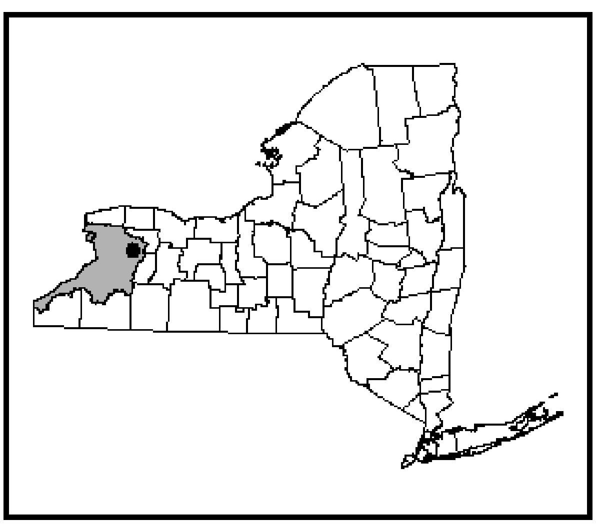
LCI Lake Water Quality Summary

General Information

Lake Name:	**Attica Reservoir #2**
Location:	Town of Attica, Wyoming County, NY
Basin:	Niagara River/Lake Erie Basin
Size:	5.2 hectares (13 acres)
Lake Origins:	Earthen dam built in 1925
Major Tributaries:	Crow Creek
Watershed Area:	8.7 Square Miles
Lake Tributary to:	Tonawanda Creek via Crow Creek
Water Quality Classification:	A (best intended use: potable water supply)
Sounding Depth:	7 meters (23 feet)
Sampling Coordinates:	Latitude: 42.83261, Longitude: -78.25945
Sampling Access Point:	Village of Attica Right of Way near dam
Monitoring Program:	Lake Classification and Inventory (LCI) Survey
Sampling Date:	8/4/2010, 6/9, 7/5, 8/2, & 9/13/2011
Samplers:	David Newman, Scott Kishbaugh and Erik Posner, NYSDEC Division of Water, Albany Bill Murray, Brian Hourigan, & Rick Rink, NYSDEC Division of Water, Buffalo
Contact Information:	David Newman, NYSDEC Division of Water djnewman@gw.dec.state.ny.us; 518-402-8201

Lake Maps

(sampling location marked with a circle)



Background and Lake Assessment

Attica Reservoir #2 is a small municipal reservoir on Crow Creek that supplies drinking water to the Village of Attica. Crow Creek begins at the outlet of the larger upstream Attica Reservoir #3. Reservoir #2 is surrounded by forested land with steep slopes down to the reservoir's surface. There is no public access to the reservoir, with the village's gated right-of-way being the only access point to the reservoir. The watershed of Attica Reservoir #2 is predominantly forested (~55%) with a smaller percentage of the watershed being agricultural (~30%). Crow Creek between Attica Reservoirs #3 and #2 flows in a forested corridor with agricultural lands on either side.

Attica Reservoir #2 was sampled through the NYSDEC Division of Water's Lake Classification and Inventory (LCI) program in the summer of 2010, due to a lack of water quality data in the Division of Water's database. The results of this sampling determined that the reservoir had elevated phosphorus and chlorophyll *a* levels in the surface water and elevated ammonia, iron and manganese levels in the bottom waters. Based on these results it was determined that additional data would be collected to better analyze the water quality conditions of the reservoir. The additional data was collected through the LCI's intensive monitoring (monthly sampling) in the Niagara River Basin during the summer of 2011.

Based on the data collected in August of 2010 and throughout the summer of 2011, Attica Reservoir #2 can generally be characterized as a *eutrophic*, or highly productive. The average water clarity reading (TSI = 54, typical of *eutrophic* lakes) was expected given the average phosphorus reading (TSI = 52, typical of *eutrophic* lakes) and the average chlorophyll *a* reading (TSI = 52, typical of *eutrophic* lakes). These data indicate that baseline nutrient levels may support algal blooms in the reservoir.

From July to September of 2011 the water color of the reservoir was described as having "algal greenness". The water treatment plant operator noted that between the early August and mid September sampling events that the reservoir experienced an algal bloom. In addition filamentous algae were observed to be occurring near the dam during several of the sampling events. The water clarity in the reservoir was always between 1.1 and 1.8 meters with only one reading, the June 2011, falling below the state's criteria of 1.2 meters for safe swimming conditions. Six different aquatic plant species were observed to be occurring in the reservoir, with two of them, Eurasian watermilfoil, and curlyleaf pondweed being invasive species. Both of these plants are known to grow at high densities and outcompete native plants. Currlyleaf pondweed was observed in 2010 but was not seen during the summer of 2011. Eurasian watermilfoil was also observed to be growing in the upstream Attica Reservoir #3. None of the aquatic plant species that were observed in Reservoir #2 were noted to be growing at high densities.

Attica Reservoir #2 exhibits thermal stratification, in which depth zones (warm water on top, cold water on the bottom during the summer) are established, as in most NYS waterbodies greater than six meters in depth. The thermocline in the lake was typically in the three to five meter depth range. In all except for the June 2011 sampling event anoxic (devoid of oxygen) conditions occurred below 5 meters in depth. These reduced oxygen conditions were also seen at Reservoir #3. pH readings indicate slightly basic/alkaline waters and conductivity readings indicate hard water. The oxygen reduction potential (ORP) readings typically fell below zero in the hypolimnion (bottom waters), indicating persistent oxygen deficits. In addition many of the bottom samples had a sulfur odor, which is common in water bodies experiencing persistent oxygen deficits.

Attica Reservoir #2 appears to be typical of hardwater, weakly colored, alkaline lakes. Other lakes with similar water quality characteristics often support warmwater fisheries, although fisheries habitat cannot be fully evaluated through this monitoring program. Coldwater fisheries may be *stressed* due low dissolved oxygen levels in the bottom few meters of the reservoir.

Total phosphorus levels in the reservoir were above the state's guidance value during all sampling events, with a high percent of the total phosphorus being soluble (available for primary production in the form of algae). Iron and manganese levels in the bottom waters were elevated above the state's water quality standards and may cause taste or odor issues with finished water. Bottom water samples were analyzed for arsenic, and levels were found to be occurring above the laboratories detection limit with the August 2010 sample being slightly above the water quality standard. Elevated iron, manganese and arsenic levels are typically seen in waterbodies experiencing oxygen deficits in the bottom waters. Sodium levels in both the surface and bottom waters were found to be near 20 mg/l, which the State Health Department's guideline for "people on severely restricted sodium diets." Chloride levels were in the moderate to high range and may indicated impacts from road salting or runoff from developed areas. All other parameters fell below the state's guidance values.

When comparing Reservoirs #2 and #3 data there is an overall decline in water quality from the upstream reservoir to the downstream reservoir. In the surface waters of Reservoir #2 maximum iron and manganese as well as magnesium, potassium, sodium and chloride concentrations were all above those recorded in Reservoir #3. A similar suite of parameters in the bottom waters of Reservoir #2 were above those seen in Reservoir #3 with the addition of nutrient levels (nitrogen and phosphorus) also being higher.

Potable Water (Drinking Water)

Attica Reservoir #2 is classified for use as a potable water supply and it is currently used as a water supply reservoir for the Village of Attica. LCI data are not sufficient to evaluate potable water use; however the data collected indicate that iron levels in the surface water *stress* the use of the reservoir as a drinking water supply in addition manganese and magnesium levels *threaten* the use of surface water for drinking. Direct hypolimnetic withdrawals from the reservoir would be *impaired* by elevated iron and manganese levels. Arsenic, magnesium, and ammonia levels *threaten* the use of hypolimnetic waters. The water treatment plant operator indicated that in late August of 2011 the Village was having taste and odor problems with its finished water. The operator also indicated that typically when the reservoir turns over in the fall high magnesium levels area recorded.

Contact Recreation (Swimming)

Attica Reservoir #2 is classified for contact and non-contact recreation however access to Reservoir #2 is prohibited preventing recreational use of the reservoir. Bacteria data would be needed to evaluate the safety of the reservoir for swimming—these are not collected through the LCI, the Village of Attica may collect these data at their raw water intake. The data collected through the LCI indicate that low water clarity and high phosphorus levels would *threaten* the use of the reservoir for swimming.

Non-Contact Recreation (Boating and Fishing)
The data collected through the LCI indicate that boating and fishing are *threatened* by the occurrence of the aquatic invasive species Eurasian watermilfoil and curlyleaf pondweed. Both plants are known to grow at nuisance levels and may make recreational activities in and on waterbodies difficult.

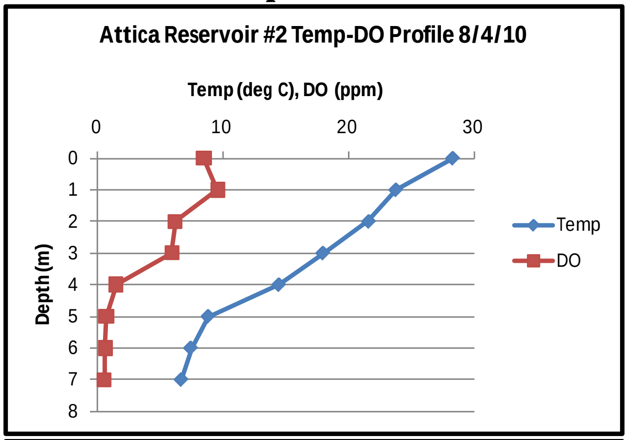
Aquatic Life
The biological community of the reservoir may be *threatened* by the occurrence of Eurasian watermilfoil and curlyleaf pondweed. In addition the low dissolved oxygen levels seen in the hypolimnion during most of the summer may *stress* aquatic life susceptible of high summer water temperatures such as trout.

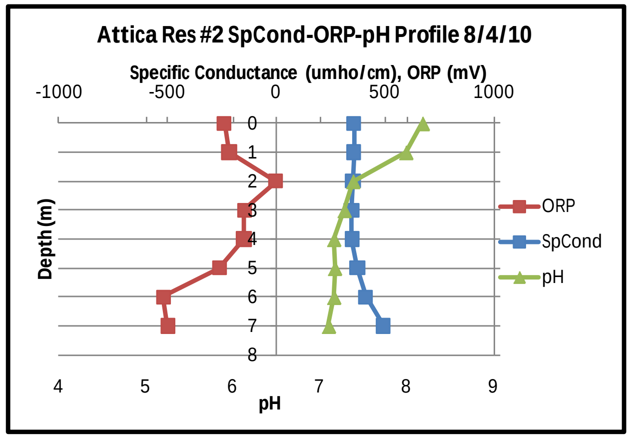
Aesthetics
Field observations did not indicate any impacts to the aesthetics of the reservoir.

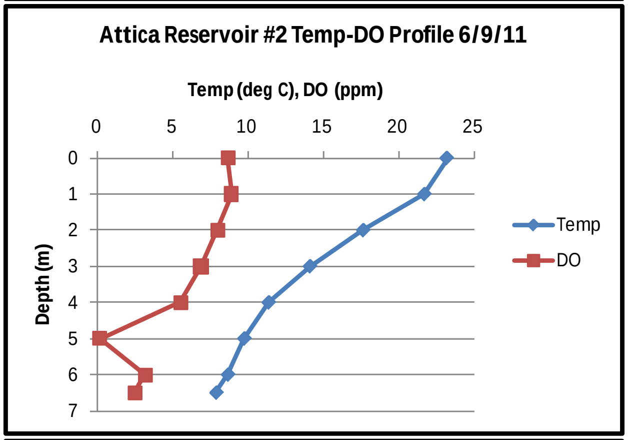
Additional Comments
- Periodic surveillance for invasive exotic plant species may help to prevent the establishment and spread of any new invaders, given the escalating problems with exotic aquatic weeds in New York State.
- The use of best management practices by on the agricultural lands within the watershed may help reduce nutrient levels within the reservoir.
- Filling in gaps and widening the forested buffer along Crow Creek may also help reduce water quality problems within the reservoir.

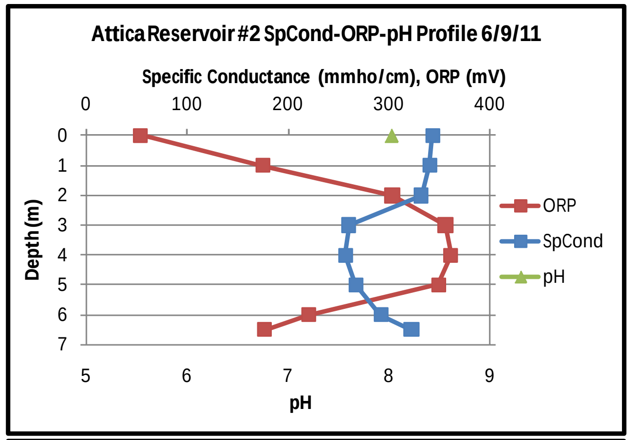
Aquatic Plant IDs
Exotic Plants:	*Myriophyllum spicatum* (Eurasian watermilfoil)
	Potomogeton crispus (curlyleaf pondweed)
Native Plants:	*Elodea canadensis* (common waterweed)
	Sagittaria latifolia (broad leafed arrowhead)
	Lemna minor (duckweed)
	Najas flexilis (slender naiad)

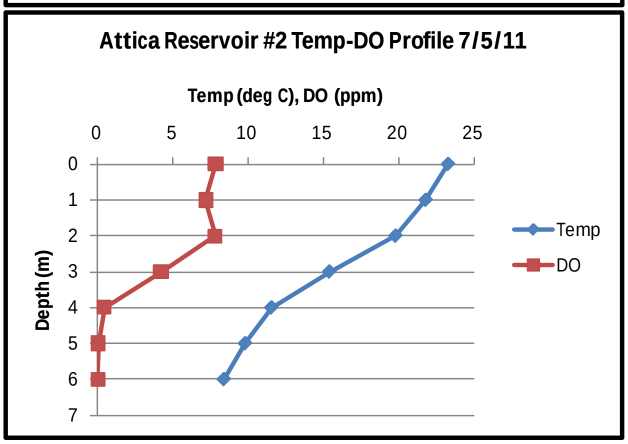
Time Series: Depth Profiles

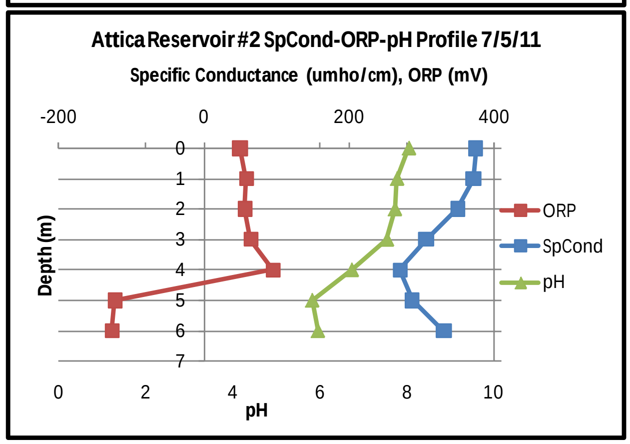


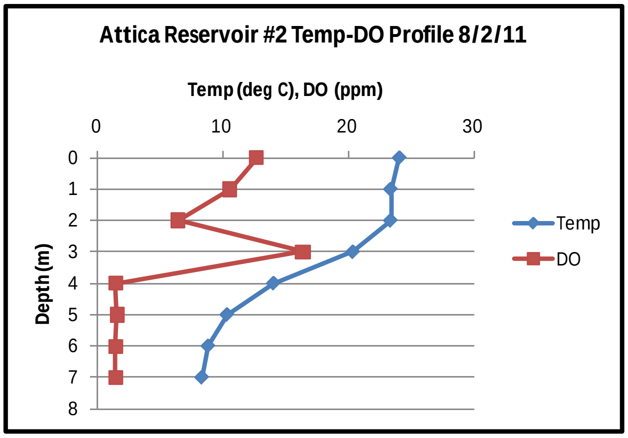


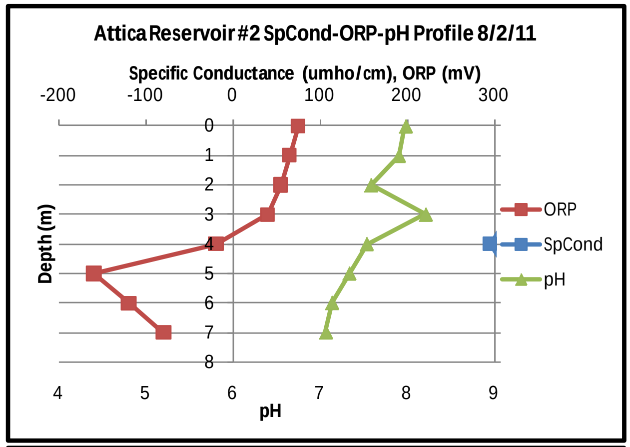


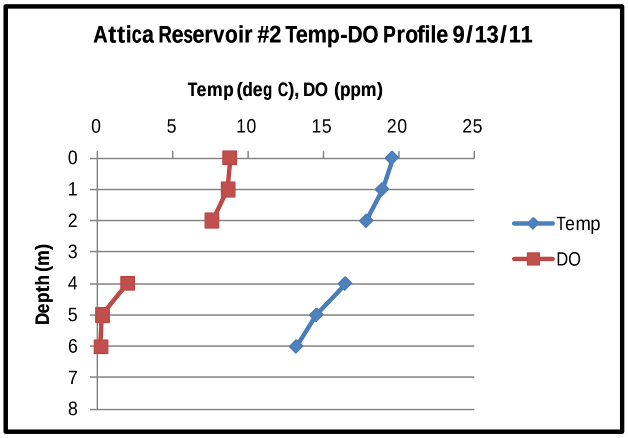


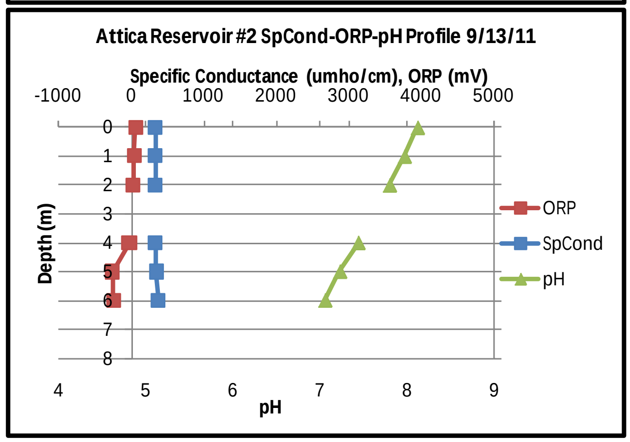




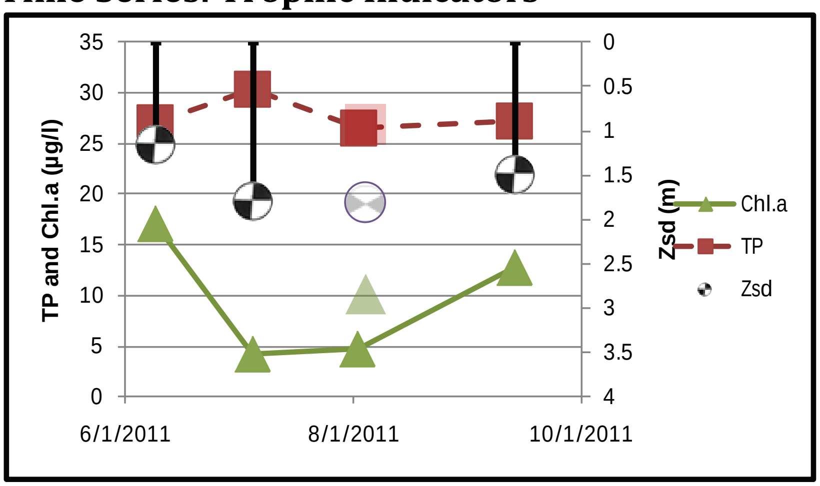








Time Series: Trophic Indicators



WQ Sampling Results

Surface Samples

	UNITS	N	MIN	AVG	MAX	Scientific Classification	Regulatory Comments
SECCHI	meters	4	1.16	1.5625	1.8	Eutrophic	25% of readings violate DOH guidelines
TSI-Secchi			51.5	53.8	57.9	Eutrophic	No pertinent water quality standards
TP	mg/l	5	0.0266	0.02766	0.0304	Eutrophic	100% of readings violate water quality standards
TSI-TP			51.4	52.0	53.4	Eutrophic	No pertinent water quality standards
TSP	mg/l	5	0.0076	0.0112	0.0144	High % soluble Phosphorus	No pertinent water quality standards
NOx	mg/l	5	0.207	0.381	0.571	Elevated nitrate	No readings violate water quality standards
NH4	mg/l	5	0.005	0.025	0.048	Low ammonia	No readings violate water quality standards
TKN	mg/l	5	0.41	0.522	0.71	Intermediate organic nitrogen	No pertinent water quality standards
TN/TP	mg/l	5	54.56	71.72	83.45	Phosphorus Limited	No pertinent water quality standards
CHLA	ug/l	5	4.3	9.82	17.1	Eutrophic	No pertinent water quality standards
TSI-CHLA			44.93	51.66	58.47	Eutrophic	No pertinent water quality standards
Alkalinity	mg/l	5	105	112.4	127	Moderately Buffered	No pertinent water quality standards
TCOLOR	ptu	5	15	24.4	30	Weakly Colored	No pertinent water quality standards
TOC	mg/l	5	4.7	5.38	6.2		No pertinent water quality standards
Ca	mg/l	5	35.4	38.76	44.4	Strongly Supports Zebra Mussels	No pertinent water quality standards
Fe	mg/l	5	0.156	0.201	0.286		No readings violate water quality standards
Mn	mg/l	5	0.0523	0.115	0.23		No readings violate water quality standards
Mg	mg/l	5	7.61	7.878	8.81		No readings violate water quality standards
K	mg/l	5	1.64	1.812	2.01		No pertinent water quality standards
Na	mg/l	5	17.5	18.72	21.1		20% of readings violate water quality guidance values
Cl	mg/l	5	26.9	29.36	33.4	Significant road salt runoff	No readings violate water quality standards
SO4	mg/l	5	9.9	11.22	11.9		No readings violate water quality standards

* Non-detect (ND) values were set to half the detection limit for calculating the average

Bottom Samples

	UNITS	N	MIN	AVG	MAX	Scientific Classification	Regulatory Comments
TP-bottom	mg/l	5	0.0398	0.12654	0.247	Elevated deepwater phosphorus	No pertinent water quality standards
TSP-bottom	mg/l	5	0.0109	0.04664	0.0872	High % soluble phosphorus	No pertinent water quality standards
NOx-bottom	mg/l	5	ND	0.05696	0.11	No evidence of DO depletion	No readings violate water quality standards
NH4-bottom	mg/l	5	0.558	1.7026	3.62	Evidence of DO depletion	40% of readings violate DOH guidelines
TKN-bottom	mg/l	5	1.16	2.322	4.17		No pertinent water quality standards
Alk-bottom	mg/l	5	101	131	175	Moderately Buffered	No pertinent water quality standards
TCOLOR-bottom	ptu	5	33	62.4	86	Highly Colored	No pertinent water quality standards
TOC-bottom	mg/l	5	5.9	7.78	9.5		No pertinent water quality standards
Ca-bottom	mg/l	5	29.8	38.98	49	Strongly Supports Zebra Mussels	No pertinent water quality standards
Fe-bottom	mg/l	5	0.172	3.8344	11.4	Taste or odor likely	80% of readings violate water quality standards
Mn-bottom	mg/l	5	1.58	3.778	8.51	Taste or odor likely	100% of readings violate water quality standards
Mg-bottom	mg/l	5	6.4	7.582	8.73		No readings violate water quality standards
K-bottom	mg/l	5	2.03	2.03	2.03		No pertinent water quality standards
Na-bottom	mg/l	5	13.1	15.42	18.5		No readings violate water quality standards
Cl-bottom	mg/l	5	20.7	24.2	30.4		No readings violate water quality standards
SO4-bottom	mg/l	5	ND	4.68	8.7	May have rotten egg odor	No readings violate water quality standards
As-bottom	mg/l	5	1.5	4.7	10.8	Potable water impaired by elevated arsenic	No readings violate guidance values

Lake Perception

	UNITS	N	MIN	AVG	MAX	Scientific Classification
WQ Assessment	1-5, 1 best	5	2	3	4	Definite Algal Greenness
Weed Assessment	1-5, 1 best	5	3	3.4	4	Plants Grow to Lake Surface
Recreational Assessment	1-5, 1 best	5	2	3	4	Excellent for Most Uses

Legend Information

General Legend Information

Surface Samples	= integrated sample collected in the first 2 meters of surface water
SECCHI	= Secchi disk water transparency or clarity - measured in meters (m)
TSI-SECCHI	= Trophic State Index calculated from Secchi, = 60 – 14.41*ln(Secchi)

Laboratory Parameters

ND	= Non-Detect, the level of the analyte in question is at or below the laboratory's detection limit
TP	= total phosphorus- milligrams per liter (mg/l) Detection limit = 0.003 mg/l; NYS Guidance Value = 0.020 mg/l
TSI-TP	= Trophic State Index calculated from TP, = 14.42*ln(TP*1000) + 4.15
TSP	= total soluble phosphorus, mg/l Detection limit = 0.003 mg/l; no NYS standard or guidance value
NOx	= nitrate + nitrite nitrogen, mg/l Detection limit = 0.01 mg/l; NYS WQ standard = 10 mg/l
NH4	= total ammonia, mg/l Detection limit = 0.01 mg/l; NYS WQ standard = 2 mg/l
TKN	= total Kjeldahl nitrogen (= organic nitrogen + ammonia), mg/l Detection limit = 0.01 mg/l; no NYS standard or guidance value
TN/TP	= Nitrogen to Phosphorus ratio (molar ratio), = (TKN + NOx)*2.2/TP > 30 suggests phosphorus limitation, < 10 suggests nitrogen limitation
CHLA	= chlorophyll *a*, micrograms per liter (µg/l) or parts per billion (ppb) Detection limit = 2 µg/l; no NYS standard or guidance value
TSI-CHLA	= Trophic State Index calculated from CHLA, = 9.81*ln(CHLA) + 30.6
ALKALINITY	= total alkalinity in mg/l as calcium carbonate Detection limit = 10 mg/l; no NYS standard or guidance value
TCOLOR	= true (filtered or centrifuged) color, platinum color units (ptu) Detection limit = 5 ptu; no NYS standard or guidance value
TOC	= total organic carbon, mg/l Detection limit = 1 mg/l; no NYS standard or guidance value
Ca	= calcium, mg/l Detection limit = 1 mg/l; no NYS standard or guidance value
Fe	= iron, mg/l Detection limit = 0.1 mg/l; NYS standard = 0.3 mg/l
Mn	= manganese, mg/l Detection limit = 0.01 mg/l; NYS standard = 0.3 mg/l
Mg	= magnesium, mg/l Detection limit = 2 mg/l; NYS standard = 35 mg/l
K	= potassium, mg/l Detection limit = 2 mg/l; no NYS standard or guidance value
Na	= sodium, mg/l Detection limit = 2 mg/l; NYS standard = 20 mg/l
Cl	= chloride, mg/l Detection limit = 2 mg/l; NYS standard = 250 mg/l
SO4	= sulfate, mg/l Detection limit = 2 mg/l; NYS standard = 250 mg/l
As	=arsenic, mg/l Detection limit = 3.2 mg/l; NYS standard = 10 mg/l

Field Parameters

Depth	= water depth, meters
Temp	= water temperature, degrees Celsius
D.O.	= dissolved oxygen, in milligrams per liter (mg/l) or parts per million (ppm)

NYS standard = 4 mg/l; 5 mg/l for salmonids

pH	= powers of hydrogen, standard pH units (S.U.) Detection limit = 1 S.U.; NYS standard = 6.5 and 8.5
SpCond	= specific conductance, corrected to 25ºC, micromho per centimeter (µmho/cm) Detection limit = 1 µmho/cm; no NYS standard or guidance value
ORP	= Oxygen Reduction Potential, millivolts (MV) Detection limit = -250 mV; no NYS standard or guidance value

Lake Assessment

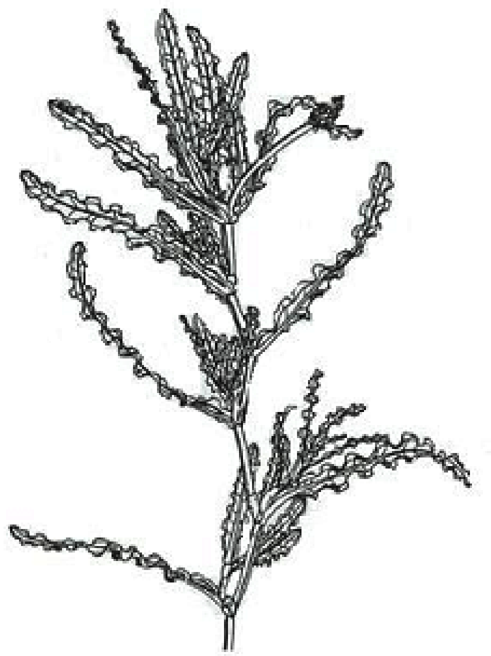
WQ Assessment	**= water quality assessment**, 5 point scale, 1= crystal clear, 2 = not quite crystal clear, 3 = definite algae greenness, 4 = high algae levels, 5 = severely high algae levels
Weed Assessment	**= weed coverage/density assessment**, 5 point scale, 1 = no plants visible, 2 = plants below surface, 3 = plants at surface, 4 = plants dense at surface, 5 = plants cover surface
Recreational Assessment	**= swimming/aesthetic assessment**, 5 point scale; 1 = could not be nicer, 2 = excellent, 3= slightly impaired, 4 = substantially impaired, 5 = lake not usable

Invasive Plant Profiles

Potamogeton crispus

COMMON NAME: curlyleaf pondweed

ECOLOGICAL VALUE: While this is not a native plant to New York state, it has become well established in many lakes and does not disrupt the aquatic ecosystem as do other (recently-introduced) exotics, although it still can out-compete native species and dominate a macrophyte community, particularly in late spring and early summer (before the peak growing season for other native and non-native macrophytes).



DISTRIBUTION IN UNITED STATES: In hard or brackish, often polluted waters, naturalized from Europe and common in New England, western Massachusetts, with a range extending from Quebec west to Minnesota, south to Alabama and Texas, and scattered throughout the western states

DISTRIBUTION IN NEW YORK: widespread and often abundant along the Hudson River and Finger Lakes basins, with some occurrences in far western New York

DEGREE OF NUISANCE: *Potamogeton crispus* may establish easily and grow abundantly, reaching nuisance levels, although the extent of coverage and nuisance conditions is limited by the growing season (winter through early-mid summer)

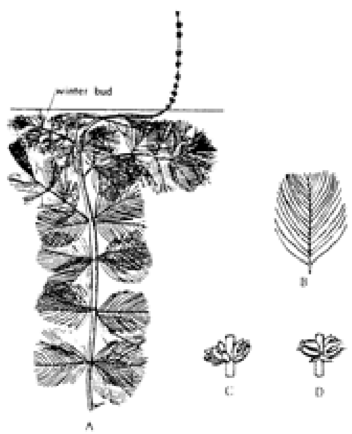
COMMENTS: *Potamogeton* is a highly variable genus within the pondweed family. Species within the genus often are characterized by two leaf types- firm floating leaves and thin emersed leaves. Many mature species have flowers borne in spikes (for wind pollination), conspicuous in early summer. Identification of the individual species can be extremely difficult, particularly among the narrow-leaved pondweeds. The *Potamogeton* are distinguished from the other genus within the pondweed family by having alternate leaves (unlike the *Zanichellia* and *Najas*), and by their presence in fresh or estuarine waters (unlike the *Zostera*). There are nearly 30 species found within New York State, some quite rare and others extremely common. *P. crispus* is one of the four major non-native exotic plant species in New York state, and has served as the impetus for several lake restoration and plant management programs. However, it naturally dies out in many lakes by early to mid summer, often to be replaced by other monocultures. It is characterized by finely-toothed leaf margins and a 'lasagna'-like leaf appearance.

Line drawing- Crowe, G.E. and C.B. Hellquist. Aquatic and wetlands plants of northeastern North America. 2000

Myriophyllum spicatum

COMMON NAME: Eurasian water milfoil

ECOLOGICAL VALUE: like most submergents, *Myriophyllum* harbors aquatic insects, provides hiding, nurseries, and spawning areas for amphibians and fish, and provides some food for waterfowl. However, *Myriophyllum spicatum* may dominate a water system, restricting boat traffic, recreational activities and water movement. While infestations of milfoil create favorable shelter for small fishes and invertebrates, they also commonly crowds out more desirable waterfowl plants



Myriophyllum spicatum: A. habit of submersed form with emergent inflorescence, × ½. B. leaf, × 1. C. flowers, × 2. D. fruits, × 2.

DISTRIBUTION IN UNITED STATES: locally abundant and aggressive from Quebec and New England west to Ontario, Michigan, Wisconsin, and British Columbia, south to Florida, Oklahoma, Texas, Washington, California, and Mexico (the range of this plant continues to increase each year)

DISTRIBUTION IN NEW YORK: found in increasing amounts throughout the State, except in the interior Adirondacks and the Long Island area (although it has recently been discovered in both locations)

DEGREE OF NUISANCE: like most exotics, *M. spicatum* establishes easily, and once established, often becomes the dominant plant in the macrophyte community, growing abundantly to nuisance levels

COMMENTS: while some species of *Myriophyllum* have earned a reputation for aggressive and opportunistic growth, most of the species in this genus are not nearly so robust, and often peacefully coexist with other submergent plants. The individual species within the *Myriophyllum* genus are superficially similar, so complete plants, including flowers (often pink) and fruits, are often needed for positive identification. The leaf structures and patterns of the milfoil closely resemble those of the *Ceratophyllum* (coontail) and *Utricularia* (bladderwort), and as a result, these plants are often confused for each other, particularly when viewed from a slight distance. Peak growth for most species is in mid-summer. *M. spicatum* is distinguished from other milfoils by having smaller flower-leaf structures on the emergent spike, flat-topped ends on the upper most submerged leaves, and red tips during the peak growing season and white to slightly pinkish stems. *Myriophyllum* spreads and reproduces vegetatively. This is one of the most discussed and well-known plants in the state, due to its propensity to form dense canopies that overwhelm the underlying native plant populations. Improved surveillance has greatly expanded the known range of this species within the state, though the range may have concurrently extended due to spread from boat traffic, waterfowl, and water transport from infected to uncontaminated lakes. Appropriate control strategies avoid excessive fragmentation.

Line drawing- Crowe, G.E. and C.B. Hellquist. Aquatic and wetlands plants of northeastern North America. 2000