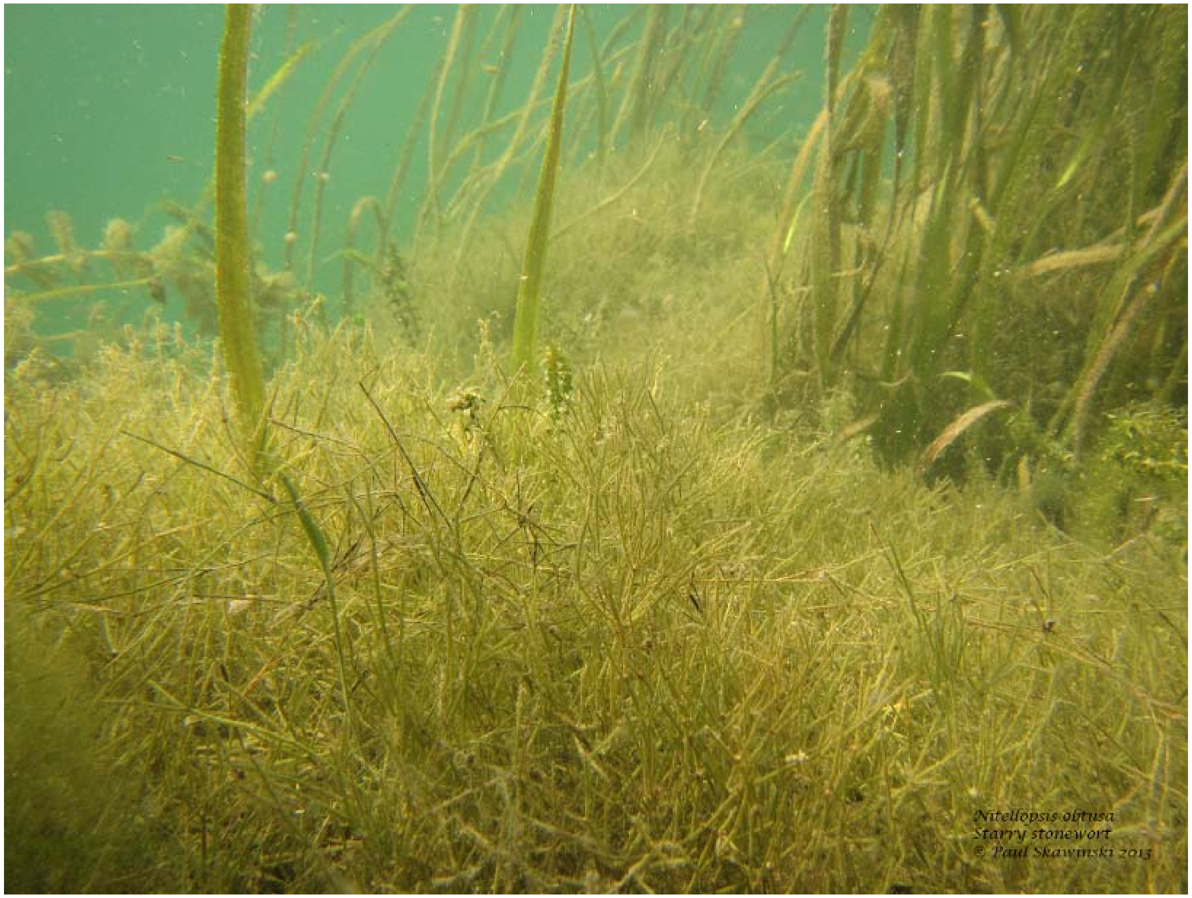
What have we learned about managing starry stonewort (*Nitellopsis obtusa*)?



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Wisconsin DNR

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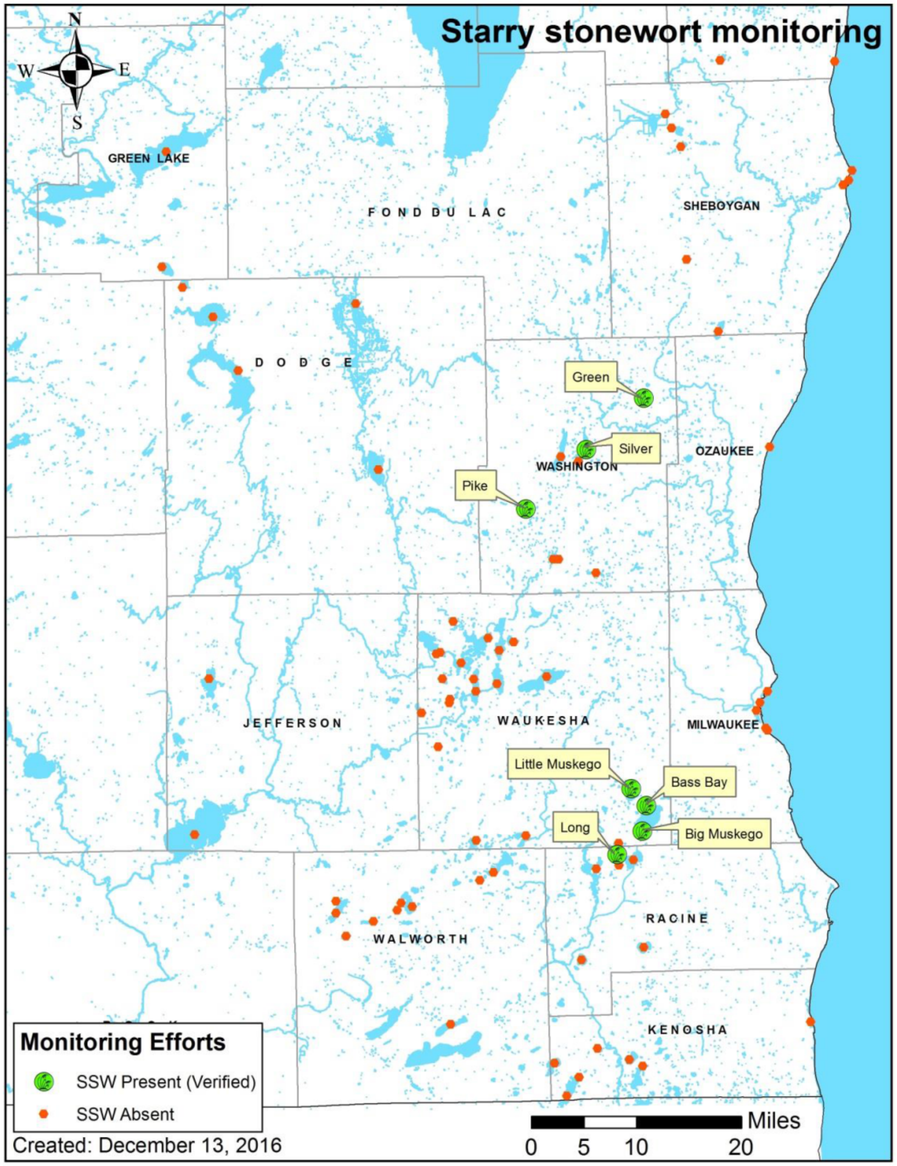
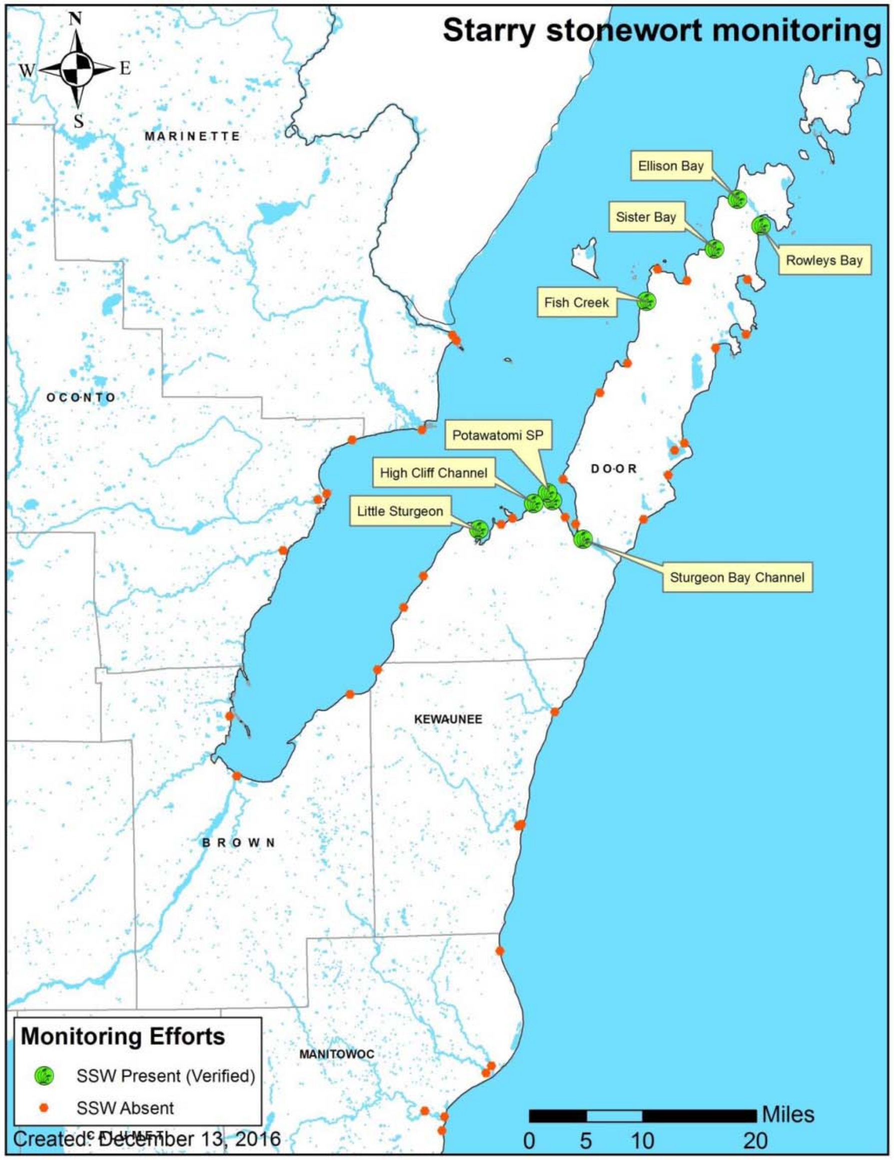
Outline

- Distribution of *Nitellopsis* in Wisconsin
- Three lakes, six management evaluation areas
  - Description of evaluation methods
  - Herbicide concentration exposure monitoring
  - Efficacy on *Nitellopsis*
  - Impacts on non-target plant species

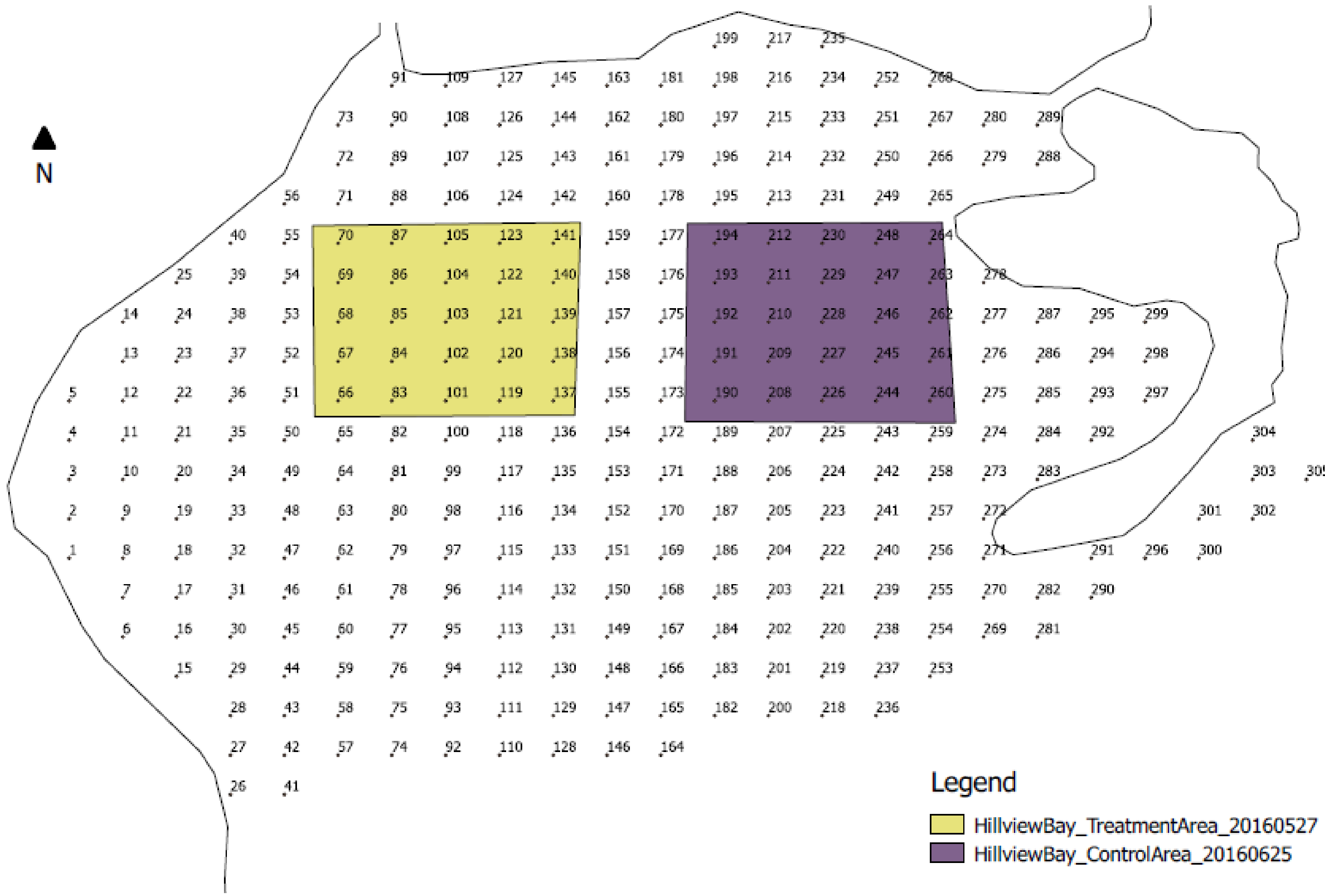
Starry stonewort is localized in Wisconsin





Management Evaluations

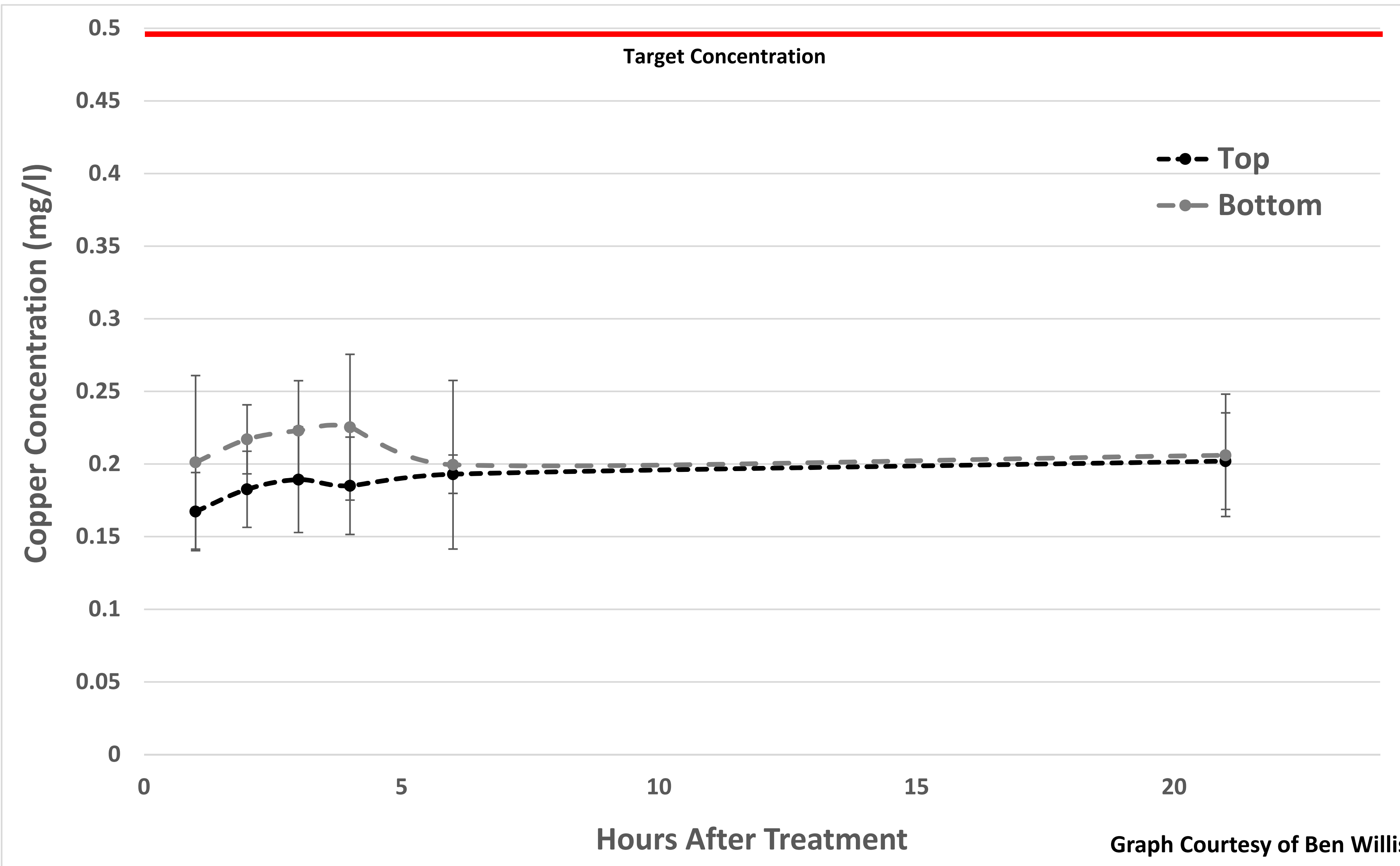
Little Muskego Lake (470 acres) – Hillview Bay (27 acres)
2.4 acre treatment area
Copper (0.5 ppm target concentration)



Little Muskego – Hillview Bay
Herbicide Concentration Monitoring

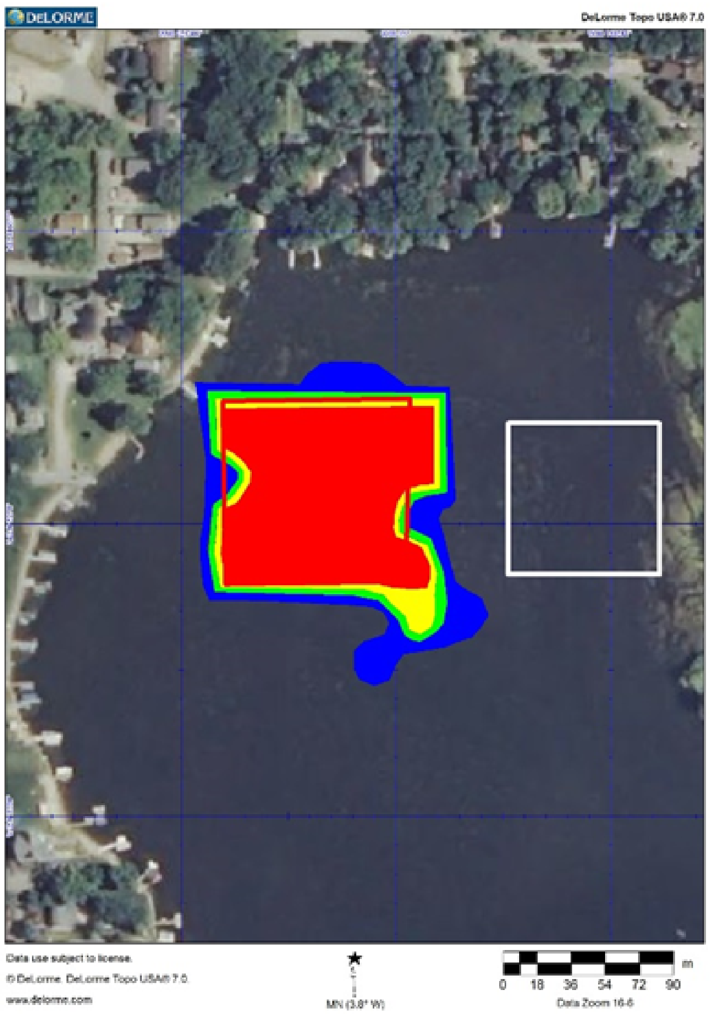
Table 2. Color key for measured dye concentration contour ranges	
	Dye Conc.
contour color	range (ppb)
red	7.5 - > 10
yellow	5.0 - 7.5
green	2.5 - 5.0
dark blue	1.0 - 2.5
background levels = 0.25 to 0.80 ppb	

Little Muskego Lake – Hillview Bay
Herbicide Concentration Exposure
Copper (0.5 ppm, granular formulation)

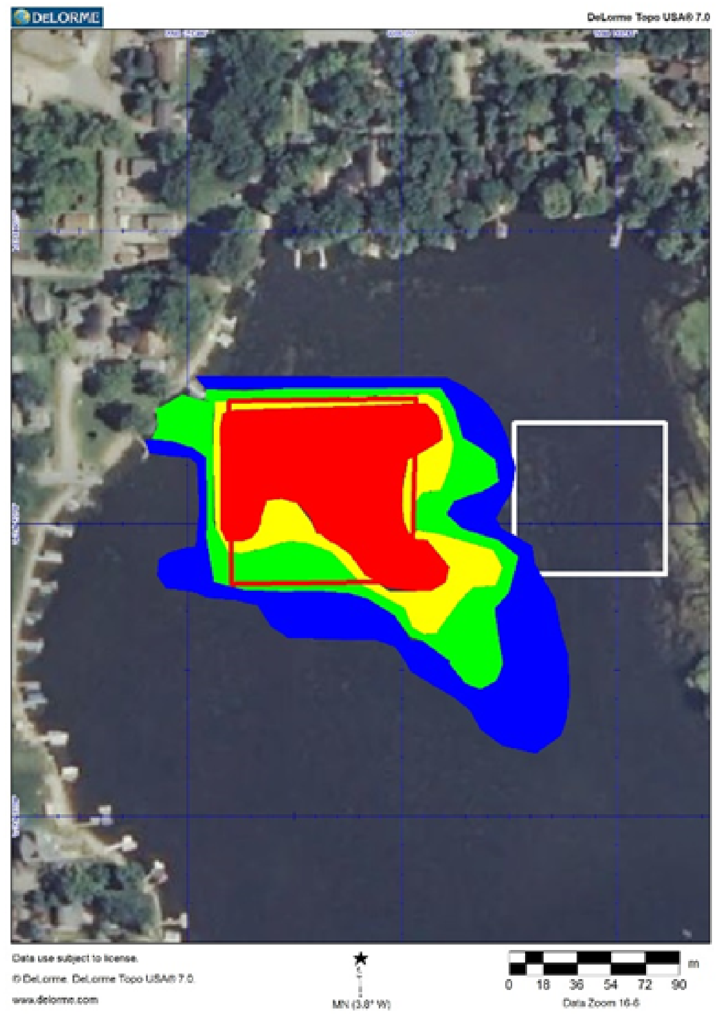


Hillview Bay - Water Movement
Dye Dissipation

0.5 HAT



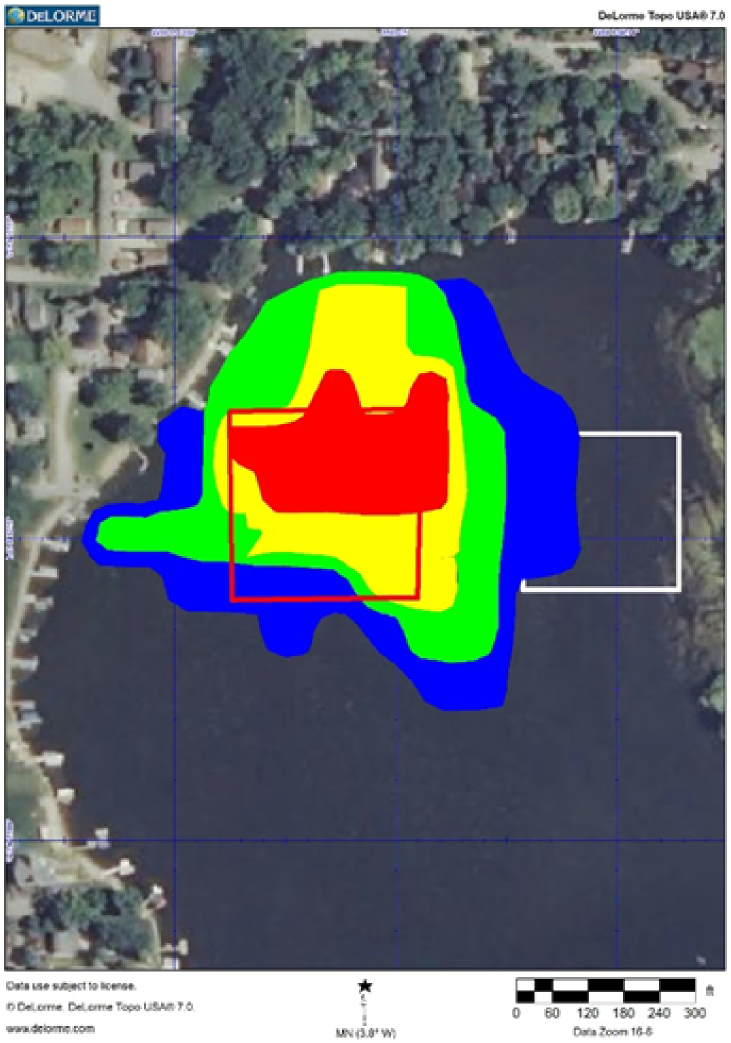
4 HAT



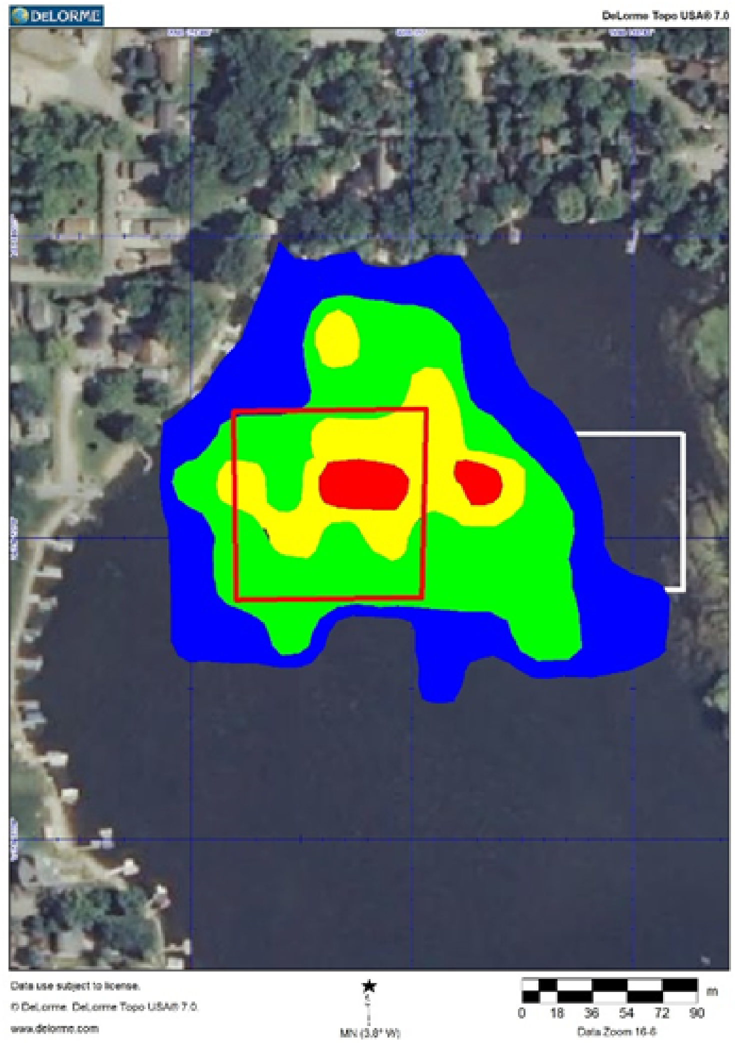
Images Courtesy of John Skogerboe

Hillview Bay - Water Movement
Dye Dissipation

8.0 HAT



24 HAT



Images Courtesy of John Skogerboe

Hillview Bay, Little Muskego Lake
June 29 Treatment
Copper (0.5 ppm target concentration)

Treatment Area (N=25)

	Pre July 2015	Pre May 2016	Post July 2016	Post August 2016	August 2016 Bulbil Only Sites
Nitellopsis	100	100	88	96	36
Chara*	88	32	**12**	4	
Vallisneria*	88	4	**28**	36	

Control Area (N=25)

	Pre July 2015	Pre May 2016	Post July 2016	Post August 2016	August 2016 Bulbil Only Sites
Nitellopsis	84	80	68	76	36
Chara*	100	68	**84**	52	
Vallisneria*	100	8	**40**	40	

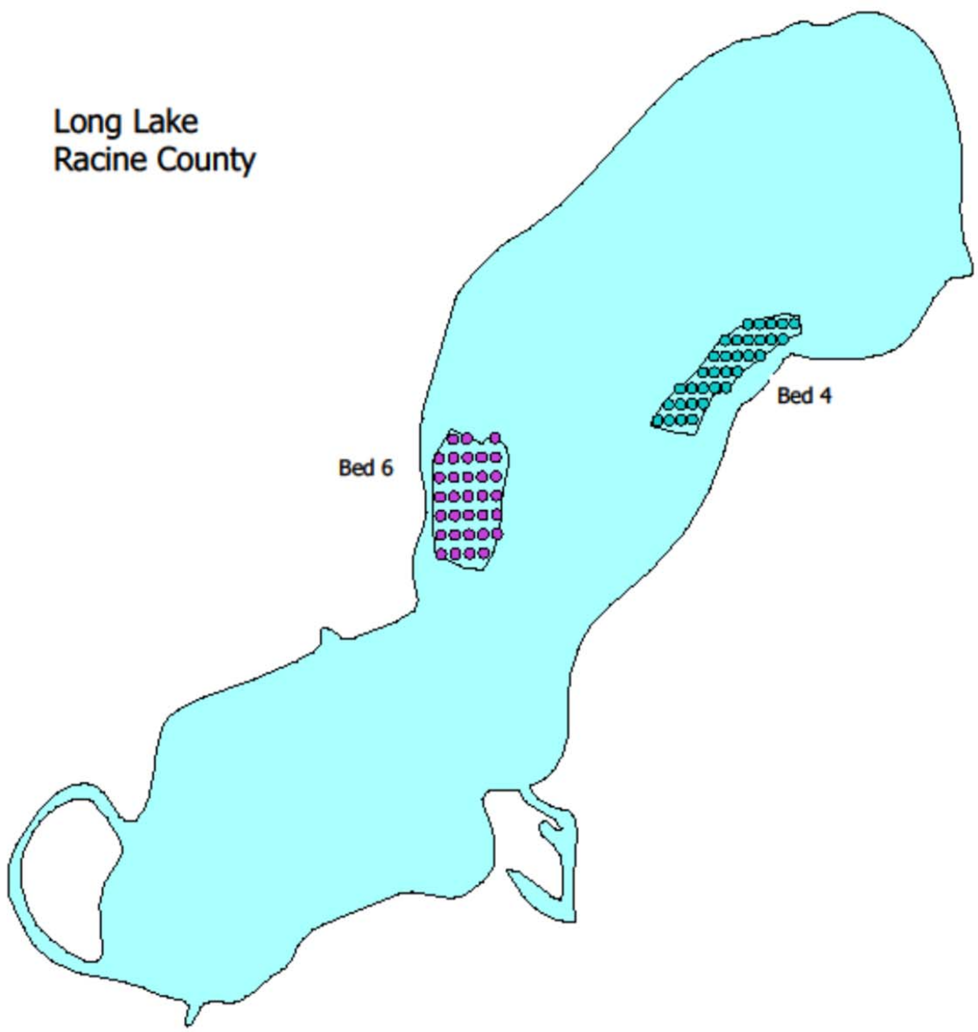
Whole Bay (N=282)

	Pre July 2015	Pre May 2016	Post July 2016	Post August 2016	August 2016 Bulbil Only Sites
Nitellopsis*	60	53	**78**	78	10
Chara*	82	63	**57**	42	
Vallisneria*	83	5	**64**	60	

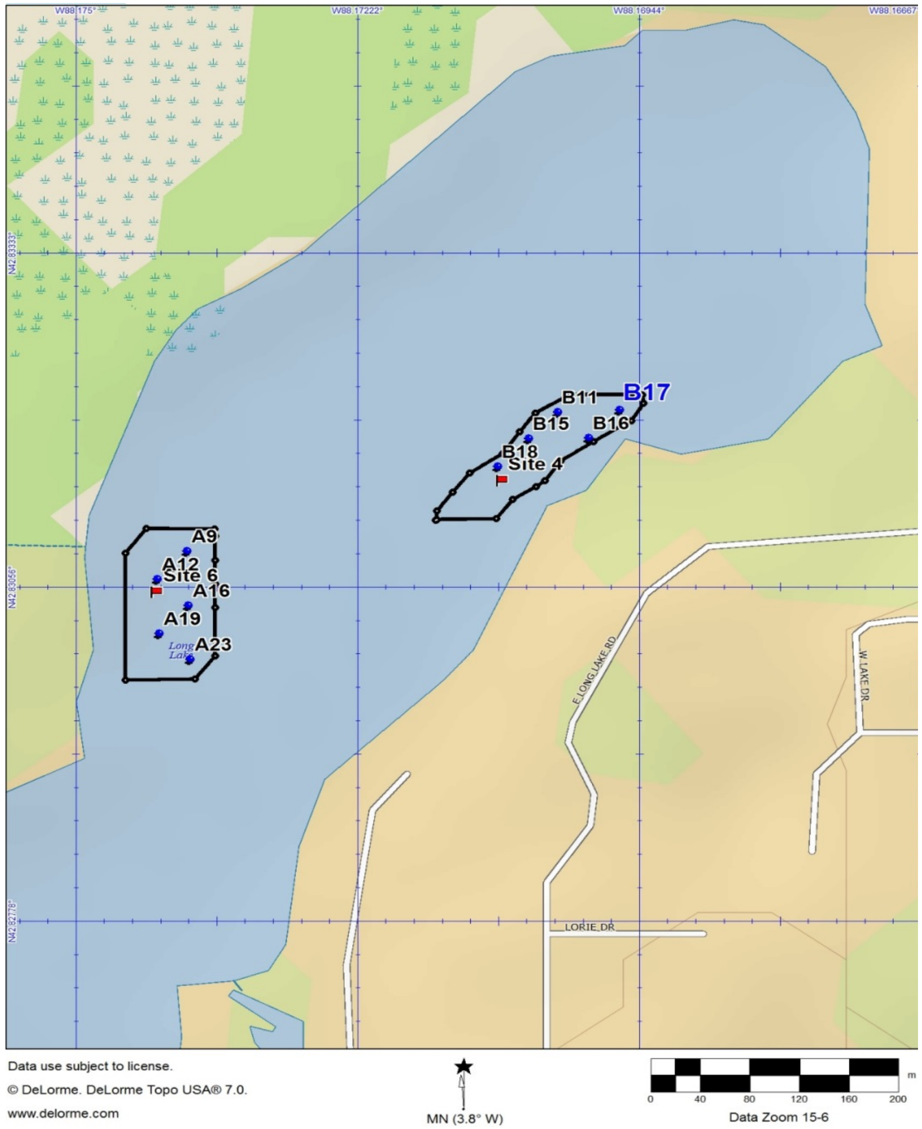
Frequency of dominant plant species in Hillview Bay, Little Muskego Lake before and after a copper (Komeen crystal) treatment. Bold * items indicate a statistically significant ($p < 0.05$) difference between 2015 pre-treatment and 2016 post-treatment surveys.

Biomass Reduction

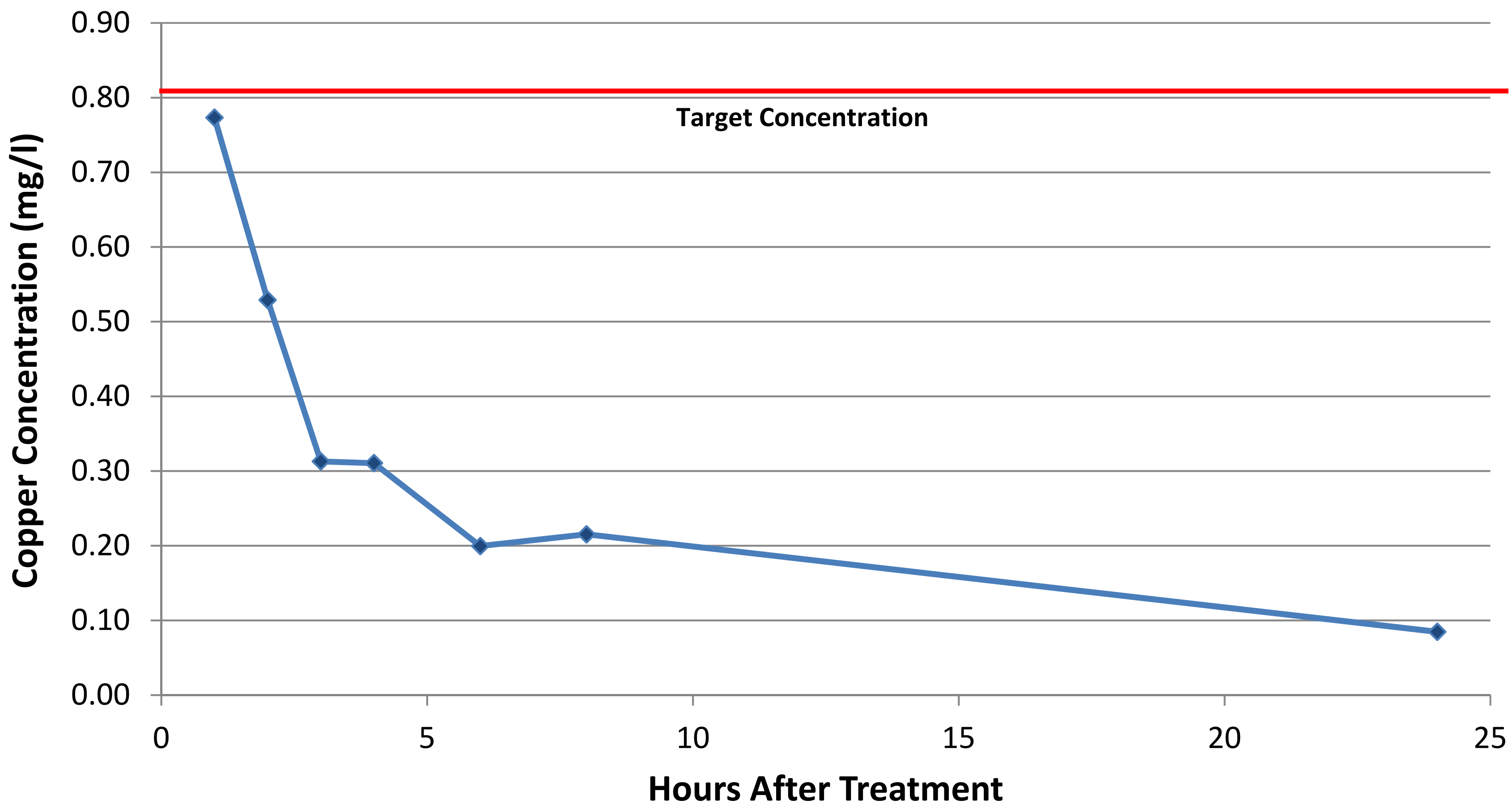
Long Lake (105 acres)
0.75 - 1 acre treatment areas (Bed 4)
2.7 acre treatment area (Bed 6)



Long Lake
Herbicide Concentration Monitoring



Long Lake – Site 6
June 8, 2016
Herbicide Concentration Exposure
June 8 - copper (0.8 ppm, liquid formulation)

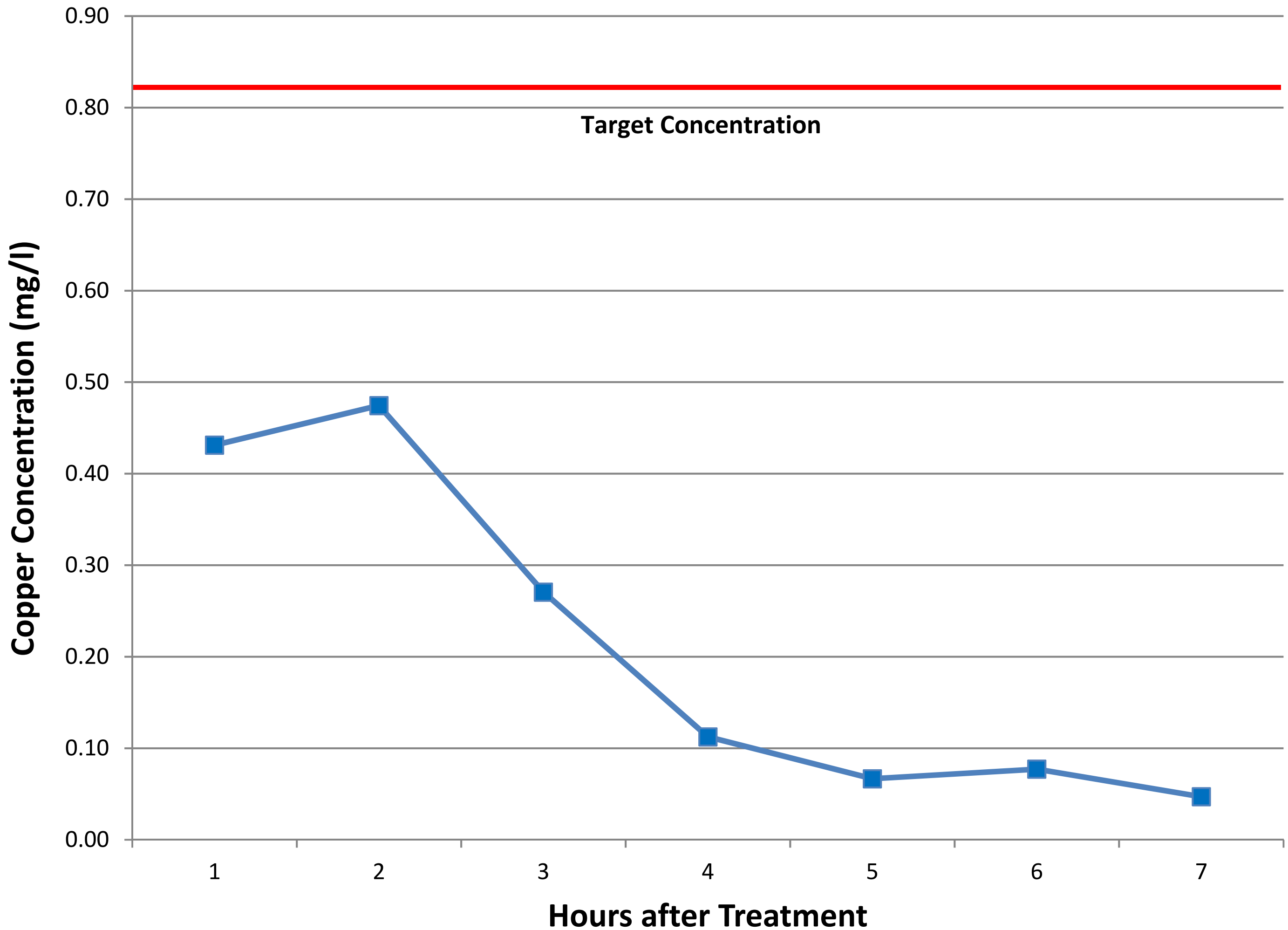


Long Lake – Site 6
June 8 - copper (0.8 ppm)
June 29 - copper (0.8 ppm) + hydrothol (0.29 ppm)

	Pre	Post	p	Significant change
Myriophyllum spicatum,Eurasian water milfoil	**8**	**2**	**0.044**	*
Ceratophyllum demersum, Coontail	20	19	0.923	n.s.
Chara sp., Muskgrasses	15	9	0.142	n.s.
Elodea canadensis, Common waterweed	**8**	**2**	**0.044**	*
Lemna minor	**8**	**0**	**0.003**	**
Lemna trisulca, Forked duckweed	**22**	**13**	**0.029**	*
Najas guadalupensis, Southern naiad	3	3	0.966	n.s.
Nymphaea odorata	12	15	0.375	n.s.
Potamogeton amplifolius	3	0	0.081	n.s.
Potamogeton illinoensis or gramineus	1	4	0.150	n.s.
Stuckenia pectinata, Sago pondweed	5	4	0.758	n.s.
Utricularia vulgaris, Common bladderwort	16	15	0.900	n.s.
Vallisneria americana, Wild celery	1	2	0.534	n.s.
Filamentous algae	**10**	**24**	**0.000**	***
Nitellopsis obtusa, starry stonewort	8	11	0.360	n.s.

Pre (June 6) to post (August 4) treatment comparison of aquatic plants in Long Lake treatment area #6 (N=30).

Long Lake – Site 4
June 16, 2016
Herbicide Concentration Exposure
1 acre - June 16 - copper (0.83 ppm) + flumioxazin (0.15 ppm)

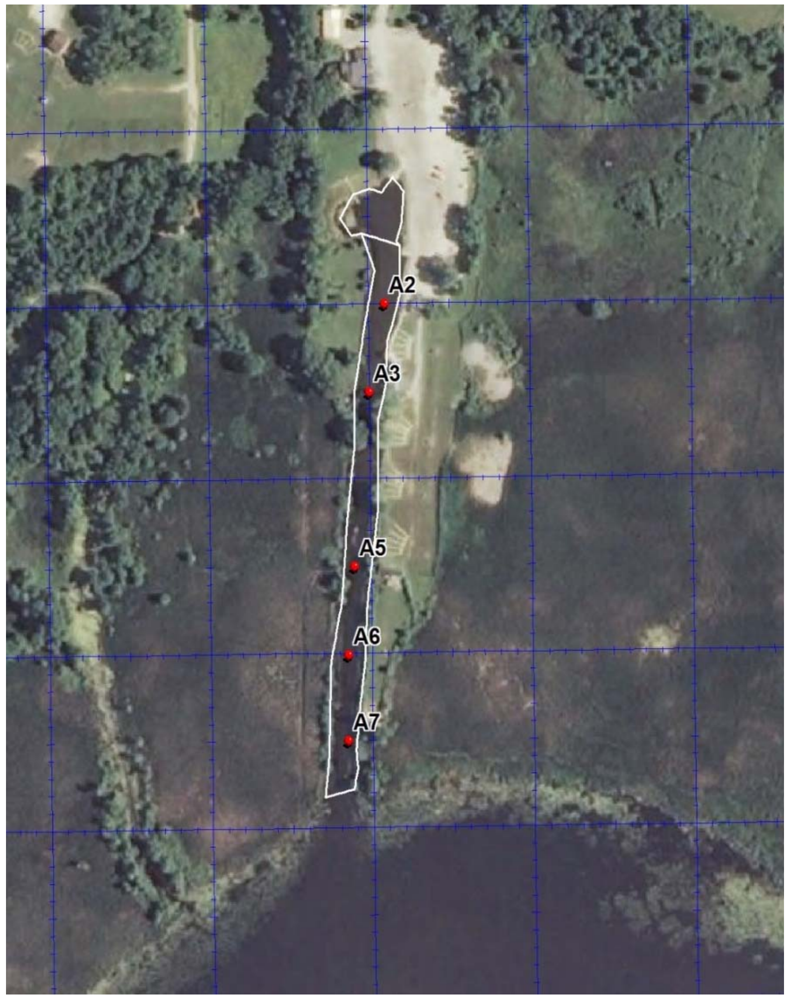


Long Lake – Site 4
1 acre - June 16 - copper (0.83 ppm) + flumioxazin (0.15 ppm)
0.74 acre - June 29 - copper (0.8 ppm) + diquat (0.35 ppm)

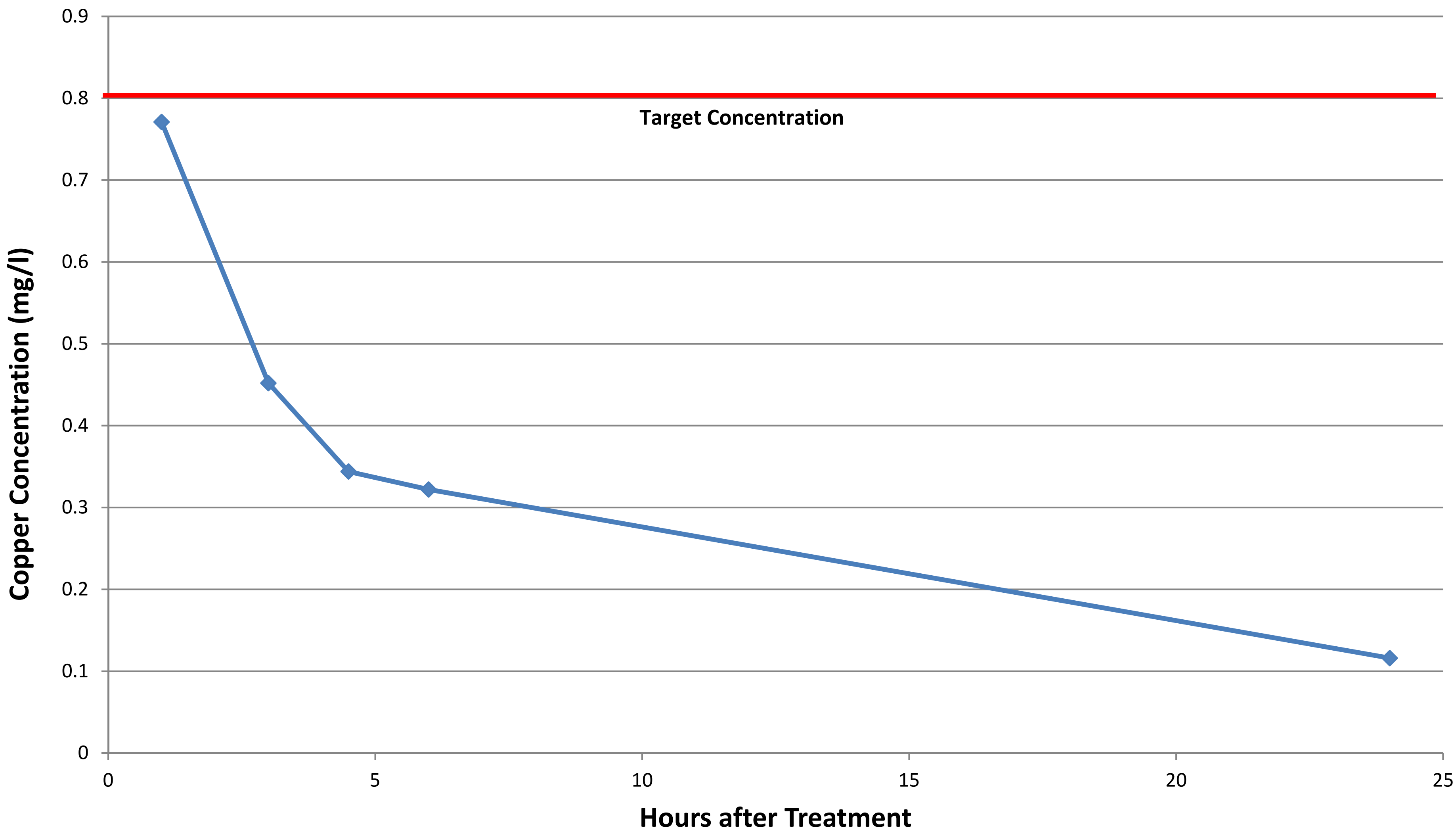
	Pre	Post	p	Significant change
Myriophyllum spicatum,Eurasian water milfoil	1	1	1.000	n.s.
Potamogeton crispus,Curly-leaf pondweed	6	2	0.130	n.s.
Ceratophyllum demersum, Coontail	15	15	1.000	n.s.
Chara sp., Muskgrasses	14	18	0.309	n.s.
Elodea canadensis, Common waterweed	1	3	0.301	n.s.
Lemna trisulca, Forked duckweed	1	3	0.301	n.s.
Najas guadalupensis, Southern naiad	**1**	**6**	**0.045**	*****
Potamogeton illinoensis, Illinois pondweed	2	4	0.390	n.s.
Stuckenia pectinata, Sago pondweed	4	4	1.000	n.s.
Utricularia vulgaris, Common bladderwort	5	9	0.224	n.s.
Vallisneria americana, Wild celery	10	4	0.068	n.s.
Filamentous algae	**8**	**22**	**0.000**	*******
Nitellopsis obtusa, starry stonewort	**6**	**14**	**0.030**	*****

Pre (June 6) to post (August 4) treatment comparison of aquatic plants in Long Lake treatment area #4 (N=31).

Big Muskego Lake (2194 acres)
Hunter's Nest Channel - 1.5 acre treatment area



Big Muskego Lake – Hunter's Nest
June 27, 2016
Herbicide Concentration Exposure
copper (0.8 ppm) + hydrothol (0.17 ppm)

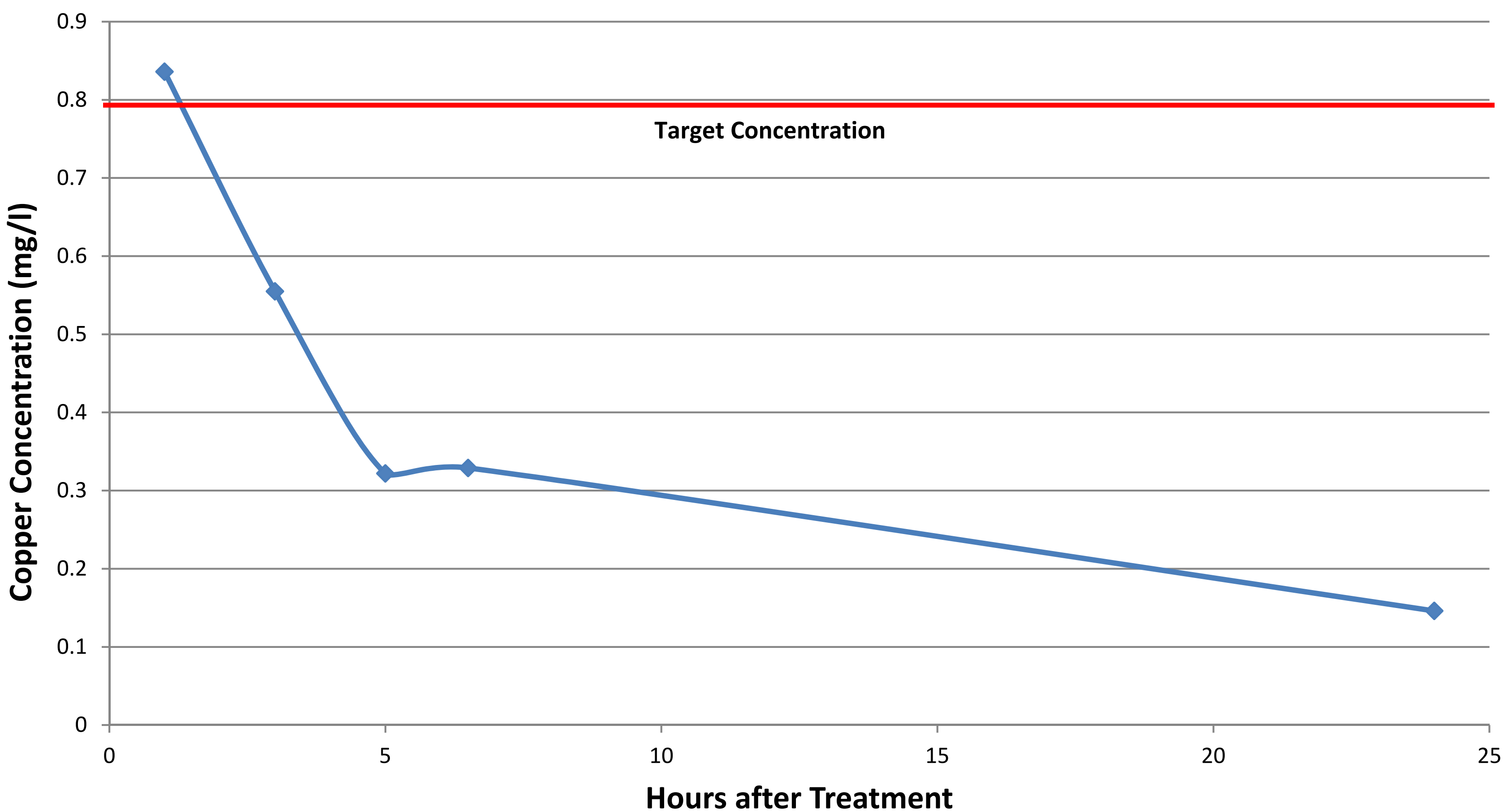


Big Muskego Lake – Hunter's Nest Channel
September 24, 2015 and June 27, 2016
copper (0.8 ppm) + hydrothol (0.17 ppm)

Site	**9/23/15 Weight (g)**	10/14/15 Weight (g)	10/26/15 Weight (g)	**6/23/16 Weight (g)**	7/12/16 Weight (g)	8/2/16 Weight (g)
1A	**334**	0	0	**19**	40	2
1B	**6.5**	0	0.2	**0**	34	0.1
2A	**3.25**	0	0	**166**	14	0
2B	**0.5**	0	0	**35**	2	0
3A	**9**	0.2	0	**0.75**	9	74
3B	**1.8**	0	1	**11**	13	85
4A	**396**	0.8	24	**1533**	0.1	1423
4B	**1853**	0.3	2.8	**1035**	0.1	1088
5A	**849**	3	16	**1856**	290	453
5B	**901**	56	20	**131**	1	367
6A	**81**	19	2	**905**	547	155
6B	**117**	0	3	**1254**	4	202
7A	**84**	0	0	**877**	4	315
7B	**43**	10	0	**675**	83	632
8A	**385**	32	2	**877**	158	78
8B	**480**	0.7	0.2	**760**	14	178
Mean	**346.5031**	7.625	4.45	633.4219	75.825	315.7563

Big Muskego Lake (2194 acres)
Durham Landing - 1.3 acre treatment area

Big Muskego Lake – Durham Landing
June 27, 2016
Herbicide Concentration Exposure
copper (0.8 ppm, liquid) + hydrothol (0.17 ppm, liquid)

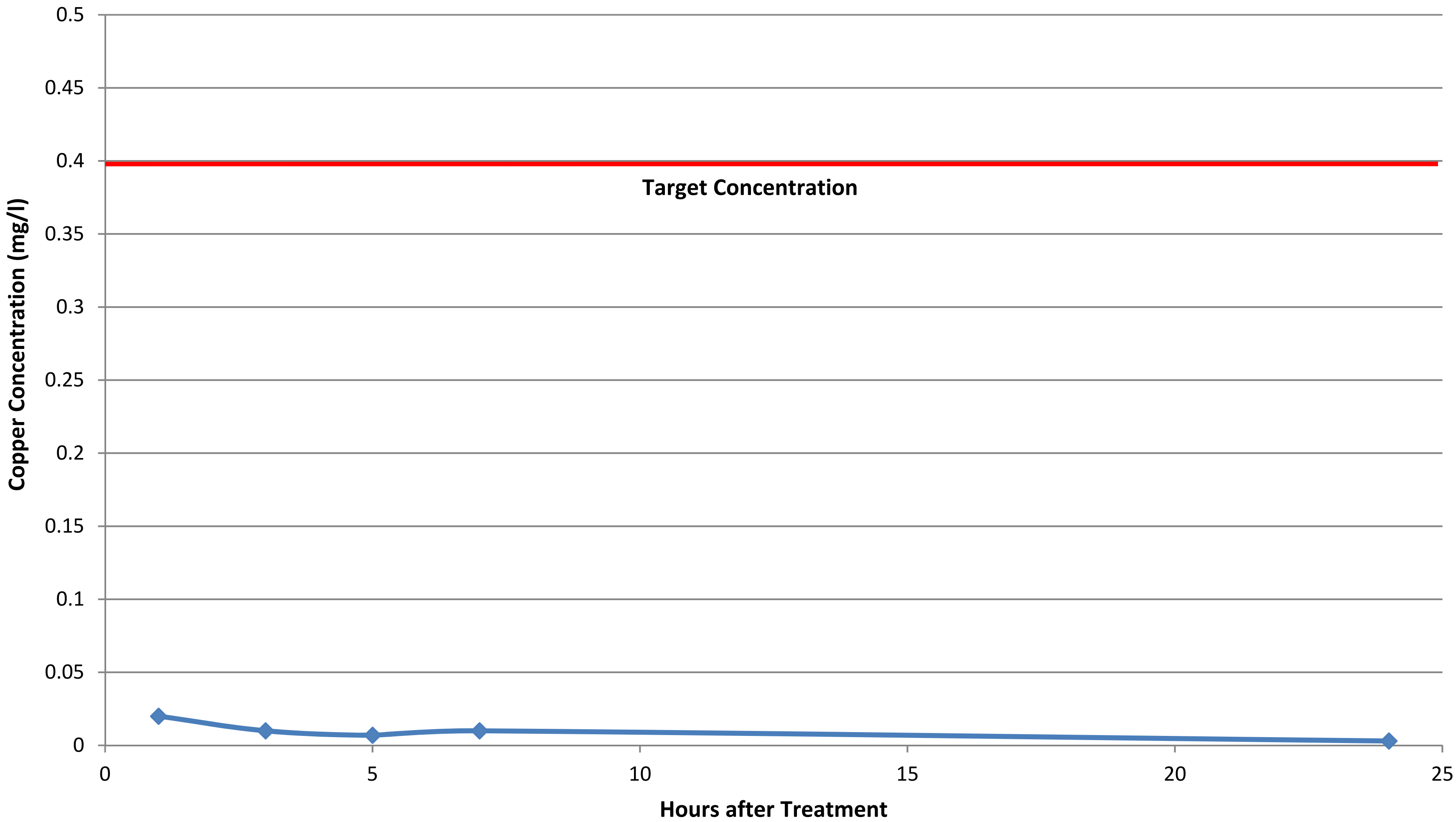


Big Muskego Lake – Durham Landing
June 27 - copper (0.8 ppm) + hydrothol (0.17 ppm)

Site	9/23/15 Weight (g)	10/14/15 Weight (g)	10/26/15 Weight (g)	**6/23/16 Weight (g)**	7/12/16 Weight (g)	8/11/16 Weight (g)
1A	25	0	0	**0**	0	0
1B	0	0	0	**0**	0	0.1
2A	0	0		**0**	0	0
2B	22	0		**0**	0	0
3A	3.75	0	111	**0**	0	0
3B	15.5	0	62	**0**	0	0
4A	720	0	1.1	**4**	0	0
4B	90	0	0.2	**41**	3.5	6
5A	3.7	610	3200	**412**	706.5	0
5B	803	590	1975	**50**	0.1	62
6A	1803	3250	1560	**0**	0.1	595
6B	588	0	1790	**0**	0.7	94
7A	5	690	560	**0**	0	0
7B	1701	1070	1120	**0**	0.1	0
8A	66	1860	460	**0**	0	0
8B	1503	983	840	**0**	0	0
Mean	459.3094	565.8125	834.2357	**31.6875**	44.4375	47.31875

Big Muskego Lake – Boxhorn Landing
0.75 acre treatment area

Big Muskego Lake – Boxhorn Landing
June 27, 2016
Herbicide Concentration Exposure
copper (0.4 ppm, granular formulation)



Big Muskego Lake – Boxhorn Boat Landing
September 24, 2015 – flumioxazin (0.2 ppm)
June 27, 2016 - copper (0.4 ppm)

	9/23/15	10/14/15	10/26/15	**6/23/16**	7/12/16	8/2/16
Site	**Weight (g)**	Weight (g)	Weight (g)	**Weight (g)**	Weight (g)	Weight (g)
1A	**0.5**	0.6	0.3	**1808**	509	234
1B	**3.9**	0.1	0	**385**	804	199
2A	**0.3**	0	0	**20**	9	0
2B	**0.3**	0	0	**30**	1	0
3A	**10.5**	0	0	**86**	10	97
3B	**0.1**	0	0	**9.6**	30	2
4A	**2.9**	0	0.2	**0**	2313.6	0
4B	**0.6**	3.2	0	**0**	135.8	0
5A	**2.1**	0	0	**10**	42	6
5B	**0.2**	0	0	**498**	13	19
6A	**3.5**	0	0	**0**	0.1	1
6B	**0.2**	0	0	**0**	11	0.1
7A	**3.75**	0	0	**0**	8	65
7B	**0.2**	0	0	**0**	0	1
8A	**24.25**	0.3	1.3	**8.75**	623	3
8B	**14.5**	1.3	0.1	**21**	530	0
Mean	4.2375	**0.34375**	0.11875	179.7719	314.9688	**39.19375**

Treatment Evaluation Summary

Lake	County	Date(s) Treated	Product(s)	Rate(s)	Treatment area	% SSW Change (Pre vs. Post)
Little Muskego	Waukesha	06/29/2016	Copper	0.5 ppm	2.4 acres	-12%
Long	Racine	06/08/2016	Copper	0.8ppm	2.7 acres	+27%
		06/29/2016	Copper + Hydrothol	0.8 ppm + 0.29 ppm	2.7 acres	
		06/16/2016	Copper + Flumioxazin	0.83 ppm + 0.15 ppm	1.0 acres	+57%
		06/26/2016	Copper + Diquat	0.83 ppm + 0.35 ppm	0.74 acres	
Big Muskego	Waukesha	09/24/2015	Copper + Hydrothol	0.8 ppm + 0.17 ppm	1.5 acres	-10%
		06/27/2016	Copper + Hydrothol	0.8 ppm + 0.17 ppm	1.5 acres	
		06/27/2016	Copper + Hydrothol	0.8 ppm + 0.17 ppm	1.3 acres	+33%
		09/24/2015	Flumioxazin	0.2 ppm	0.75 acres	+89%
		06/27/2016	Copper	0.4 ppm	0.75 acres	

Wisconsin
Treatment Evaluation Summary

- No herbicide treatment has provided more than short-term (< 1 year) control.
- Herbicide treatments may reduce SSW biomass in the short-term, but don’t kill the entire plant.
- Native charophytes and macrophytes can be impacted by treatments.
- Copper half-life within 0-4 hours after treatment
- At least some of the degradation/dissipation appears to be due to off-site water movement.

Potential Next Steps

- Attempt overwinter water level drawdown for bulbil control.
- Attempt dredging pilot project at small pioneer stands near boat landings.
- Treat more often in one lake to determine if repeated treatments improves efficacy. Track native impacts.
- Attempt to use herbicides within a barrier system to gain longer herbicide exposure time.
- Sequencing of different management techniques (i.e. – herbicide in barrier then dredging).
- Work with other Great Lakes states to publish a compilation of efficacy of management techniques tried to date.
- Begin to measure bulbils to track reduction of the “seedbank.”

What are other states learning?

Minnesota

- No reduction using copper in open water – 2016 evaluations
- Field trials using herbicides within a barrier system – 2017 evaluation
- Field trials using suction harvest followed by herbicide treatment - 2017 evaluation

Michigan

- No biomass reduction using copper herbicide in open water field trials
- Field trials using sediment barriers

Indiana

- Substantial biomass reduction using copper herbicide in open water field trial

Pennsylvania

- No reduction using copper or sodium peroxyhydrate in open water

Ongoing research

New York Botanical Gardens – Dr. Ken Karol

- Determining how long it takes to desiccate bulbils.
- Determine if freezing will control bulbils.
- Determine if AIS decontamination techniques (bleach, etc) affect bulbil sprouting.
- Study the genetics of North American and native populations to track the trajectory of spread in North America.

Central Michigan University/The Nature Conservancy – Dr. Anna Monfils/Dr. Lindsay Chadderton

- Efficacy of various management techniques – field trials
  - Benthic barriers
  - Herbicide treatments
  - Harvesting and herbicide treatments

University of Minnesota Aquatic Invasive Species Research Center – Dr. Dan Larkin

- Testing how long starry stonewort can remain viable out of water
- Laboratory experiments to test the efficacy and selectivity of different algaecides

Army Corps of Engineers – Dr. Kaytee Pokrzywinski

- Hosting a multi-state meeting to discuss starry stonewort management in September 2017

Questions