the Fall Creek treatment zone, following the discovery of hydrilla patches in Fall Creek, the Stewart Park Pond, and golf course backwater in August 2013. Physical removal of isolated hydrilla patches in the SE corner of Cayuga Lake occurred in late August 2013. Divers working within

netted barriers carefully removed whole hydrilla plants by hand. Following physical removal, benthic mats were placed over the hydrilla patches in 2013 and 2014 to block sunlight and prevent regrowth.

A recommendation from the Hydrilla Task Force will be provided in early 2015 in consultation with external peer reviewers. The Task Force will retain the services of the external peer review team to guide management decisions throughout the duration of the eradication project. In 2015, the Task Force anticipates herbicide treatments in Cayuga Inlet and Fall Creek similar to that of 2014, as well as proactive treatments in the southeast corner of Cayuga Lake.

The Hydrilla Task Force continues to evaluate the role of navigational dredging in the long-term plans for the eradication of hydrilla in Cayuga Inlet. Although most of the dredging project activities will be staged and implemented independently of the hydrilla eradication project, it is anticipated that this Plan will be updated as additional guidance and recommendations about the application of navigational dredging tools for hydrilla eradication are developed.

Integrated Management

The selection of a preferred treatment each year does not necessarily preclude all other options. The preferred treatment for the overall project may not be the best option for small, site-specific areas. Concurrent or future projects may also impact treatment plans. Every effort is being made to consider all aspects that will impact the effectiveness of the overall treatment plan. Towards that end, below is a list of other management actions that have been discussed or used to date.

Benthic mats were considered for several boat launches (3 acres) in the Inlet for spread prevention and as a component of the eradication program. The boat launches are set back from the main Inlet channel in small bays. There was a concern that the fluridone liquid being delivered via upstream injectors might not mix adequately in those bays to treat the hydrilla. This concern was ultimately addressed by the use of pelletized fluridone.

The Task Force set aside funds and developed strategies for the use of benthic mats in the lake if hydrilla was found. Hand harvesting and chemical treatments were also options for use in the lake but due to the delay in getting the necessary permits in place for chemical treatments after a hydrilla ‘find’, hand harvesting and benthic mats were deemed the most practical treatment option. Extensive monitoring did not detect hydrilla in the lake, eliminating the need for any management actions in the lake in 2012. However, after the discovery and removal of isolated hydrilla patches in the SE corner of Cayuga Lake in August of 2013, benthic mats were installed to prevent possible regrowth. This option will be considered if additional hydrilla is discovered in the lake moving forward.

The Merrill Sailing Center and the future Ithaca College Rowing Facility both performed small dredging operations around their facilities early in 2012. The entities worked closely with DEC permit staff to adjust disposal requirements for the dredged material due to the risk of spreading hydrilla. Additional monitoring was performed around the Merrill Sailing Center which, like earlier survey work, did not indicate the presence of hydrilla in the area.

Dredging irrigation channels or small ponds is a viable treatment option for hydrilla infestations. It is not a practical option in a water body like the Inlet, but may be a possible option for the Stewart Park Pond and golf course backwater areas. The Inlet has been slated for navigational dredging for several years and plans are currently being looked at by the City of Ithaca. With that in mind, the Hydrilla Task Force will participate in development of the navigational dredging plans to minimize any disruption of the hydrilla program and potentially to use the dredging project as a means to accelerate the removal of hydrilla tubers from the system.

Pre-, During- and Post-Treatment Actions

Plant Monitoring (Continuous):

As with other efforts in 2011, no framework existed for the specific actions taken. Monitoring actions were informed by work in other states on hydrilla and standard monitoring practices for aquatic plants. To the extent possible, monitoring was conducted in excess of accepted standards to compensate for the overall lack of information on monoecious hydrilla, and to inform development of future treatment plans. A Monitoring Plan was developed in advance of the 2012 growing season and is available on the StopHydrilla.org website.

Monitoring for hydrilla began in August of 2011, with the initial goal of mapping the extent of the infestation. A collaboration of professionals and volunteers made multiple trips in the Inlet, Fall Creek, Cascadilla Creek, limited portions of Six Mile Creek and the southern end of Cayuga Lake. No hydrilla was found in Fall Creek or Six Mile Creek. No rooted hydrilla was found in the lake, though a few floating fragments were found. Plant response to the herbicide treatment was tracked, noting both the die-off of material and subsequent re-growth. Effectiveness of the DASH treatment was also monitored based on plant material removed, buried or left behind.

Hydrilla monitoring in 2012 included both the Inlet and the southern portion of Cayuga Lake, with the goals of determining plant presence/absence, location, growth, spread, and treatment timing. Plant monitoring of the treatment area was conducted in the spring (pre-herbicide application) from June 22 – July 3, 2012 and in the fall (post-treatment) from November 16 – 27, 2012. Fifty-meter grids were used to determine sampling points using the point intercept method and two rake-tosses while recording GPS coordinates.203 locations were sampled pre and post-herbicide application. In-lake monitoring, which included monitoring the lake-inlet mixing zone and into the mouth of Fall Creek, included 1119 sample points on a 50x50 meter grid and were sampled between July 10th and August 27th, 2012. Metrics collected included plant species presence, abundance and GPS locations following time-tested methodology commonly used to evaluate herbicide efficacy. Native and rare plant presence and abundance were part of this monitoring. Measures of Hydrilla status (dead, alive, re-growth, roots, tubers, turions) were quantified after each survey to determine herbicide efficacy. Similar maps have been generated for each of the plant species identified in these surveys, and are available on at StopHydrilla.org.

Divers were considered for use in the Southern portion of Cayuga Lake to enhance monitoring for hydrilla to determine if it has spread into the lake, and potentially as agents to deploy deep-water hand harvesting. This work was thought to be especially critical in 2012 and 2013 to make sure negative find results were not the result of too little sampling. A diver was brought in to assess the usefulness of this method. While the diver did find the only live sprig of hydrilla after chemical treatment began, it was not due to factors unique to diving. Visibility was too poor for identification of plant materials underwater. The diver was removing plant material en-masse and bringing to the boat for identification. One of those grabs included the single sprig of hydrilla. Rake toss sampling uses the same process. Divers and aquatic plant specialists were consulted, and they concurred that diving is not the preferred survey method, due to the poor clarity, dangerous diving conditions, and other logistic considerations. As a result, diving will not be used in the future.

Hydrilla monitoring in 2013-2014 included the Cayuga Inlet, Fall Creek, and the southern portion of Cayuga Lake, with the goals of determining plant presence/absence, location, growth, spread, and treatment timing. Plant monitoring of the treatment area was conducted in the spring (pre-herbicide application) and in the fall (post treatment) through the end of November.

Monitoring for presence/absence of hydrilla in local water bodies will need to continue indefinitely to protect against establishment of new infestations of hydrilla.

Tuber Monitoring (Continuous):

The ultimate goal in hydrilla eradication is to remove all tubers from the system. Tubers can remain dormant in sediment for a number of years, and can germinate throughout the growing season. Little is known about

Figure 20: Hydrilla Tuber Monitoring Sites Located in the Cayuga Inlet and Fall Creek

germination cues. The length of tuber viability and lack of knowledge regarding germination cues result in the need for lengthy treatment efforts. Tuber density monitoring is key to determining the effectiveness of the treatment efforts.

Tuber monitoring began in the fall of 2011 and has continued regularly, except for in January and February, and will continue through the eradication effort. Four long-term tuber monitoring sites, shown in **Figure 20,** have been established in the Cayuga Inlet: the Cornell Boathouse Bay, the Ithaca Farmer's Market/Cascadilla kayak launch, Inlet at mouth of Linderman Creek, and south of the Route 79 Bridge. Long-term tuber monitoring sites have also been established in Fall Creek.

Tuber monitoring will continue to dictate the timing of initial herbicide application (used to determine timing of endothall treatments in 2012 through 2014) and the use of both long-exposure liquid herbicides and additional spot or pelleted herbicide treatments ("bump" treatments). It will also be used to track trends in tuber densities and determine the end date for treatments.

Sampling took place on a weekly basis (approximately), other than winter months, and 20-22 cores were collected at each location (in 2011-2012) and analyzed for tuber presence and density along with measurements of any vegetative growth above or below sediment surface. Core samples at each location were increased from 22 up to 44 in 2013, and from 44 to 100+ in 2014. A summary of the collected data shows a steep decline in tuber density from fall 2011/Early 2012 from a range of 60 to 800 tubers per sq. meter (depending on location), decreasing to less than 10% viable tubers in 2013. These data are displayed in **Figures 15** through **Figure 18** (Johnson, 2013).

Additional information about the tuber monitoring activities is can be found in the Monitoring Plan on StopHydrilla.org.

Water Quality Monitoring (Continuous during treatment seasons):
The Tompkins County Health Department and the Regional DEC office set sampling regimens. Sampling is designed to meet multiple goals:

1. Determine efficacy of treatment
2. Determine timing of chemical 'bump' treatments
3. Track potential chemical drift
4. Monitor public drinking water for contamination
5. Ensure permit compliance

A more detailed discussion about water quality monitoring sampling plants and results are available at Stophydrilla.org

Flow Measuring Studies

Three liquid chemical injection points were established for the 2012 – 2014 treatment program. The rate of injection is determined by USGS stream gauge data. Injection points were established on the Cayuga Inlet, Six Mile Creek and Cascadilla Creek. The inlet gauge was relocated by the USGS in advance of the treatment to provide better stream discharge data, which will benefit all users of the data. Cascadilla Creek does not have a gauge and the Six Mile Creek stream gauges are located further upstream providing valuable information for pre-existing users. Calculations were made based on relative watershed size to estimate stream flow in Cascadilla Creek and in the relevant area of Six Mile Creek. Flow rates in the Cayuga Inlet treatment zone were monitored on a daily basis by Allied Biological, SePRO, and the Local Task Force. No high flow events occurred in 2012. Several high flow events occurred during the 2013 and 2014 treatment seasons, which led to the shutdown of the fluridone injection units for a period of approximately 24hrs each time (as required by the pre-established, high-flow contingency plan). Injection units were turned on again when flow rates dropped below contingency threshold levels.

Early Response-

Benthic mats were planned for several boat launches in the Inlet, and in any small areas of the lake where hydrilla might be found. Benthic mats were installed in the SE corner of the lake following diver removal of isolated patches of hydrilla in August of 2013, and again in 2014. Continuing to budget for benthic mat use in the lake is still a prudent step to take given the extent of the lake floor that is not sampled during any given season.

Small hydrilla infestations were removed by hand from the Fall Creek cove area in September of 2014. Hand pulling activities were initiated or overseen by the Hydrilla Task Force of the Cayuga Watershed. Individual plant or small bed hand pulling is expected to be initiated in response to future findings reported through the monitoring program or via reports from observers in the Inlet, Fall Creek or the lake. The public is urged to report any suspicious findings through the StopHydrilla.org website.

The outreach activities conducted by Cornell Cooperative Extension, Cayuga Lake Watershed Network, Floating Classroom, and the larger Task Force consistently focus on reducing spread of invasives (generally) and hydrilla (specifically) through various vectors of transport. The Task Force has worked closely with marina owners, the Allan H. Treman Park staff, the college crew teams, and others “on the ground” at public and private launch sites to impress upon boaters the importance of preventing hydrilla from leaving or entering the Inlet.

Source Management

A comprehensive plan to eradicate hydrilla must recognize and address the source(s) of infestation. This is a particular challenge for invasive plants for several reasons:

1) The actual source of most invasive plant infestations (the “seed”) is not known. The source or vector of transport for the initial hydrilla fragment, turion, or tuber for the Cayuga Inlet infestation is not known and almost certainly cannot be determined.
2) The “cause” of invasive plant growth is not well understood in the abstract or for specific infestations. Although nutrients, sediment, and other growth factors can significantly influence the extent of invasive plant growth, the specific limiting agents are unknown.
3) Reducing or eliminating these factors-, intercepting nutrients or sediments before they enter an infestation zone may not prevent future invasive plant establishment or bed formation, and may not be effective at reducing existing infestations.

Expending significant time and resources into eradicating an existing population would be inappropriate without expending time and resources into source management and preventative measures. These include intercepting and (where possible) eliminating new hydrilla inputs, education to keep Inlet, Lake residents and

visitors on the lookout for new hydrilla sources, and minimizing nutrient and sediment sources that can provide a more hospitable habitat for new infestations and less hospitable habitat for native plant communities.

The following strategies have been employed to address source management issues:

Transit:

Tompkins County passed a boat transit law in 2012, which prohibits entering, or exiting a waterbody with visible plants or animals materials attached to the watercraft, as well as the transport of invasives within the county. The impetus for this 2012 law was the Cayuga Inlet infestation.

Newly proposed NYSDEC invasive species transports regulations were also announced in October of 2013 and January of 2014. October's proposed regulations focused on source control for invasive species. The proposed regulations "include a list of prohibited species which shall be unlawful to knowingly possess with the intent to sell, import, purchase, transport or introduce; a list of regulated species which shall be legal to possess, sell, purchase, propagate and transport but may not be knowingly introduced into a free-living state; and require a permit for research, education and other approved activities involving prohibited species and release of regulated species into a free-living state" (NYSDEC, 2013). Violation of these regulations can result in fines and possible revocation of nursery and commercial licenses. More information about these regulations can be found at: http://www.dec.ny.gov/regulations/2359.html

In January of 2014, NYSDEC also proposed new aquatic invasive species regulations, which focused on preventing the introduction and spread of invasive species at DEC state boat launches. The proposed regulatory changes will require boaters to remove all visible plants and animals from boats, trailers and associated equipment and to drain boats before launching at or leaving a DEC boat launch and waterway access. These regulations went into effect in June of 2014. More information on these regulations can be found at: http://www.dec.ny.gov/press/95172.html

Education

Numerous outreach and education activities are conducted as part of this Project, as cited previously in this Plan. A letter was sent to all local marina owners outlining sound practices for preventing transport of hydrilla. Generic invasive species pamphlets created by the NYSDEC Invasive Species Coordination Unit and hydrilla-specific materials available on the state Cornell Cooperative Extension website, have been distributed at a number of public events, and are available to boaters at launch sites in the area and within the infestation zone. Collaborative outreach efforts have been established between the Task Force Outreach Committee, local/regional/statewide agencies, organizations and businesses. Public meetings, presentations, and a strong presence at community events (fishing tournaments, boating/water festivals, Ithaca Famers' Market, etc.) was a major focus of the 2012 season and beyond. NYSDEC has provided educational materials to the Local Task Force to develop hydrilla/invasive species outreach efforts. Marina/Boat launch/Boat Owner education materials can be found at Stophydrilla.org.

In addition, the Cayuga Lake Watershed Network (CLWN, Outreach Committee stakeholder) has spearheaded the volunteer "Hydrilla Hunter" initiative. Through education and outreach events, the CLWN has teamed up with local lakeshore residents and homeowner associations to inform and train volunteers to monitor lakeshore areas for hydrilla/invasive species growth. Hydrilla Hunters help to provide further outreach to the community, as well as essential monitoring beyond that of the Cayuga Inlet hydrilla treatment/monitoring zones. More information on the CLWN and Hydrilla Hunters can be found at: http://www.cayugalake.org/hydrilla-hunters.html

Weed disposal

CCE has provided guidance to lake residents and the community about proper disposal methods for any aquatic plants pulled from their property. Although it is anticipated that any hydrilla plants found within the lake will be verified by experts and removed under the guidance of the Task Force, some incidental aquatic weed removal

may occur that will "inadvertently" include hydrilla. Tompkins County Solid Waste accepts any weeds removed by individuals (and materials collected as part of any formal hand harvesting overseen by the Task Force). Disposal guidance can be found at Stophydrilla.org.

The Task Force has also encouraged the construction and use of invasive species disposal stations at marinas and any other private or public launching sites. Disposal stations were installed at the northern end of Cayuga Lake by Cayuga County during 2013. The Local Task Force will look to install weed disposal stations at the southern end of Cayuga Lake (within Tompkins Co.) during the 2014 season and beyond.

Signage and Inspections:

Signage developed in cooperation with the state Office of Invasive Species Coordination, has been placed at each of the local boat launches within the Inlet, southern Cayuga Lake and many of the adjacent waterbodies. Hydrilla-specific signage was also developed by the Schuyler County SWCD for use in Cayuta Lake. "Infested water" signs were also posted at boat launches along the Inlet. Boat inspections are conducted at the Allan H. Treman Marina State Park by OPRHP staff, trained as part of the Finger Lakes Institute Watercraft Steward Program. Stewards generate annual reports identifying the number of boats, boaters, and frequency of finding organisms on inspected boats.

Sediment/Nutrient Control

The south end of Cayuga Lake is the subject of significant water quality studies and evaluation due to water quality issues predating the hydrilla infestation in Cayuga Inlet. The loading of nutrients (particularly phosphorus) to the south end of the lake is a significant component of these studies, which may culminate in the development of a Total Maximum Daily Load (TMDL) assessment for the. The identification and eventual management of these sources of nutrients may ultimately result in a reduction in sediment nutrients in the Inlet and south end of the lake that may contribute to a favorable habitat for hydrilla colonization. For those nutrient sources associated with sediment loading, such as eroding materials entering the lake through non-point source pollution, the activities resulting in nutrient reduction may also serve to reduce sediment loading to the lake. This will also help to favorably influence the aquatic plant habitat in the areas where hydrilla is growing or could eventually grow.

Evaluation of Efficacy

The efficacy of the Management Plan will be evaluated in several ways. The Cayuga Lake Watershed Hydrilla Monitoring Plan (available on StopHydrilla.org) will serve several purposes, but will primarily be used to evaluate the efficacy of treatment and therefore the efficacy of the Management Plan. The public outreach conducted throughout the process provides a mechanism for feedback. The external peer reviewers will focus on a few key "indicators" of success:

1. Did the Management Plan eradicate or make significant progress toward eradication of the target plants?
2. Did the Management Plan minimize the impact to non-target organisms, particularly protected plants and animals, critical environmental areas, and important fisheries resources?
3. Did the Management Plan adversely impact water quality, as evaluated by state water quality standards?
4. Did the Management Plan impact potable water uses?
5. Did the Management Plan improve or maintain recreational uses?
6. Were there any unintended consequences from the management actions?
7. Did the public think the management was successful?
8. Was the Management Plan cost effective?
9. Was the Management Plan sustainable (logistically and economically)?
10. Should the management actions be modified?

The first four questions will be answered through plant, tuber and water quality monitoring activities, as outlined in the Cayuga Inlet Hydrilla Monitoring Plan. The feedback about impacts to recreational uses, unintended consequences, and public support of and response to the Management Plan, will be generated from

the public outreach activities. The cost effectiveness, sustainability, and need for modifying the plan will be provided through interaction with the external peer review team.

The result of these evaluations will be an update to this Management Plan in subsequent years.

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