Report on the Macrophyte Monitoring of the 2019 Herbicide Treatment of Chautauqua Lake

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With offices in NJ, CT and MD

Objectives of Presentation

- **Overall Project Objective** - Conduct a 3rd party evaluation of the 2019 herbicide treatment program and document the results
- Evaluate potential risk to local drinking water supplies (CUD and CWD #2)
- 3rd part verification of applicator-collected water samples and applicator-contracted laboratory

Objectives of Presentation

- 3rd party assessment of potential herbicide drift into non-target areas and potential impacts to non-target species
- Evaluate the efficacy of herbicide treatments
- Evaluate apparent effects of herbicide treatments on ambient water quality

Chautauqua Lake - Third Party Monitoring Tasks	
Task	Description
1.1	Review Memorandum of Agreement (MOA)
1.2	Review NYSDEC Permits
1.3	Develop Third-Party Sampling and Observation Plan
1.4	Develop Compliance Checklist
1.5	Collect Pre-Treatment Samples in Accordance with 1.3
2.1	Review Treatment Schedules
2.2	Observe Permitees and their Contractor(s) During Treatment
2.3	Collect Samples and Observations in Accordance with 1.3
3.1	Collect Post-Treatment Samples and Observations in Accordance with 1.3
4.1	Provide Timely Input and Recommendations to Alliance

MOA Review

- Overall Princeton Hydro were in agreement with the MOA and its rationale.
- Environmental safeguards are appropriate
- Science-based decision-making process is to be applauded.

Permit Review

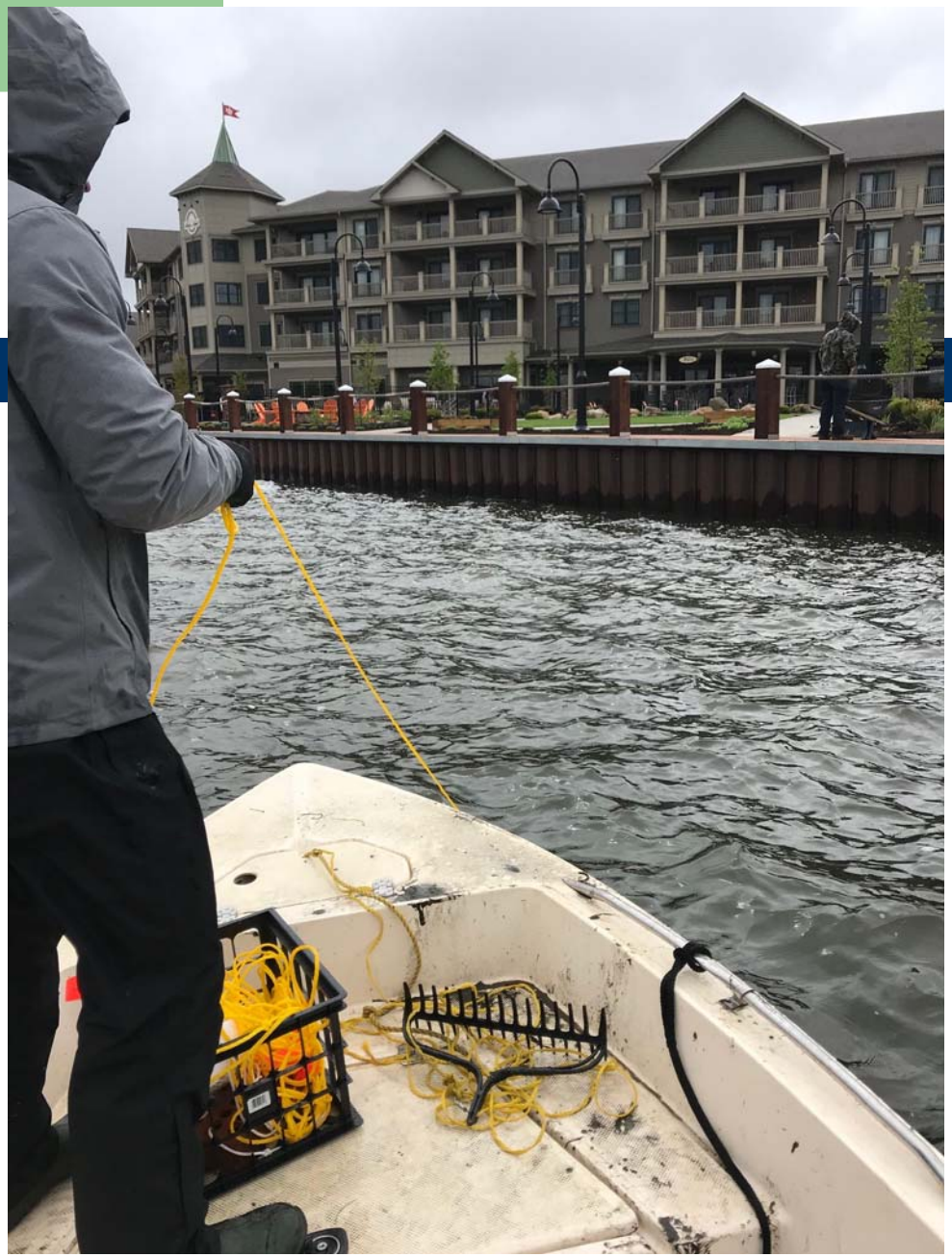
- Identified herbicides are *Aquathol K* (endothall) and *Navigate* (2,4-D).
- Treatments to be conducted by Solitude Lake Management
- Targeted species are Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*)

Permit Review

- Dosage rates are less than 60% of the respective maximum labeled dosage rates.
- 1.9 gallons per acre-foot for *Aquathol K* and 28.4 pounds per acre-foot for *Navigate*.
- The treatment areas were greater than 15,000 feet away from the water intake for the Chautauqua Institution.

Macrophyte Sampling and Observation Plan

- Monitoring of macrophytes were conducted with a combination of the line-intercept and point-intercept survey methods.
- 100’ transects perpendicular to the shoreline established with sampling points at 0’, 20’, 40’, 60’, 80’ and 100’
- Two rake tosses
- Plants identified down to species



Macrophyte Sampling and Observation Plan – Density Categories

- “Zero / None” – no plants on rake
- “Trace” – fingerful or about 25% on rake
- “Sparse” – handful or about 50% on rake
- “Moderate / Medium” – rake mostly (>75%) or entirely (100%)
- “Dense” – difficult to lift rake into boat; completely covered, large amount of plants trailing off rake (>100%)

Macrophyte Sampling and Observation Plan

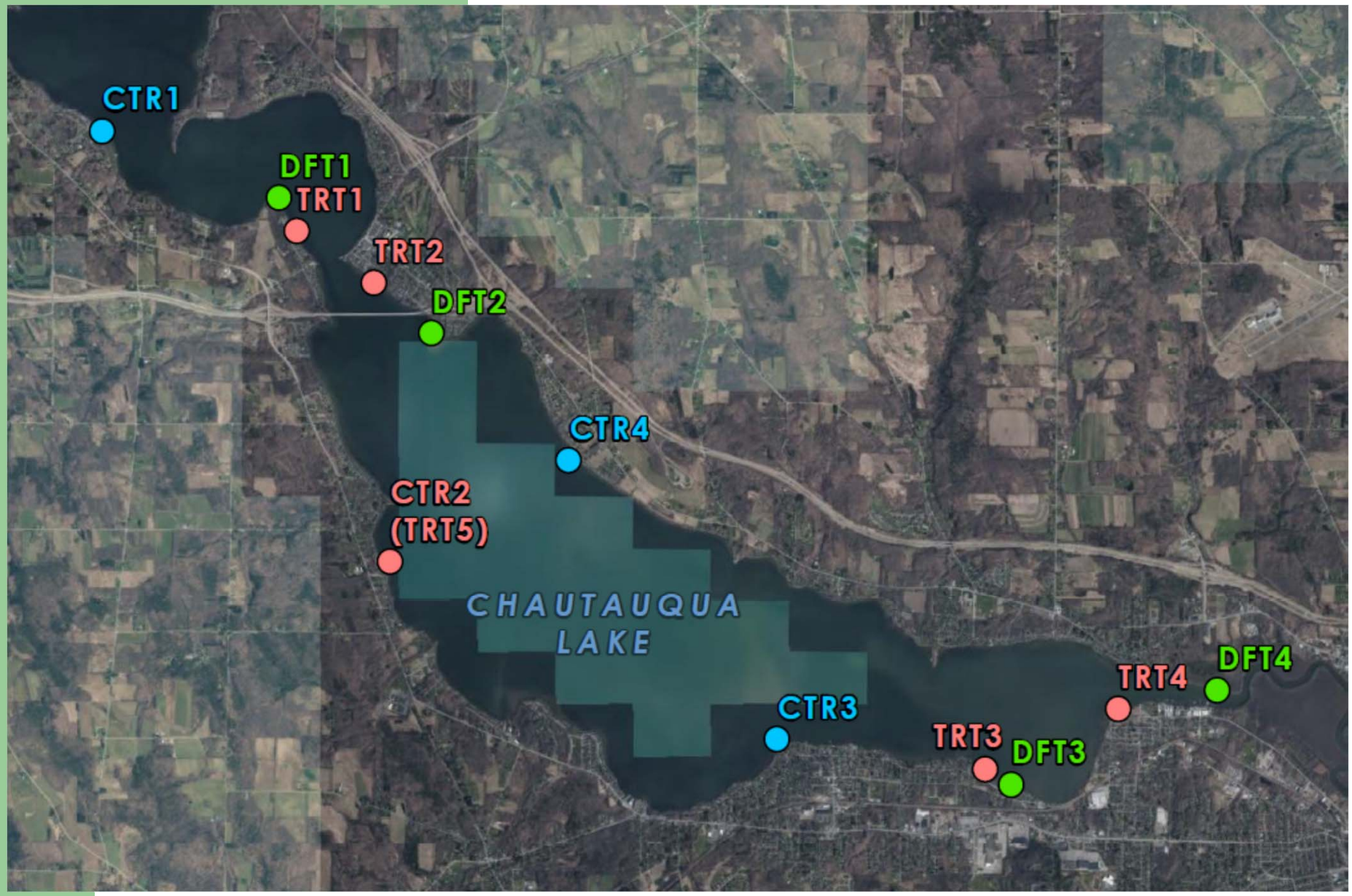
- 12 transects were established.
- Four within treated areas
- Four within areas potentially susceptible to herbicide drift
- Four within control areas not treated and not suspected of being susceptible to herbicide drift
- One site along each transect randomly selected for harvesting of biomass
- **Note, CTR2 became TRT5**

Macrophyte Sampling and Observation Plan

- Collected *in-situ* data (temperature, dissolved oxygen, pH, conductivity and water clarity (Secchi disk))
- **Started water quality monitoring at each site then focused on 40’ and 100’ transect sites due to time constraints.**

Macrophyte Sampling and Observation Plan

- Collected samples for herbicide to identify potential / possible drift of product
- Note, samples were collected by Princeton Hydro, Solitude and PWS Operators
- Also, Princeton Hydro ran a duplicate for DFT4


CTR1
DFT1
TRT1
TRT2
DFT2
CTR4
CTR2
(TRT5)
CHAUTAUQUA
LAKE
CTR3
TRT3
DFT3
TRT4
DFT4

Chautauqua Lake - Herbicide Application Areas			
Application Area	Treatment Date	Permitted Acres	Treated Acres
Ellery / Bemus Point	5/17/2019	29.7	29.7
Ellery / Arnold Bay	5/17/2019	63.1	54
Ellery / Greenhurst North	5/16/2019	17.7	17.7
Ellery / Greenhurst South	5/16/2019	15.4	15.4
Ellicott / Fluvanna	5/16/2019	51	33.8
Ellicott 60-61	5/15-16/2019	44.2	51.2
Nav Channel	5/16/2019	7.5	7.5
N Harm Woodlawn		19.3	0
N Harm Stow	5/17/2019	35	35
N Harm Hadley Bay	5/15/2019	30.2	18
N Harm Cheney Point		13.1	0
N Harm Bly Bay	5/17/2019	48.1	3
N Harm Sunrise Cove		25.5	0
Celoron	5/15/2019	48.2	48.2
Lakewood 026	5/17/2019	14.9	14.9
Lakewood 66-67	5/17/2019	18.1	18.1
Lakewood 60-62	5/16-17-2019	41.5	41.5
Total		**522.5**	**388**

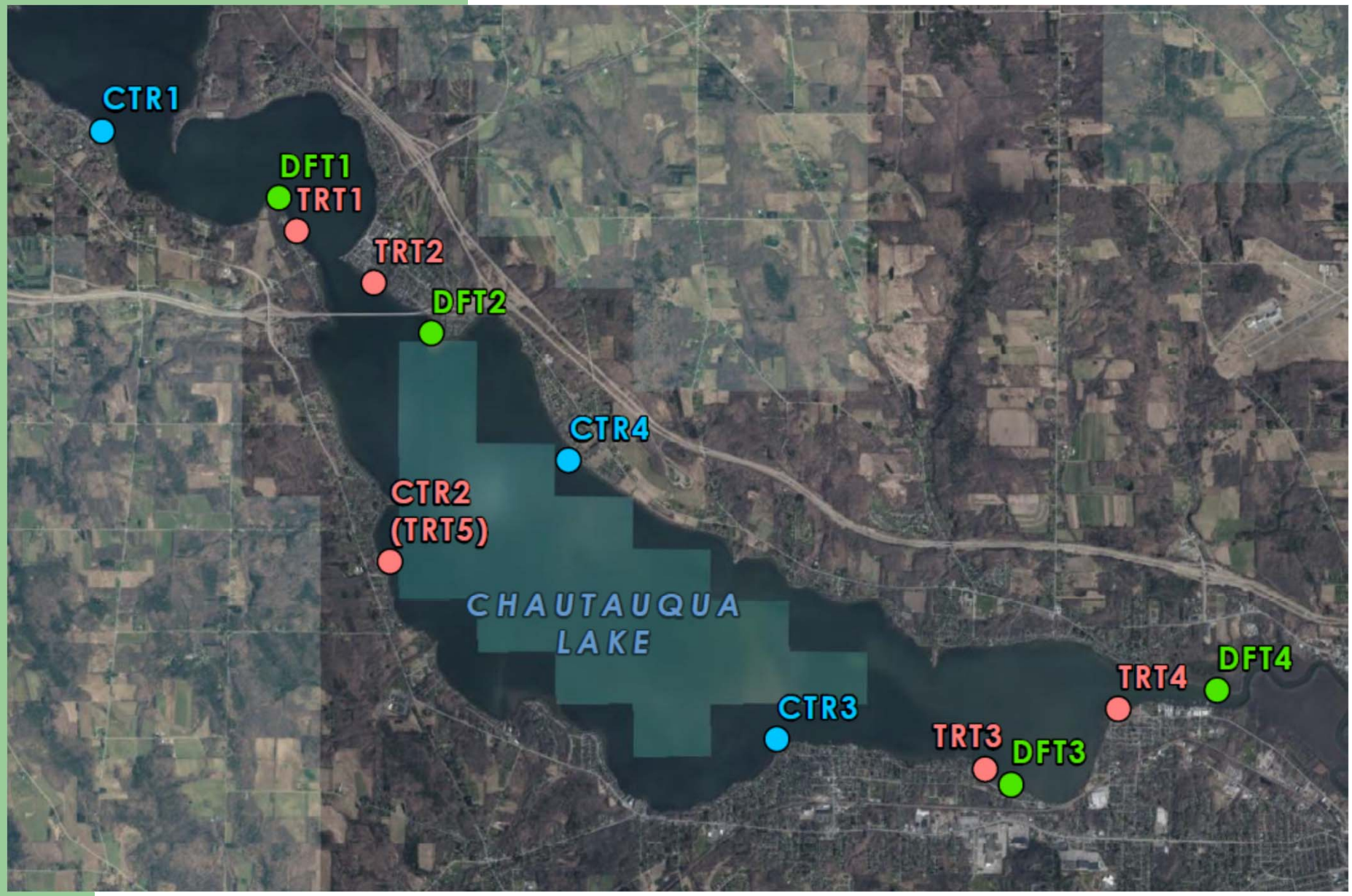
In-Situ Data

- Overall, nothing unusual. Conditions typically of a productive lake in the late spring / early summer season.
- Some elevated pH values (> 8.5) for the pre-treatment and during treatment events
- Some slightly lower pH values (6.4) and elevated pH values during the post-treatment events
- DO consistently above 5 mg/L

Chautauqua Lake - Chemical Sampling for Herbicides			
Entity	**Type**	**Dates**	**Stations**
Princeton Hydro	Pre-Treatment	5/14/2019	CTR4, DFT4, DFT4 (Dup), TRT4, CUD, CWD2
	Post-Treatment (+1 Day)	5/16/2019	CTR4, DFT4, DFT4 (Dup), TRT4
	Post-Treatment (+1-2 Days)	5/17/2019	CUD, CWD2
	Post-Treatment (+7 Days)	5/21/2019	CTR4, DFT4, DFT4 (Dup), TRT4
	Post-Treatment (+14 Days)	5/28/2019	CUD, CWD2
Solitude	Pre-Treatment	5/14/2019	CUD, NB1, CWD2, NB2
	Post-Treatment (+13-14 Days)	5/27-28/19	CUD, NB1, CWD2, NB2, CEL2, O1, ELL3
	Post-Treatment (+21 Days)	6/4/2019	NB2, CEL2, O1
PWS Operators	Post-Treatment (+8 Days)	5/22/2019	CUD, CWD2

Chautauqua Lake - Sampling Station Locations			
Station	**Latitude**	**Longitude**	**Description**
CTR4	42.13631°N	-79.363454°W	Princeton Hydro; Control
DFT4 & DFT4 Duplicate	42.112797°N	-79.272164°W	Princeton Hydro; Drift
TRT4	42.110625°N	-79.286287°W	Princeton Hydro; Treatment
CEL2	42.111571°N	-79.28337°W	Solitude; Near TRT4
O1	42.111702°N	-79.269282°W	Solitude; Near DFT4
ELL3	42.129604°N	-79.348771°W	Solitude; Near CTR4
CUD	N/A	N/A	Raw-Water Intake; Chautauqua Institution
NB1	42.211748°N	-79.463422°W	Solitude; Near Intake for Chautauqua Institution (CUD)
CWD2	N/A	N/A	Raw-Water Intake; Chautauqua Lake Estates
NB2	42.2448°N	-79.4669°W	Solitude; Near Intake for Chautauqua Lake Estates (CWD2)

Chautauqua Lake - Pre- & Post-Treatment Chemical Data (Princeton Hydro)										
Station	2,4-D					Endothall				
	ppb (µg/L)					ppb (µg/L)				
	Pre-treatment	Post-Treatment (1-2 Days)		Post-treatment (7-14 Days)		Pre-treatment	Post-Treatment (1-2 Days)		Post-treatment (7-14 Days)	
	5/14/2019	5/16/2019	5/17/2019	5/21/2019	5/28/2019	5/14/2019	5/16/2019*	5/17/2019**	5/21/2019***	5/28/2019
CTR4	ND < 0.2	ND < 0.2	-	**101.0**	-	ND < 9.0	ND < 9.0	-	**57.0**	-
DFT4	ND < 0.2	**57.7**	-	**69.6**	-	ND < 9.0	16.0	-	**55.0**	-
DFT4 (Duplicate)	ND < 0.2	47.2	-	**60.8**	-	ND < 9.0	14.0	-	Sample broken	-
TRT4	ND < 0.2	**183.0**	-	**85.4**	-	ND < 9.0	18.0	-	ND < 9.0	-
CWD2	0.279	-	ND < 0.2	-	ND < 0.2	ND < 9.0	-	ND < 9.0	-	ND < 9.0
CUD	ND < 0.2	-	ND < 0.2	-	ND < 0.2	ND < 9.0	-	ND < 9.0	-	Sample broken
NYSDEC Permit Consumptive Threshold of 50 ppb (µg/L)						NYSDEC Permit Consumptive Threshold of 50 ppb (µg/L)				
*	Endothall recovery in LFB (32%) outside acceptable limit of 69-136%. Any results are potentially low biased.									
**	Endothall recovery in the LFB (27%) was outside the acceptable limits of 69-136%. Any results are potentially low biased.									
***	Endothall recovery in the MS at 100 µg/L (67%) was outside the accepted limits of 70-142%. Any results are potentially low biased.									


CTR1
DFT1
TRT1
TRT2
DFT2
CTR4
CTR2
(TRT5)
CHAUTAUQUA
LAKE
CTR3
TRT3
DFT3
TRT4
DFT4

Chautauqua Lake - Pre- & Post-Treatment Chemical Data (Solitude or PWS Operators)								
Station	2,4-D				Endothall			
	ppb (µg/L)				ppb (µg/L)			
	Pre-treatment	Post-Treatment			Pre-treatment	Post-Treatment		
	5/14/2019	5/22/2019 (+8 Days)	5/27 & 28/2019 (+13-14 Days)	6/4/2019 (+21 Days)	5/14/2019	5/22/2019 (+8 Days)	5/27 & 28/2019 (+13-14 Days)	6/14/2019 (+21 Days)
CUD	< 2.5	< 1.0	< 2.5	-	< 7	< 20.0	7.36	-
NB1	< 2.5	-	8.2	-	< 7	-	< 7	-
CWD2	< 2.5	< 1.0	< 2.5	-	< 7	< 20.0	< 7	-
NB2	< 2.5	-	56.0	< 2.5	< 7	-	< 7	-
CEL2	-	-	108.1	< 2.5	-	-	24.76	-
O1	-	-	101.5	< 2.5	-	-	31.28	-
ELL3	-	-	3.2	-	-	-	< 7	-
NYSDEC Permit Consumptive Threshold of 50 ppb (µg/L)					NYSDEC Permit Consumptive Threshold of 50 ppb (µg/L)			

Chautauqua Lake - Macrophyte Species List	
Common name	**Scientific Name**
Curly-Leaf Pondweed	*Potamogeton crispus*
Small Pondweed	*Potamogeton berchtoldii*
Leafy Pondweed	*Potamogeton foliosus*
Sago Pondweed	*Stuckenia pectinata*
Eurasian Watermilfoil	*Myriophyllum spicatum*
Coontail	*Ceratophyllum demersum*
Elodea	*Elodea canadensis*
Water Stargrass	*Heteranthera dubia*
Emergent grass	Un-identified
Star Duckweed	*Lemna trisulca*
White Waterlily	*Nymphaea odorata*
Aquatic Moss	*Fontinalis sp.*
Chara	*Chara sp.*
Tape Grass	*Vallisneria americana*
Slender Naiad	*Najas flexilis*

Chautauqua Lake - Macrophyte Species List		
Common name	**Scientific Name**	**Coefficients of Conservatism**
Curly-Leaf Pondweed	*Potamogeton crispus*	0
Small Pondweed	*Potamogeton berchtoldii*	5
Leafy Pondweed	*Potamogeton foliosus*	4
Sago Pondweed	*Stuckenia pectinata*	3
Eurasian Watermilfoil	*Myriophyllum spicatum*	0
Coontail	*Ceratophyllum demersum*	4
Elodea	*Elodea canadensis*	2
Water Stargrass	*Heteranthera dubia*	4
Emergent grass	Un-identified	N/A
Star Duckweed	*Lemna trisulca*	7
White Waterlily	*Nymphaea odorata*	4
Aquatic Moss	*Fontinalis sp.*	N/A
Chara	*Chara sp.*	N/A
Tape Grass	*Vallisneria americana*	5
Slender Naiad	*Najas flexilis*	5

Data Analysis of Macrophyte Data

- Sign-Test, non-parametric statistical analysis utilized in assessing differences between pairs of observations.
- Species Richness
- Relative Density differences
- Biomass differences

Chautauqua Lake - Species Richness			
Site	**Pre-treatment**	**Post-treatment**	**P-value***
CTR1	2	7	
CTR2 (TRT5)	1	2	
CTR3	1	1	
CTR4	3	3	
DFT1	4	7	
DFT2	5	5	
DFT3	5	7	**0.02**
DFT4	5	5	
TRT1	4	7	
TRT2	3	7	
TRT3	5	8	
TRT4	4	4	

Chara algae, aquatic moss, and the unknown grass species were not included in this assessment. *Sign test - Significant

Chautauqua Lake - Change in Relative Density (Pre- and Post-Treatment)		
Overall Relative Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Increase	0.79
Drift (DFT)	Decrease	1.20
Treatment (TRT)*	Decrease	0.06
All	Decrease	0.39
Curly-leaf Pondweed Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Decrease	1.27
Drift (DFT)	Decrease	0.08
Treatment (TRT)*	Decrease	**0.003**
All	Decrease	**0.001**
Eurasian Watermilfoil Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Increase	1.31
Drift (DFT)	Increase	1.23
Treatment (TRT)*	Decrease	1.25
All	Increase	1.15

Coontail Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Increase	1.00
Drift (DFT)	Increase	0.61
Treatment (TRT)*	Increase	**0.004**
All	Increase	**0.007**
Star Duckweed Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	None	2
Drift (DFT)	Increase	**0.008**
Treatment (TRT)*	Increase	**0.008**
All	Increase	**0.00003**
Elodea Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Increase	1.5
Drift (DFT)	Decrease	0.45
Treatment (TRT)*	Increase	**0.004**
All	Increase	0.19
Water Stargrass Density		
Site-Types	**Overall Change (based on Average Relative Density)**	**P-value**
Control (CTR)	Increase	**0.002**
Drift (DFT)	Increase	0.08
Treatment (TRT)*	Increase	**0.00002**
All	Increase	**0.0000001**

Chautauqua Lake - Macrophyte Species List		
Common name	**Scientific Name**	**Coefficients of Conservatism**
Curly-Leaf Pondweed	*Potamogeton crispus*	0
Small Pondweed	*Potamogeton berchtoldii*	5
Leafy Pondweed	*Potamogeton foliosus*	4
Sago Pondweed	*Stuckenia pectinata*	3
Eurasian Watermilfoil	*Myriophyllum spicatum*	0
Coontail	*Ceratophyllum demersum*	4
Elodea	*Elodea canadensis*	2
Water Stargrass	*Heteranthera dubia*	4
Emergent grass	Un-identified	N/A
Star Duckweed	*Lemna trisulca*	7
White Waterlily	*Nymphaea odorata*	4
Aquatic Moss	*Fontinalis sp.*	N/A
Chara	*Chara sp.*	N/A
Tape Grass	*Vallisneria americana*	5
Slender Naiad	*Najas flexilis*	5

Chautauqua Lake - Adjusted Floristic Quality Indices (FQIs)			
Site	**Pre-treatment**	**Post-treatment**	**P-value**
CTR1	28.6	30.6	**0.001**
CTR2 (TRT5)	0.0	14.1	
CTR3	0.0	0.0	
CTR4	16.3	28.6	
DFT1	26.0	32.1	
DFT2	25.6	36.0	
DFT3	25.6	30.4	
DFT4	25.6	31.3	
TRT1	17.7	32.1	
TRT2	20.4	32.1	
TRT3	17.8	32.0	
TRT4	26.0	28.6	

Chara algae, aquatic moss, and the unknown grass species were not included in this assessment

P-values listed in **bold red** indicate a statistically significant change between Pre- and Post-treatment FQIs (α = 0.05).

Conclusions

- Water quality data showed no acute impacts related to temperature, dissolved oxygen, pH, specific conductance, or clarity in relation to the treatment.
- Chemical data showed some drift of herbicide outside of treatment areas into the drift and control zones approximately 7 to 14 days after the treatment.
- The results of split samples analyzed by both Princeton Hydro- and Solitude-contracted laboratories were in general agreement.

Conclusions

- Samples of raw (untreated) water collected near potable water intakes by the PWS Operators, split by the County Health Department and provided to Princeton and Solitude for analyses, were all well below the NYSDEC Permit Consumptive Threshold of 50 ppb.
- The herbicide treatment program was designed to substantially reduce the targeted invasive species curly-leaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil (*Myriophyllum spicatum*) with little to no impacts to native species.

Conclusions

- Between pre- and post-treatment conditions, curly-leaf pondweed displayed a statistically significant decrease in the treatment areas while Eurasian watermilfoil also displayed a decrease but this was not statistically significant. In contrast, four of the more common native species all increased from pre- to post-treatment conditions.
- Based on a comparison between pre-treatment and post-treatment conditions, community-wide species richness increased and this was statistically significant.

Conclusions

- Relative to plant biomass, total biomass declined at the treatment zones with a marked reduction in the two invasives. However, none of these declines were statistically significant.
- There were potential impacts to native SAV at drift stations DFT1 and DFT3 with a marked reduction in elodea and water stargrass, respectively. Again, not statistically significant.

Conclusions

- The adjusted floristic quality index showed a significant increase from pre- to post-treatment conditions. Thus, while the targeted invasives species declined, overall community diversity and value (native species) increased with the treatments.
- Overall, the treatment was successful at its intent, and data pertaining to this project showed adverse impacts to be minimal.

Recommendations

- Coordination of sampling station locations, sampling station nomenclature and advance coordination will likely result in more power for interpreting potential drift dynamics.

Recommendations

- Further evaluation of potential herbicide drift and its dynamics, including possible northward drift, by collecting additional paired macrophyte and chemical sampling to not only assess presence / absence of chemical drift but also significance as it relates to impacts on macrophyte growth.

Funded in partnership between the County of Chautauqua and the Chautauqua Lake and Watershed Management Alliance in support of the Chautauqua Lake Weed Management Consensus Strategy Memorandum of Agreement (MOA).

THANK YOU

Fred S. Lubnow, Ph.D.

Princeton Hydro, LLC