

Aquatic Plant Management Research Updates

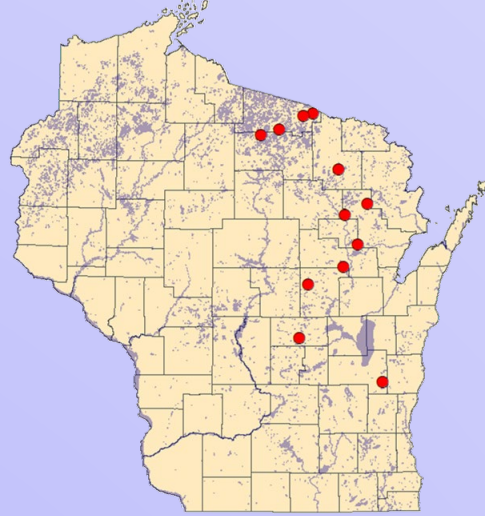


APM Industry Meeting
January 27, 2022

Select Onterra-Monitored ProcellaCOR Projects

Todd Hanke & Eddie Heath
Onterra, LLC

Onterra Projects



2019-2021

- 34 Treatments, 14 Lakes
- Application Rate 3.0-8.0 PDU/acre-ft
- Almost all highly effective
 - Less effective: Kettle Moraine, Boulder
- Emerging suite of sensitive native plant species
 - NWM, Bidens, Coontail, dicots

Lake Name	County	Target	Site	Acres	PDU/ acre-foot	Treatment Date
North Twin	Vilas	EWM	B-19	14.3	8.0	6/17/2019
		EWM	C-20	10.0	7.0	6/17/2020
South Twin	Vilas	EWM	X-21	5.4	4.5	6/9/2021
		EWM	Y-21	22.5	4.0	6/9/2021
		EWM	Z-21	30.1	4.0	6/9/2021
Kawaguesaga	Oneida	EWM	K1-19		4.0	7/16/2019
		EWM	K2-19	4.3	4.0	7/16/2019
		EWM	K3-19		5.0	7/16/2019
		EWM	E-20	15.2	3.5	6/30/2020
		EWM	F-20	12.9	5.0	6/30/2020
		EWM	P-21	3.6	3.5	6/22/2021
		EWM	Q-21	3.3	3.5	6/22/2021
		EWM	R-21	3.4	3.5	6/22/2021
Minocqua	Oneida	EWM*	M1-19	9.3	3.5	6/8/2019
		EWM*	M2-19		3.5	6/8/2019
		EWM*	B-20	17.7	4.5	6/15/2020
		EWM*	C-20	10.2	4.5	6/15/2020
		EWM*	D-20	12.8	3.0	6/15/2020
		EWM*	G-20	7.4	5.0	6/30/2020
		EWM*	O-21	13.4	4.0	6/22/2021
Berry	Oconto-Menominee	HWM	A-20	10.0	4.0	6/12/2020
Crooked	Oconto	EWM	A-20	7.9	3.0/5.0	7/6/2020
Little Saint Germain	Vilas	EWM	A-20	11.1	4.0	6/12/2020
		EWM	C-20	5.1	4.0	6/12/2020
		EWM	D-20	15.9	3.0	6/12/2020
Long	Vilas	EWM*	B-20	15.9	4.0	6/17/2020
[Big] Silver	Wausara	HWM	A-20	11.6	3.5	6/8/2020
Hatch	Waupaca	EWM?	A-21	3.0	4.0	6/17/2021
Kettle Moraine	Fond du Lac	EWM	A-21	10.0	4.0	6/10/2021
Boulder	Oconto	EWM	A-21	1.4	5.0	6/18/2021
		EWM	B-21	1.0	5.0	6/18/2021
Silver	Forest	EWM	A-21	15.0	3.0	6/23/2021
Grass (Cloverleaf Lakes)	Shawano	HWM	A-21	3.5	4.0	6/22/2021
		HWM	B-21	3.3	3.5	6/22/2021

*Presumably EWM although HWM has been documented from system

Herbicide Concentration Monitoring

2019

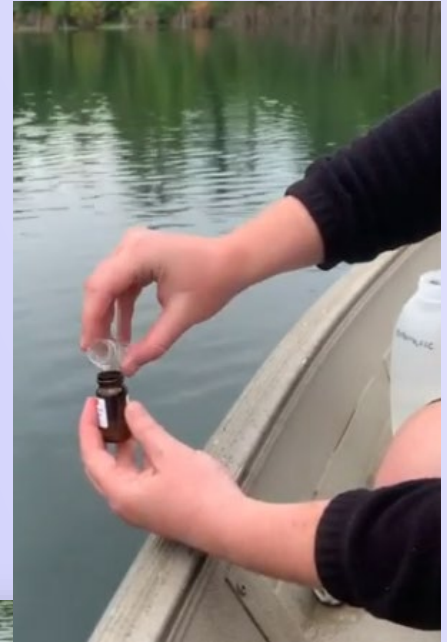
- SePRO Lab
- Most data below detection limits

2020

- EPL Lab
- Aimed at CET w/in application areas

2021

- EPL Lab
- Aimed at CET w/in AOPI



Professional EWM Mapping



Point-Based Mapping

- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

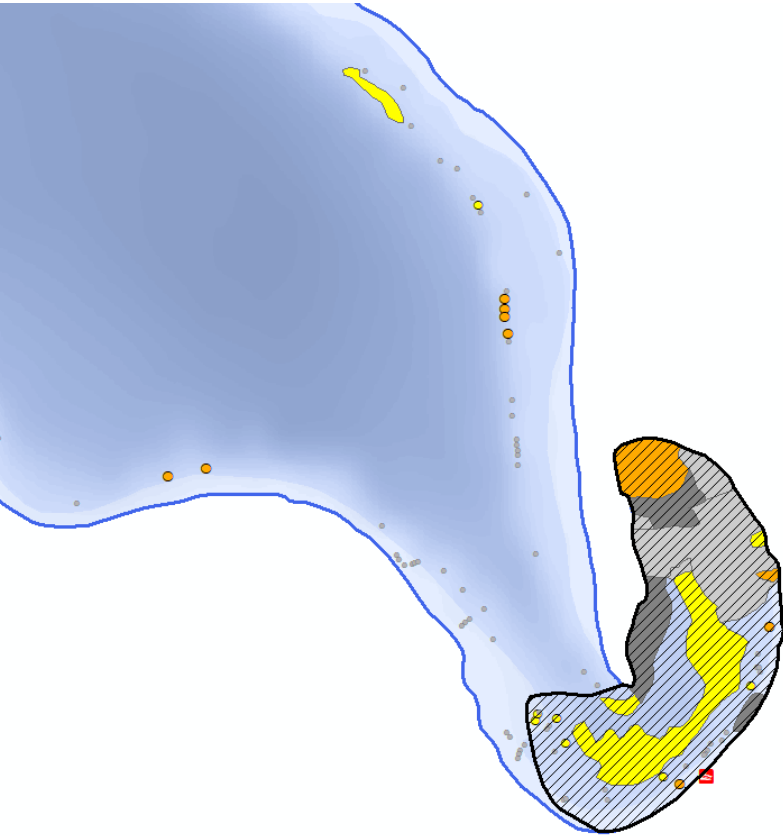


Polygon-Based Mapping

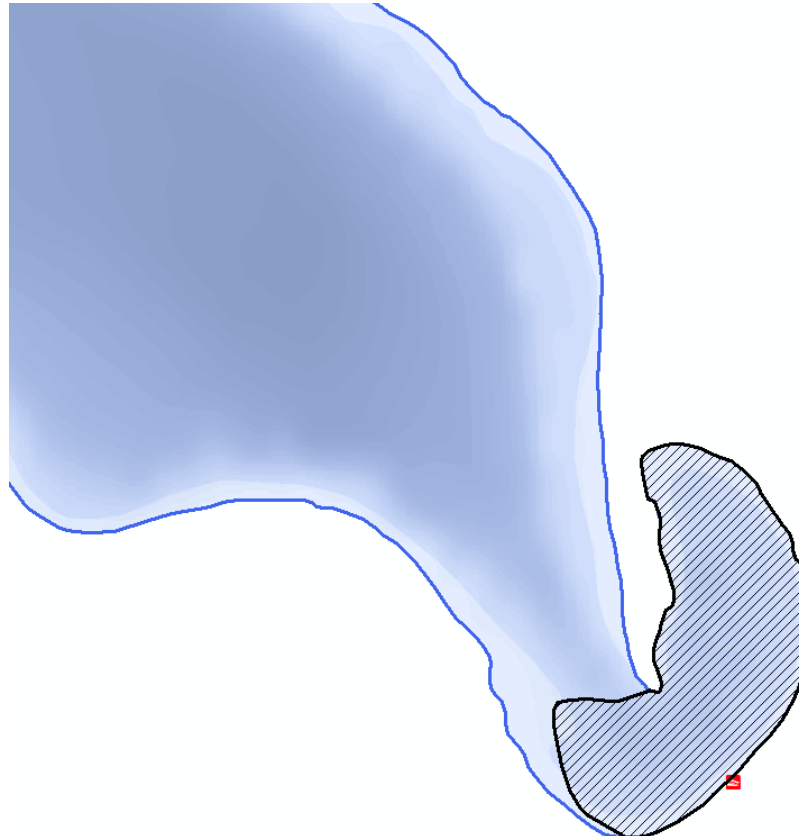
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting

HWM *[Big] Silver Lake (Waushara Co.)– Foxtail Bay*

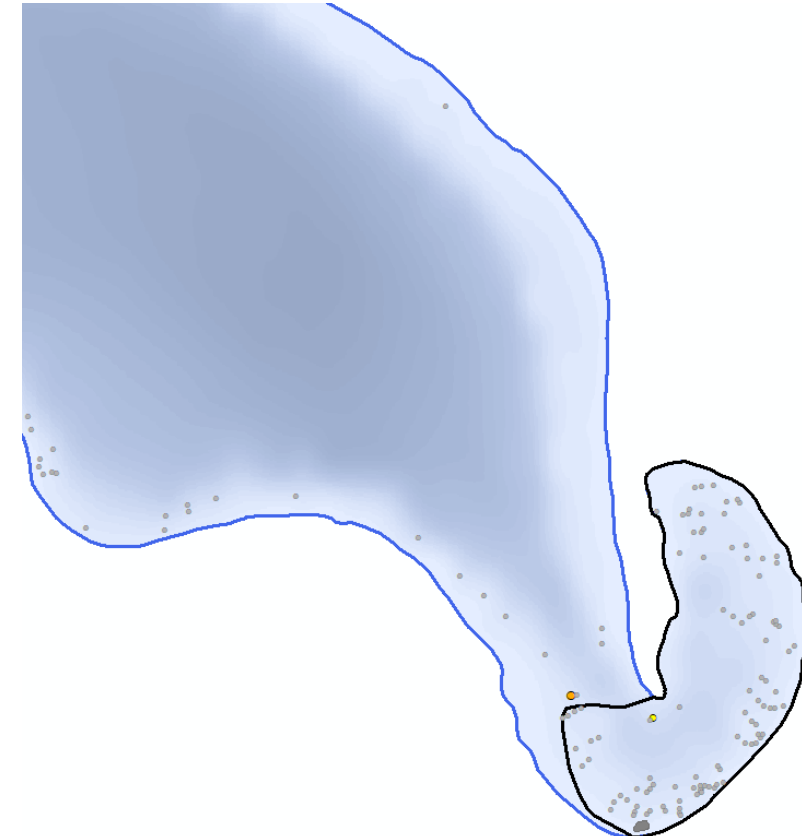
2019 (Year prior to treatment)



2020 (Year of treatment)



2021 (Year after treatment)



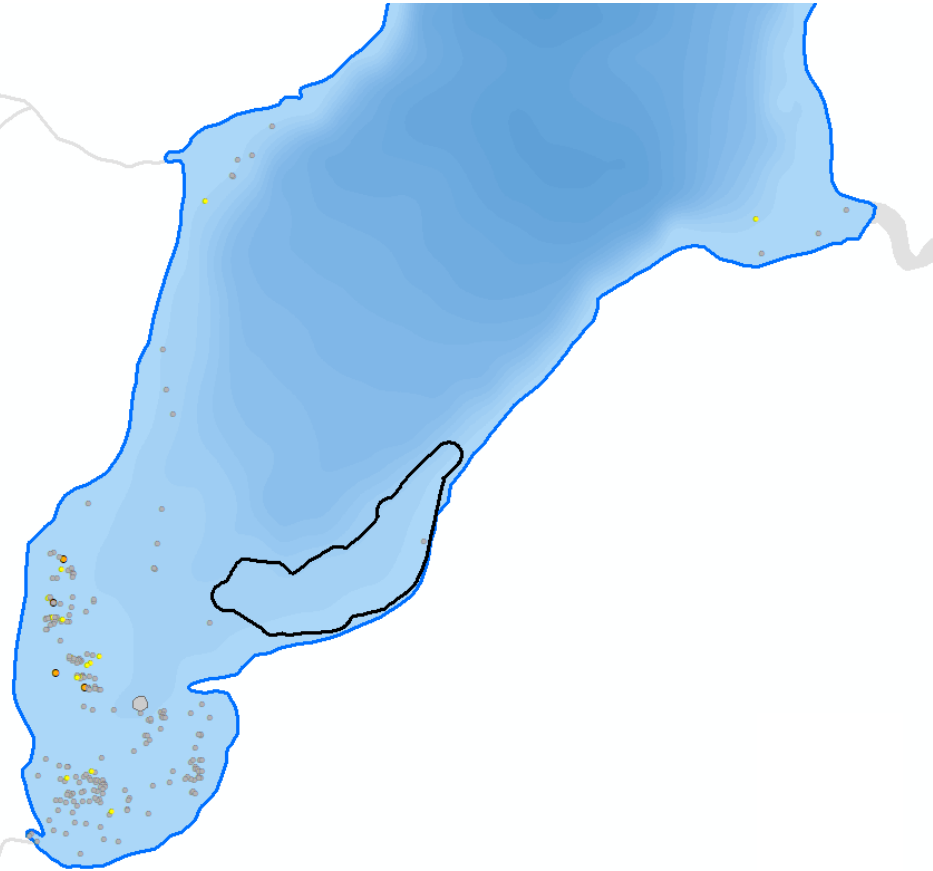
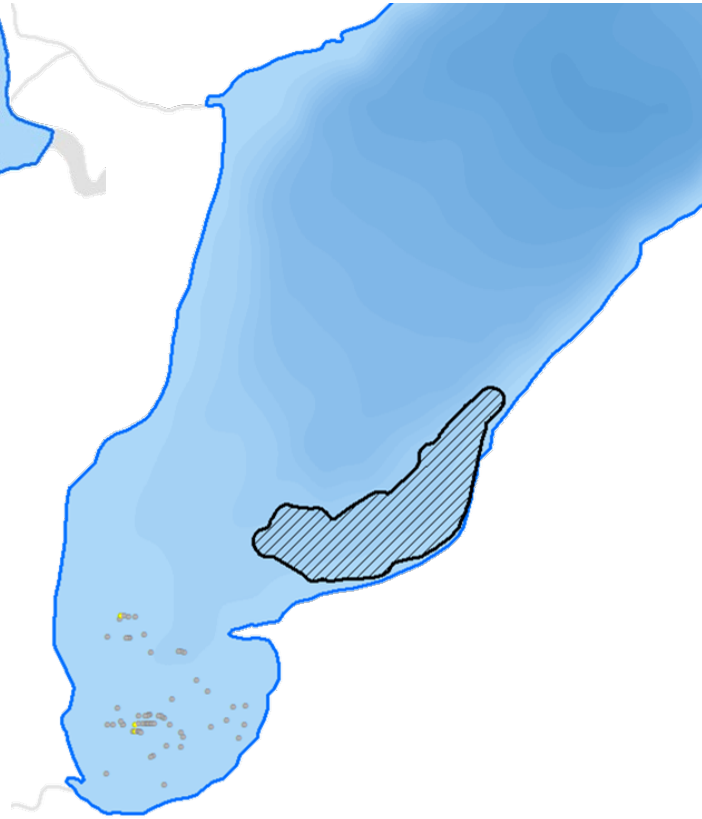
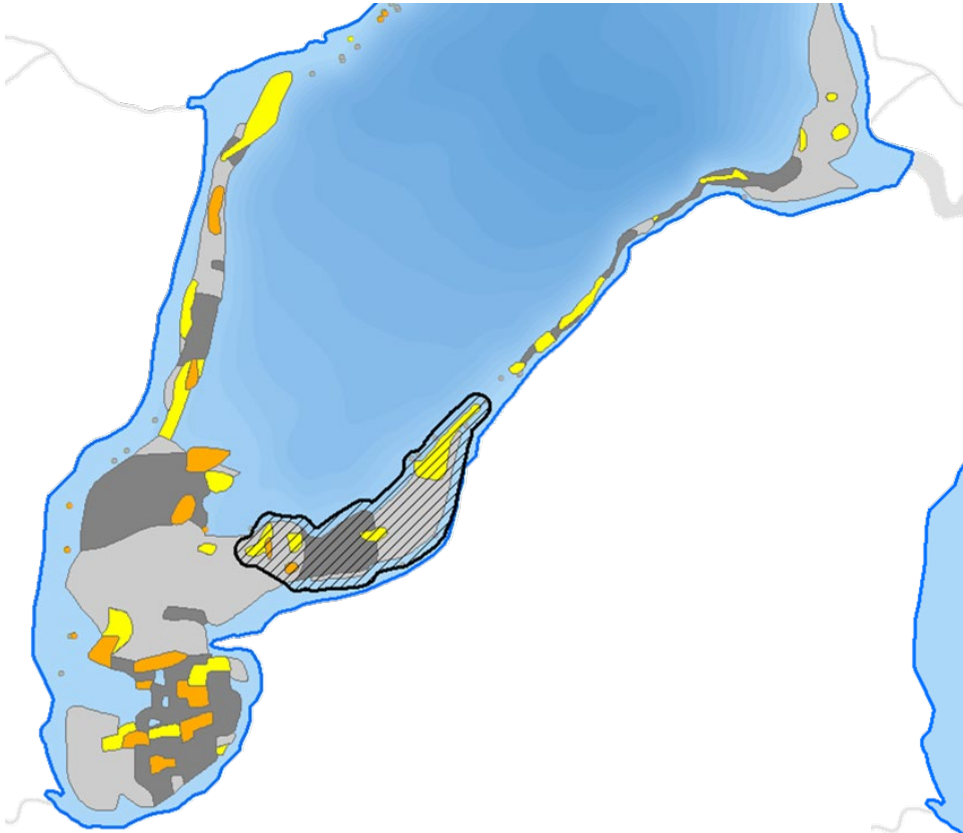
Application area: 11.6 acres
Application Rate: 3.5 PDU

Long Lake (Vilas Co.)

2019 (Year prior to treatment)

2020 (Year of treatment)

2021 (Year after treatment)

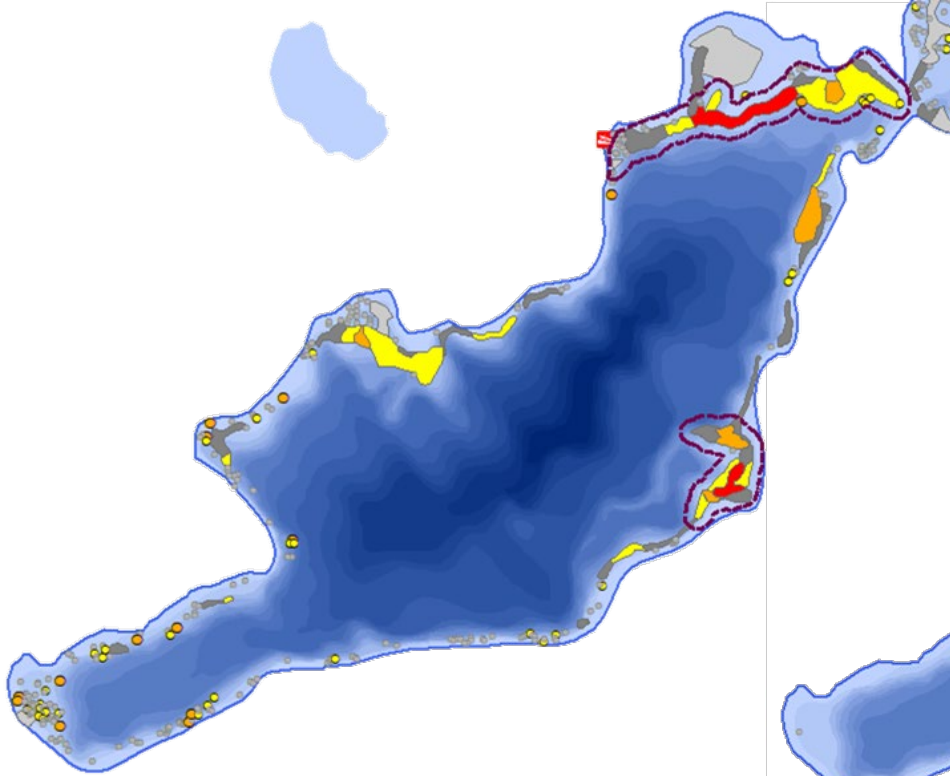


Application area: 15.9 acres

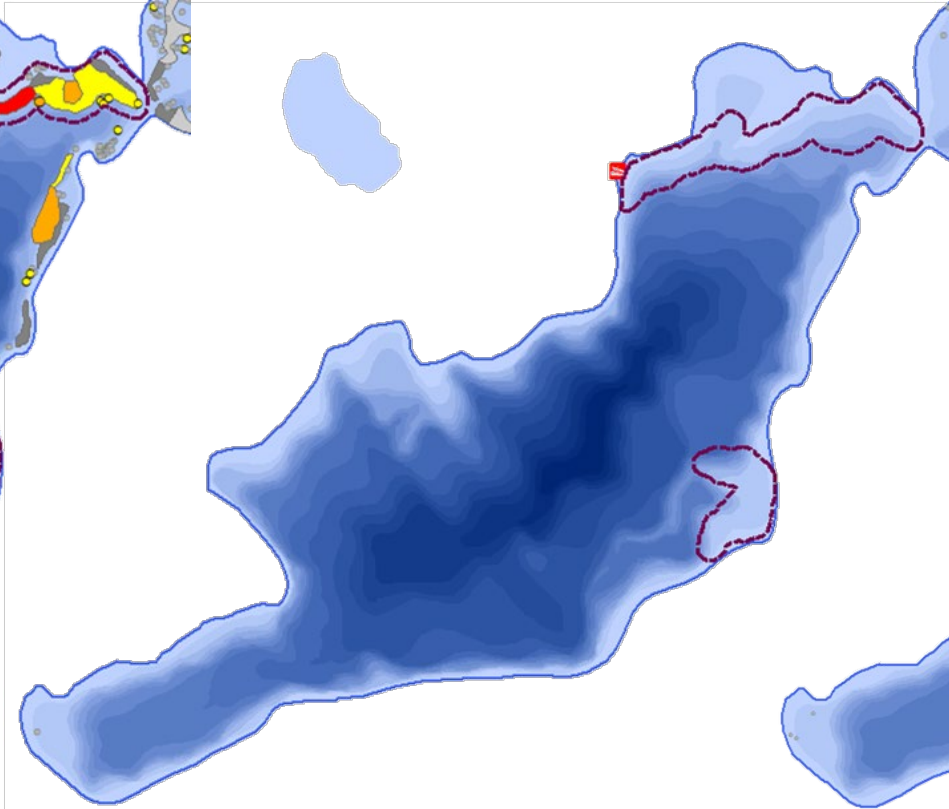
Application Rate: 4.0 PDU

Little Saint Germain Lake (Vilas Co.) – West Bay

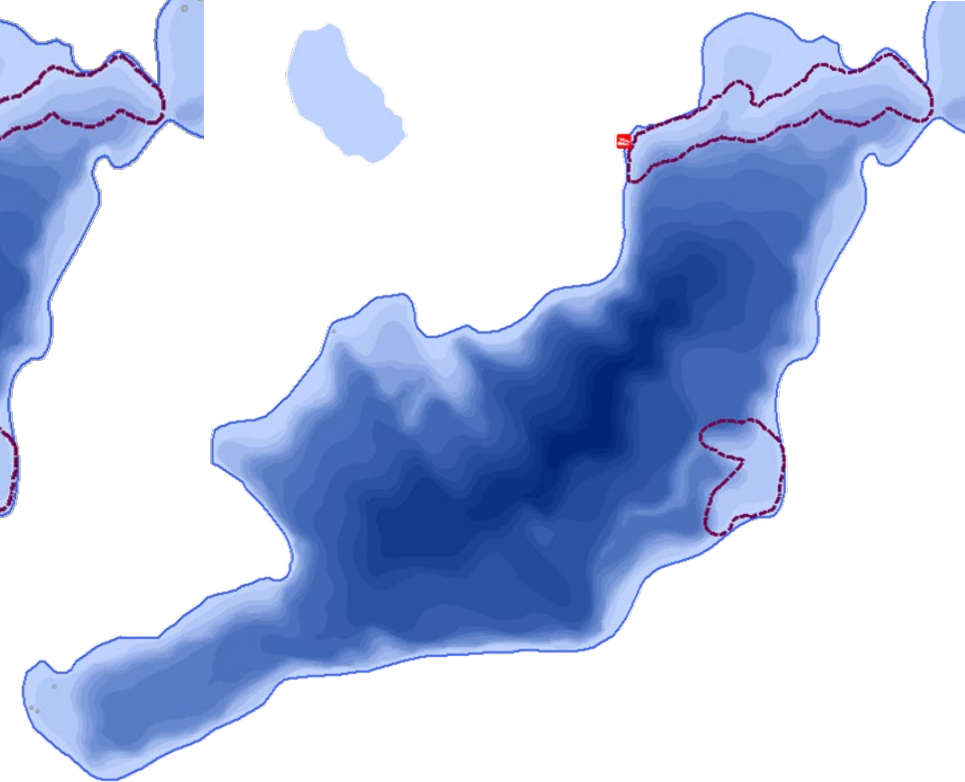
2019 (Year prior to treatment)



2020 (Year of treatment)



2021 (Year after treatment)



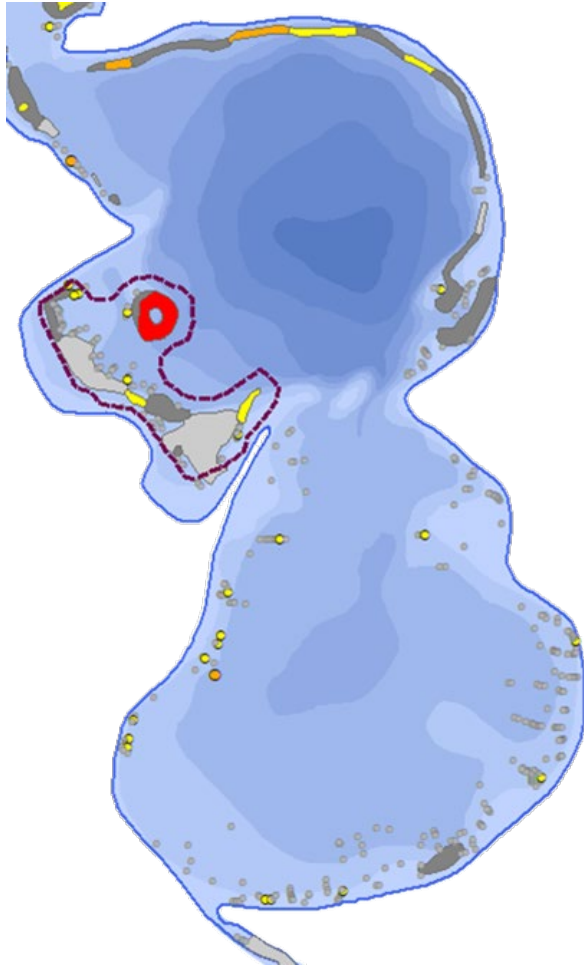
Application Area Total: 16.2 acres

Application Rate: 4.0 PDU

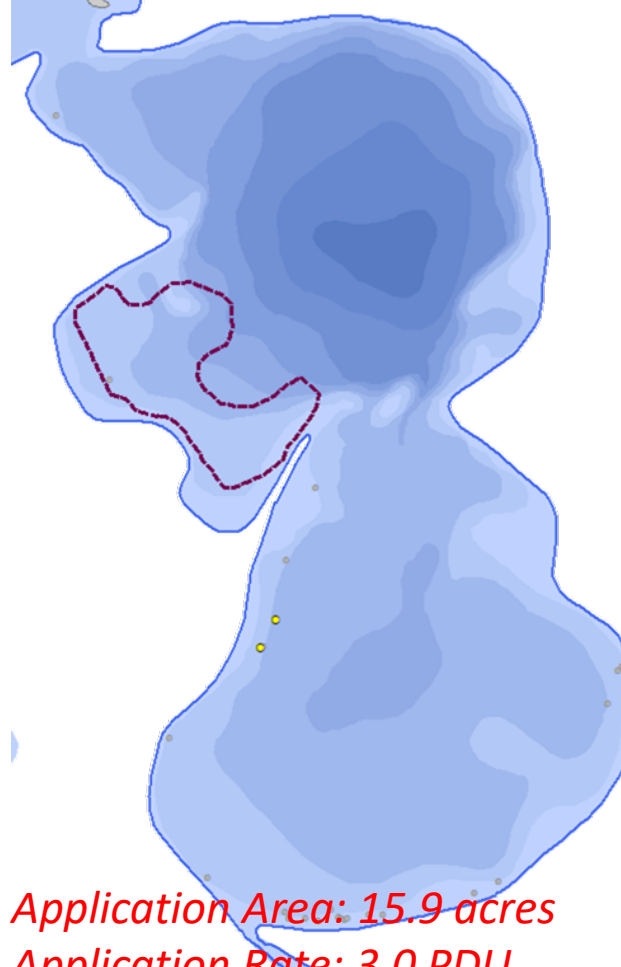
Basin-wide (210 acres) Calculation: 0.43 ppb

Little Saint Germain Lake (Vilas Co.)– South Bay

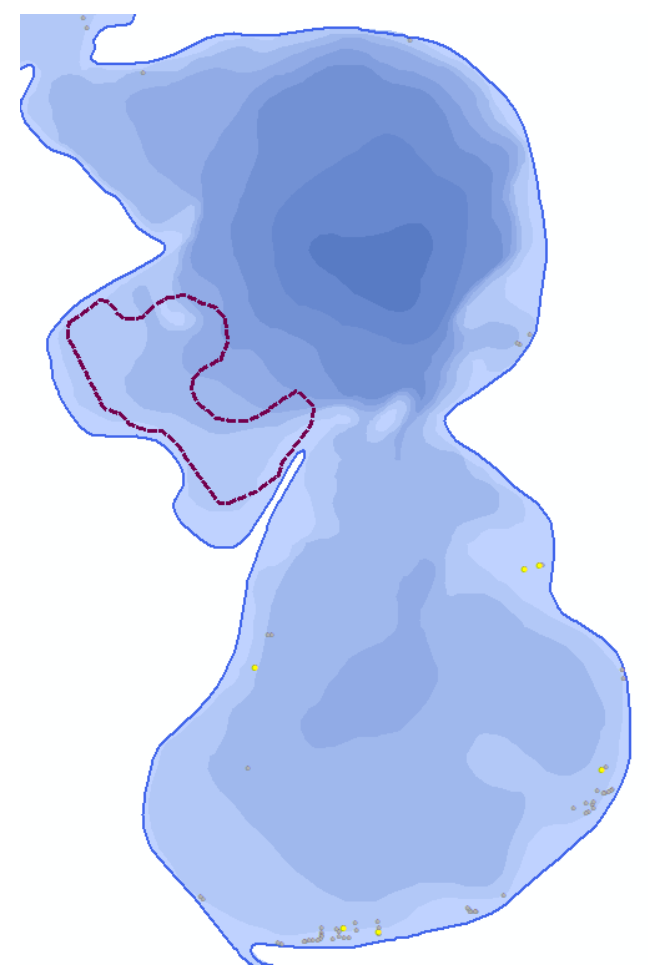
2019 (Year prior to treatment)



2020 (Year of treatment)



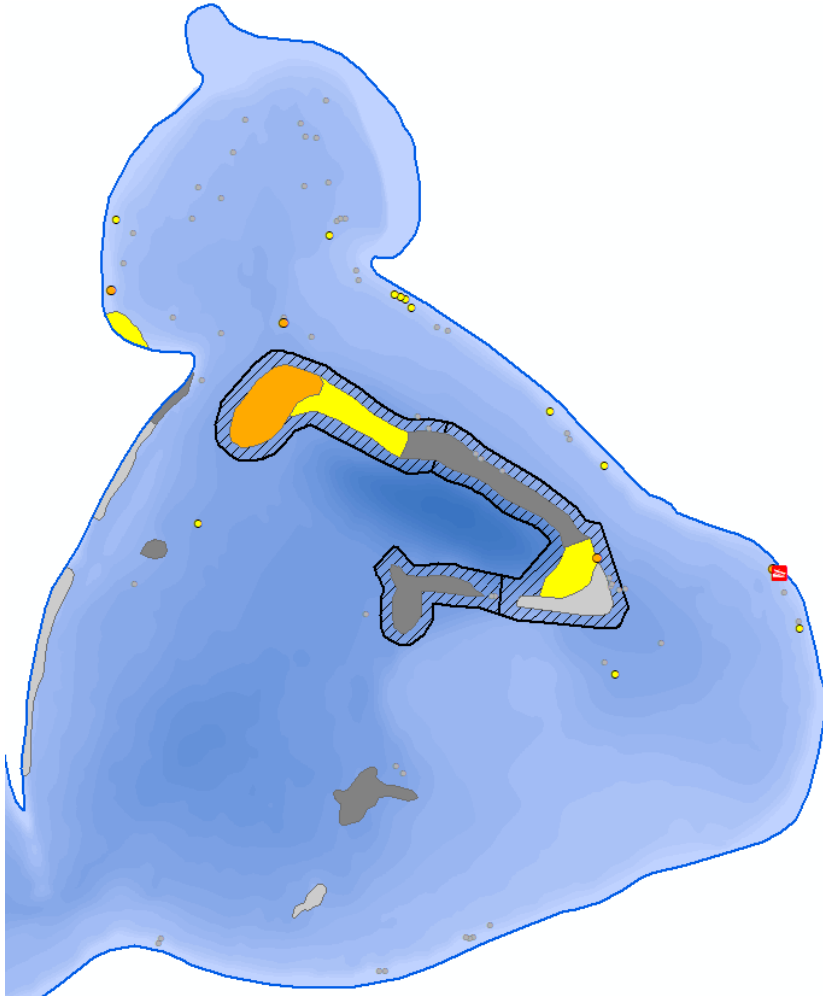
2021 (Year after treatment)



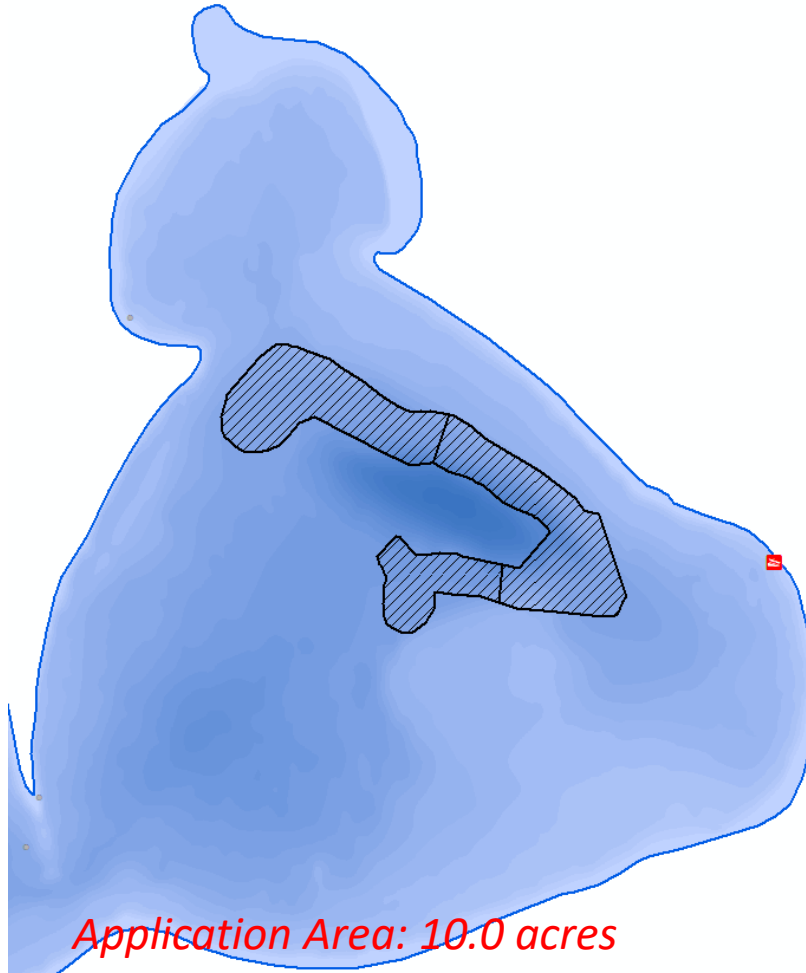
*Application Area: 15.9 acres
Application Rate: 3.0 PDU
Basin-wide (245 acres) Calculation: 0.30 ppb*

HWM *Berry Lake (Oconto Co.) – Eastern Basin*

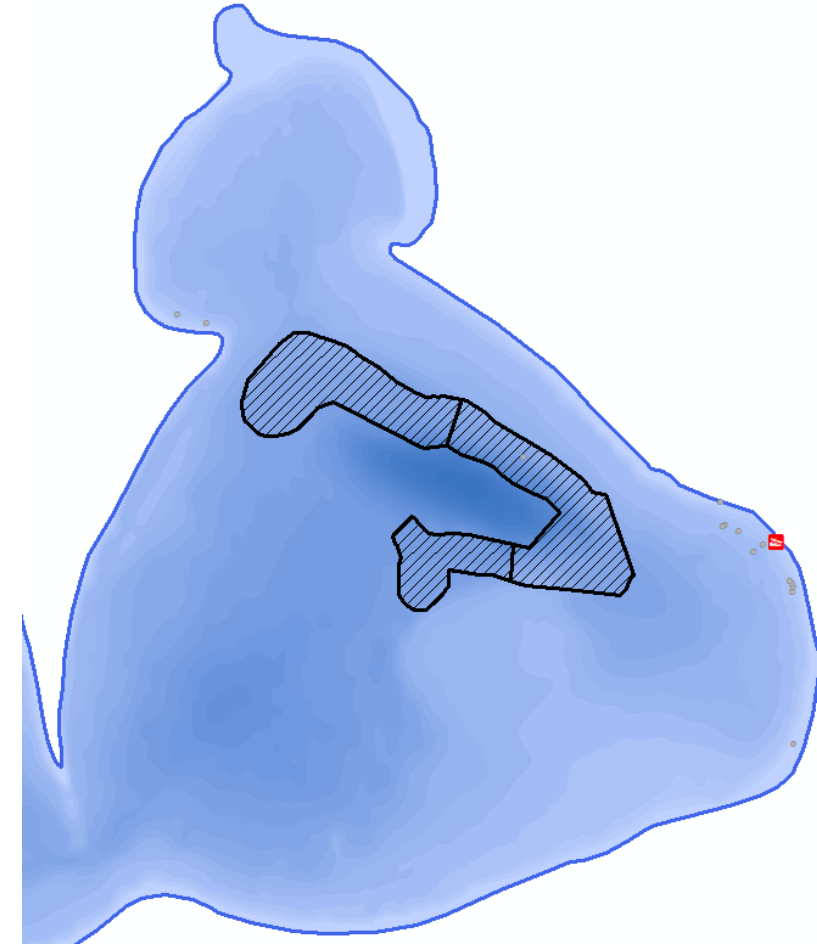
2019 (Year prior to treatment)



2020 (Year of treatment)



2021 (Year after treatment)

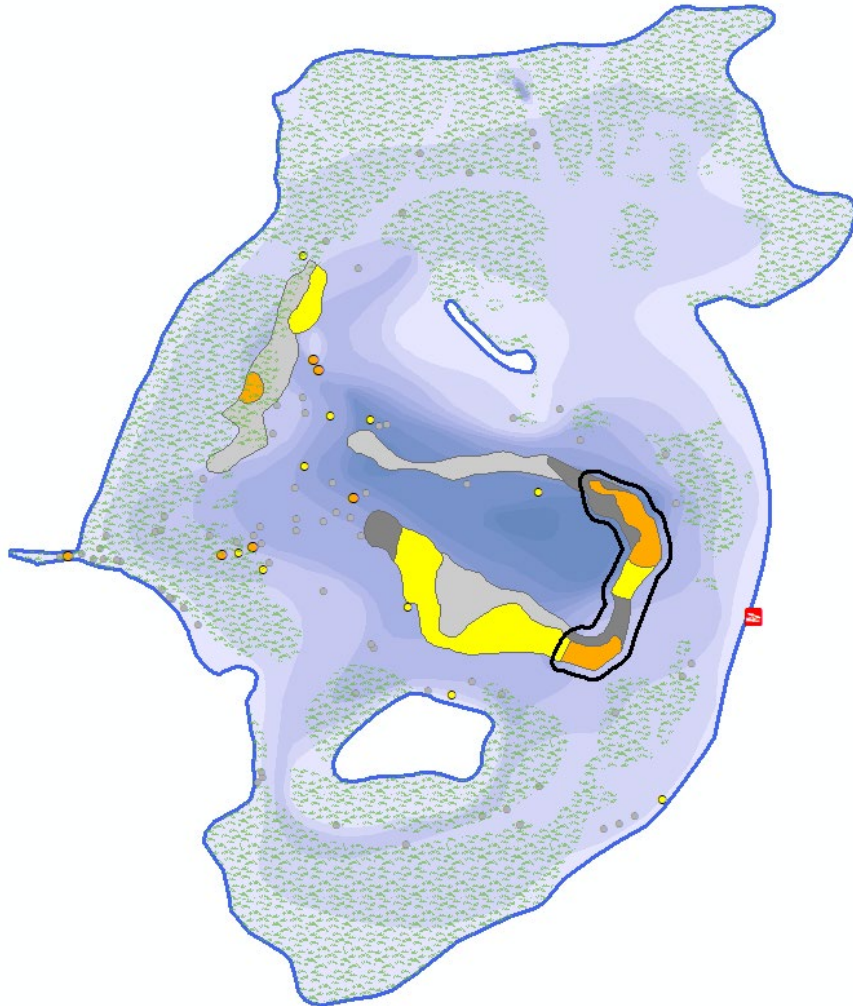


Application Area: 10.0 acres
Application Rate: 4.0 PDU
Basin-wide (131 acres) Calculation: 0.67 ppb

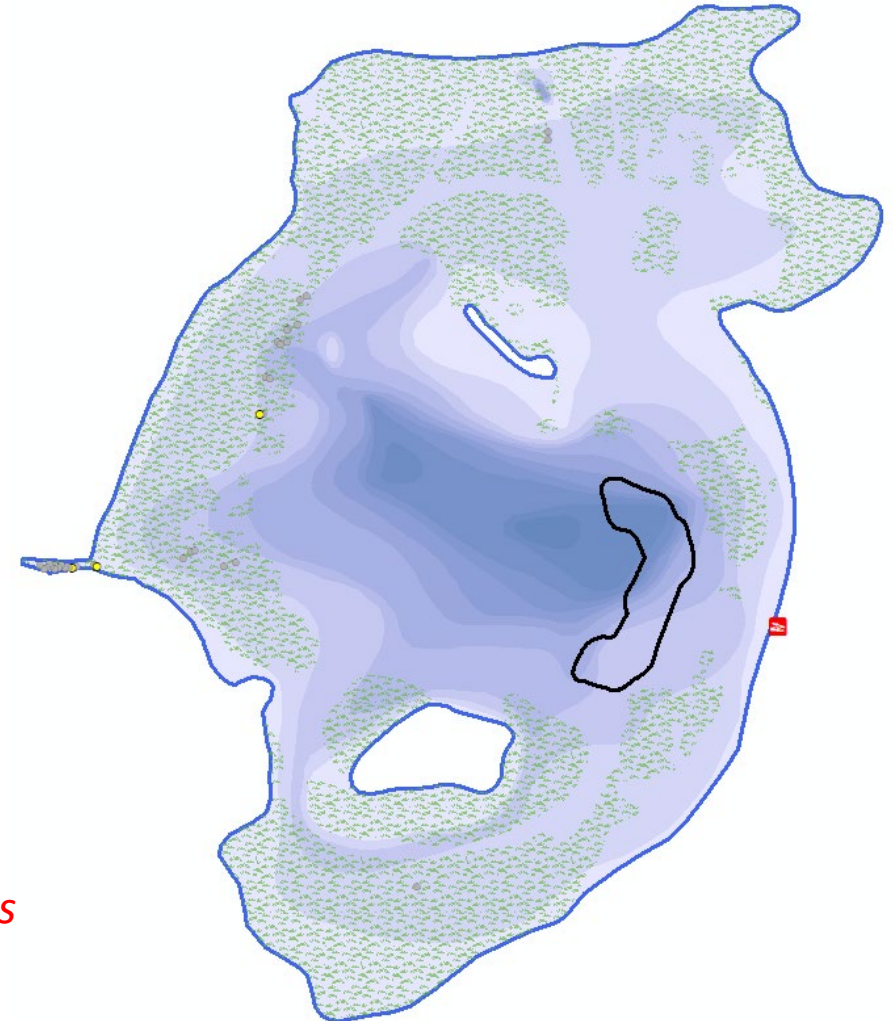
EWM?

Hatch Lake (Waupaca Co.)

2020 (Year prior to treatment)



2021 (Year of treatment)



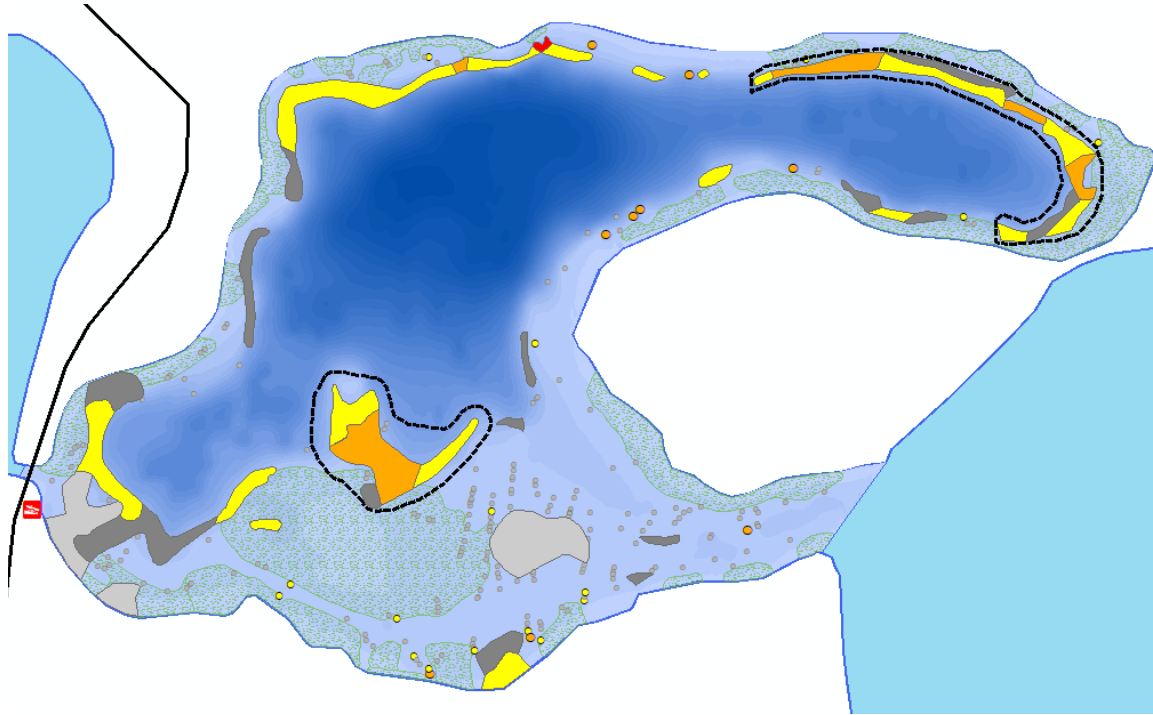
Application Area: 3.0 acres

Application Rate: 4.0 PDU

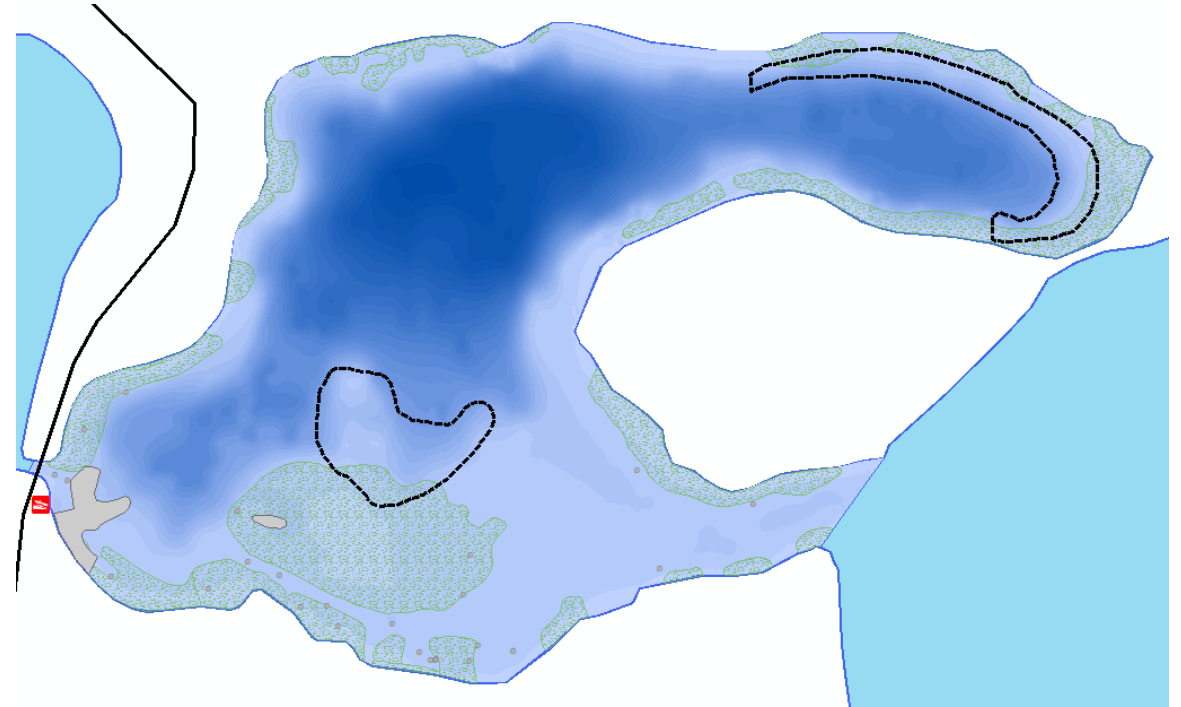
Lake-wide (121 acres) Calculation: 0.32 ppb

HWM *Grass Lake – Cloverleaf Chain (Shawano Co.)*

2020 (Year prior to treatment)



2021 (Year of treatment)



Application Area Total: 6.8 acres

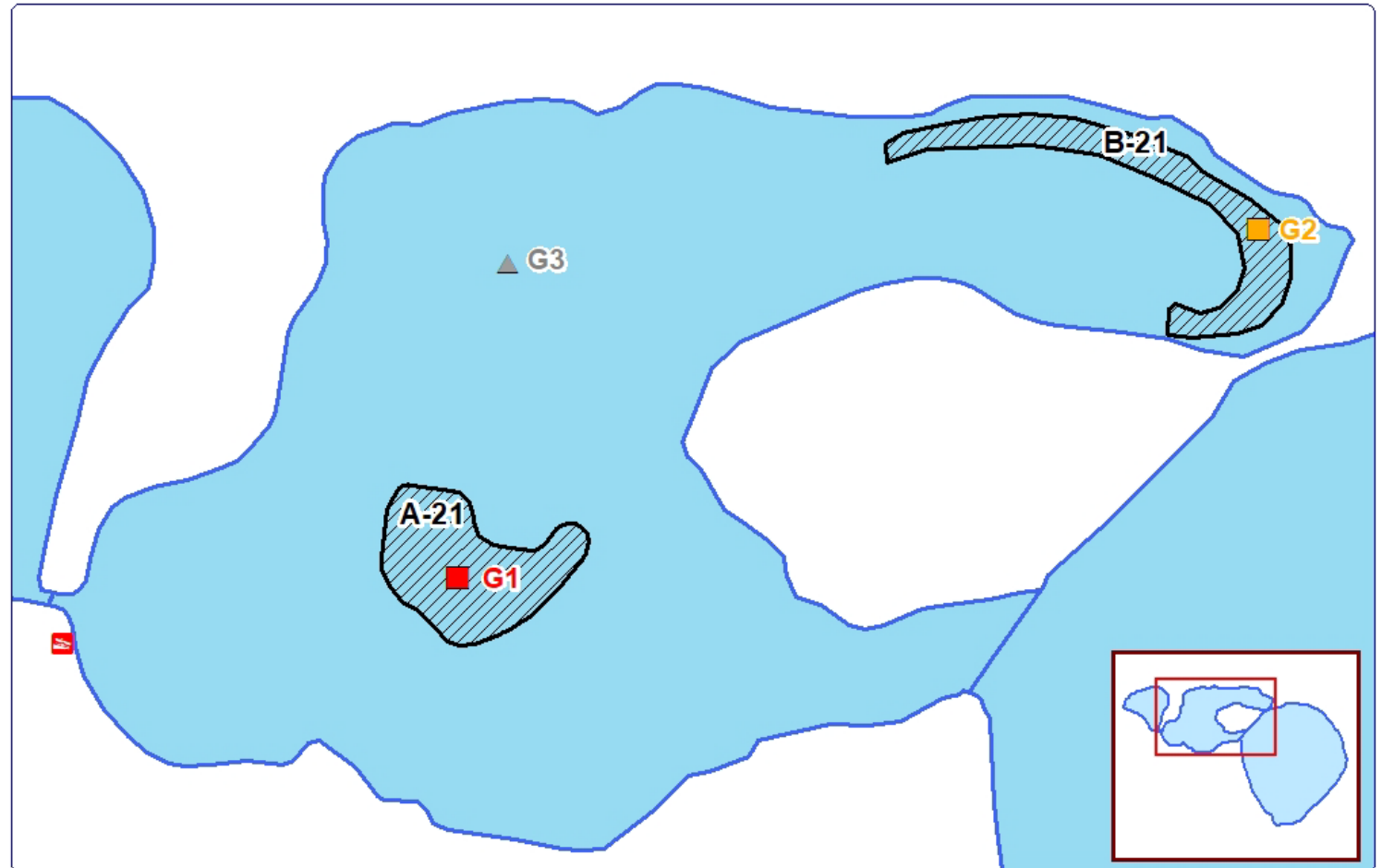
Application Rate: 3.5-4.0 PDU

Lake-wide (92 acres) Calculation: 0.26 ppb

Grass Lake 2021– Concentration Monitoring

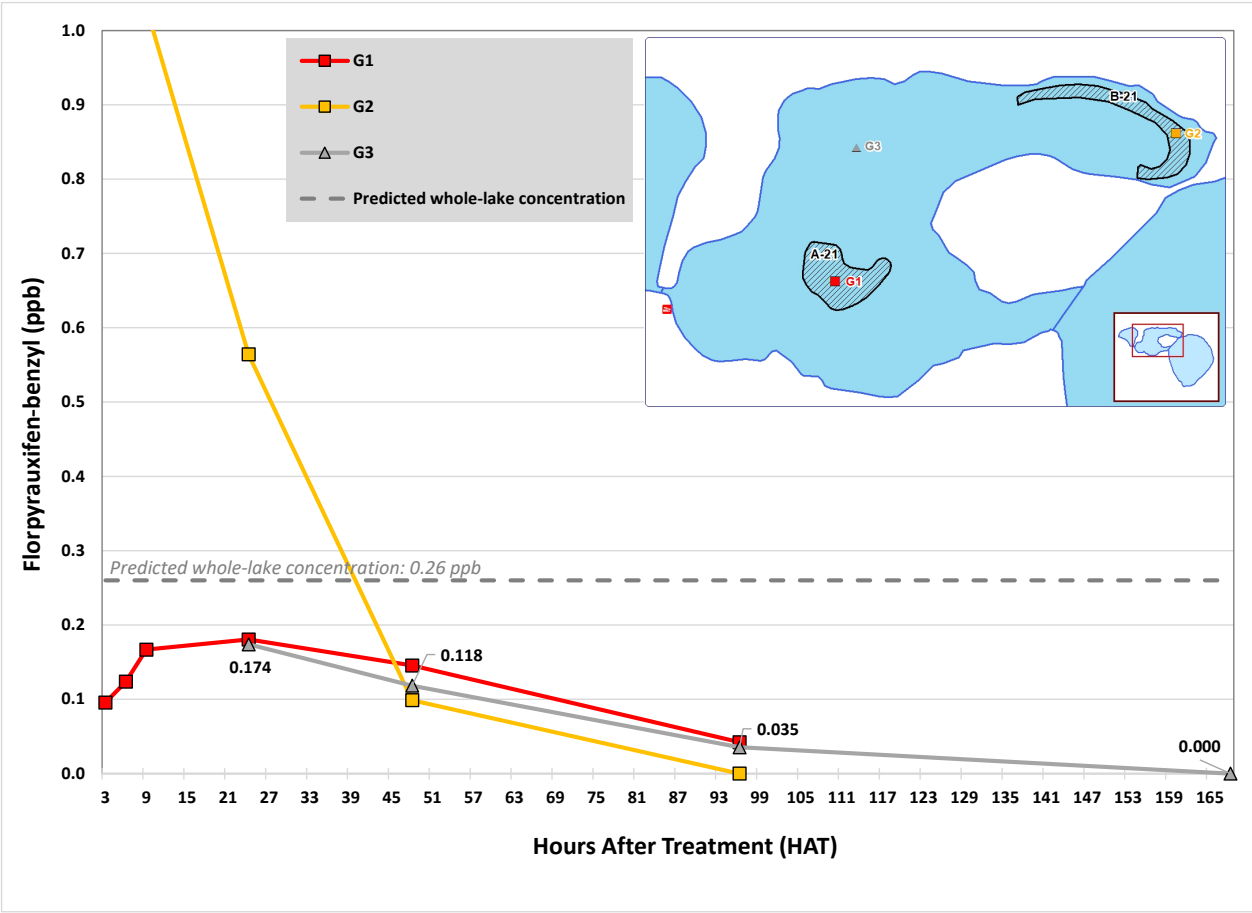
Sampling Interval Matrix (X indicates sample to be collected)			
Interval	Application Areas		Deep Hole
	G1	G2	G3
Pre-Treatment			X
3 HAT	X	X	
6 HAT	X	X	
9 HAT	X	X	X
24 HAT	X	X	X
48 HAT	X	X	X
96 HAT	X	X	X
7 DAT			X

HAT = Hours After Treatment, DAT = Days After Treatment

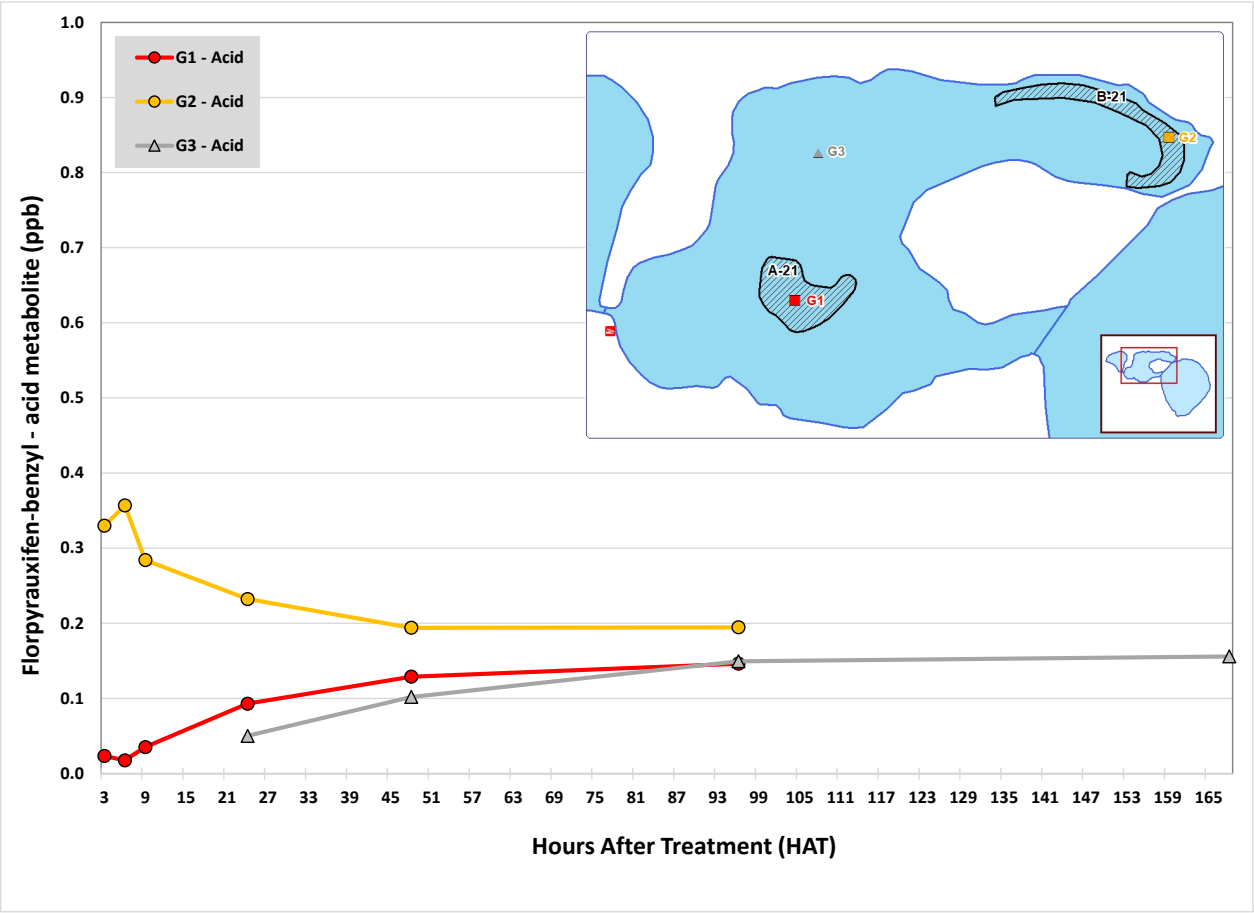


Grass Lake 2021- Concentration Monitoring

Florpyrauxifen-benzyl

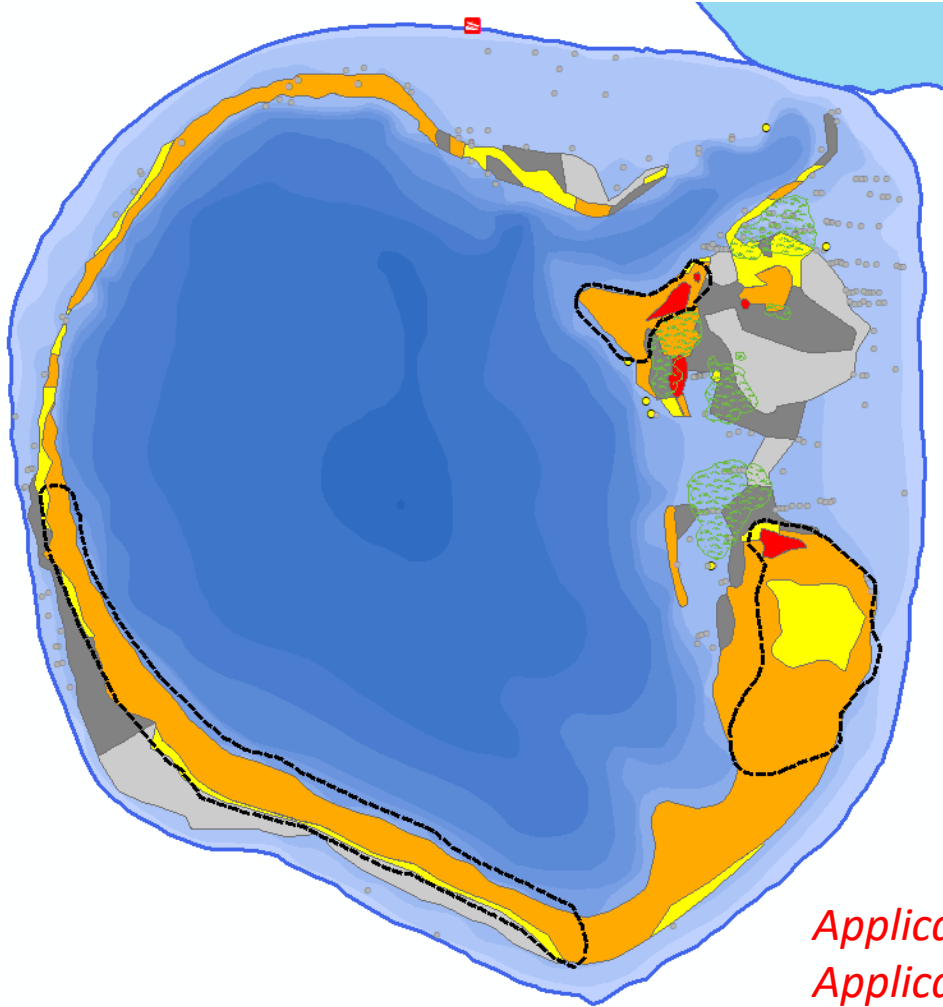


Acid metabolite

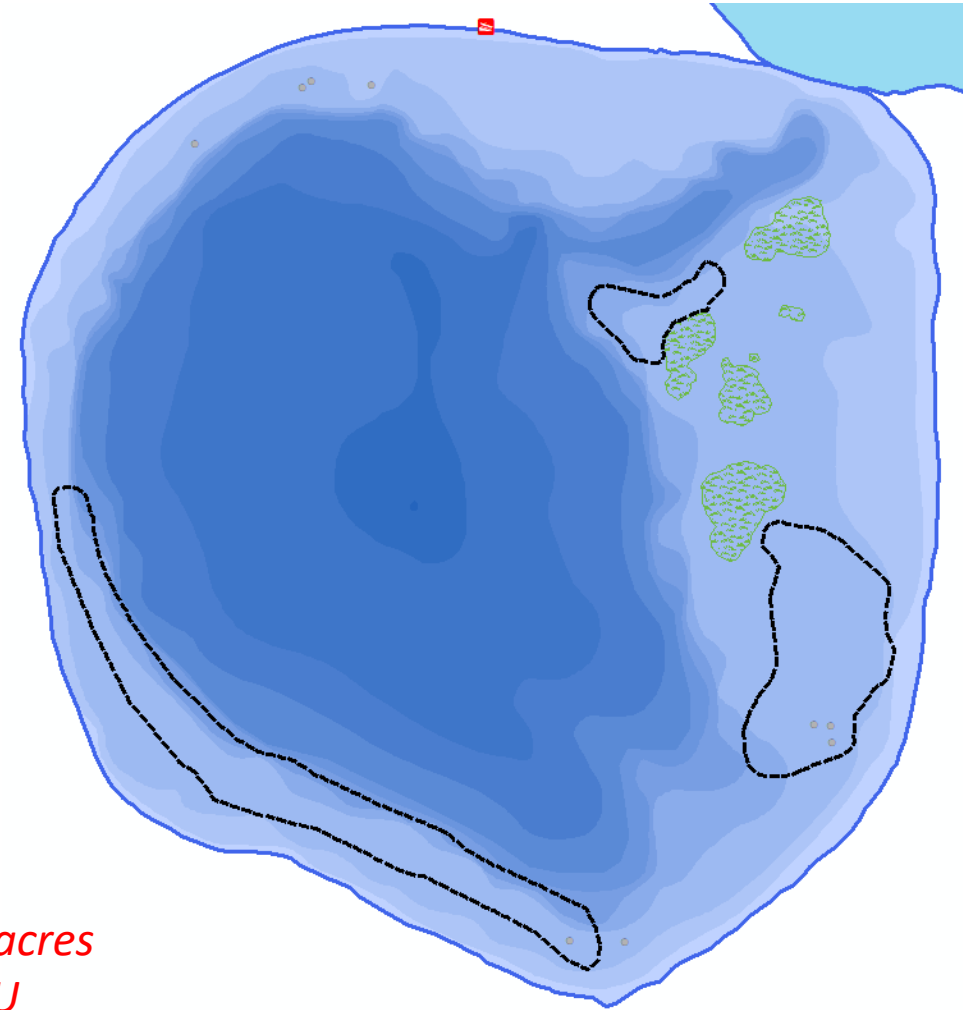


South Twin Lake (Vilas Co.)

2020 (Year prior to treatment)



2021 (Year of treatment)



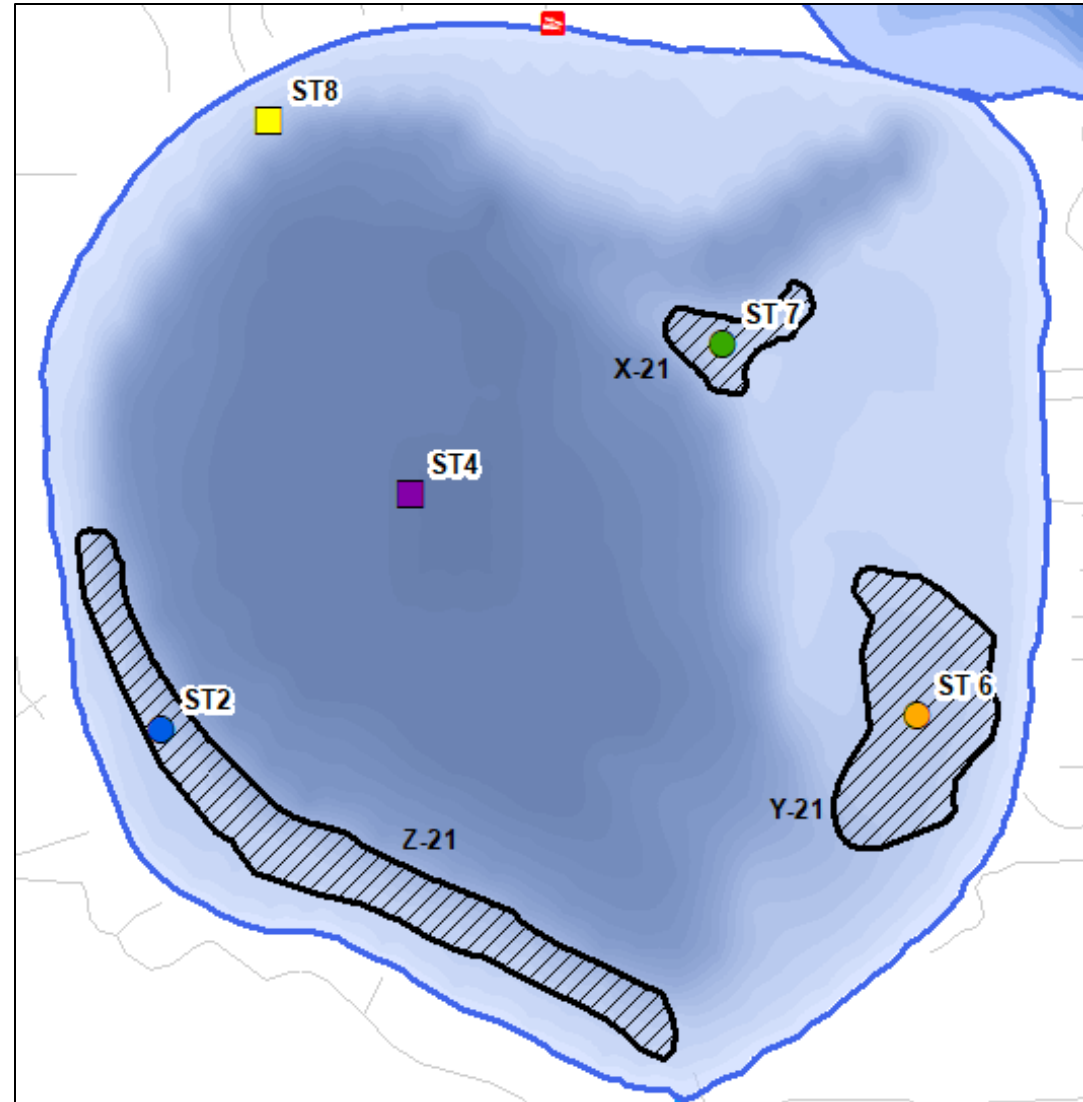
Application Area Total: 58.0 acres

Application Rate: 4.0-4.5 PDU

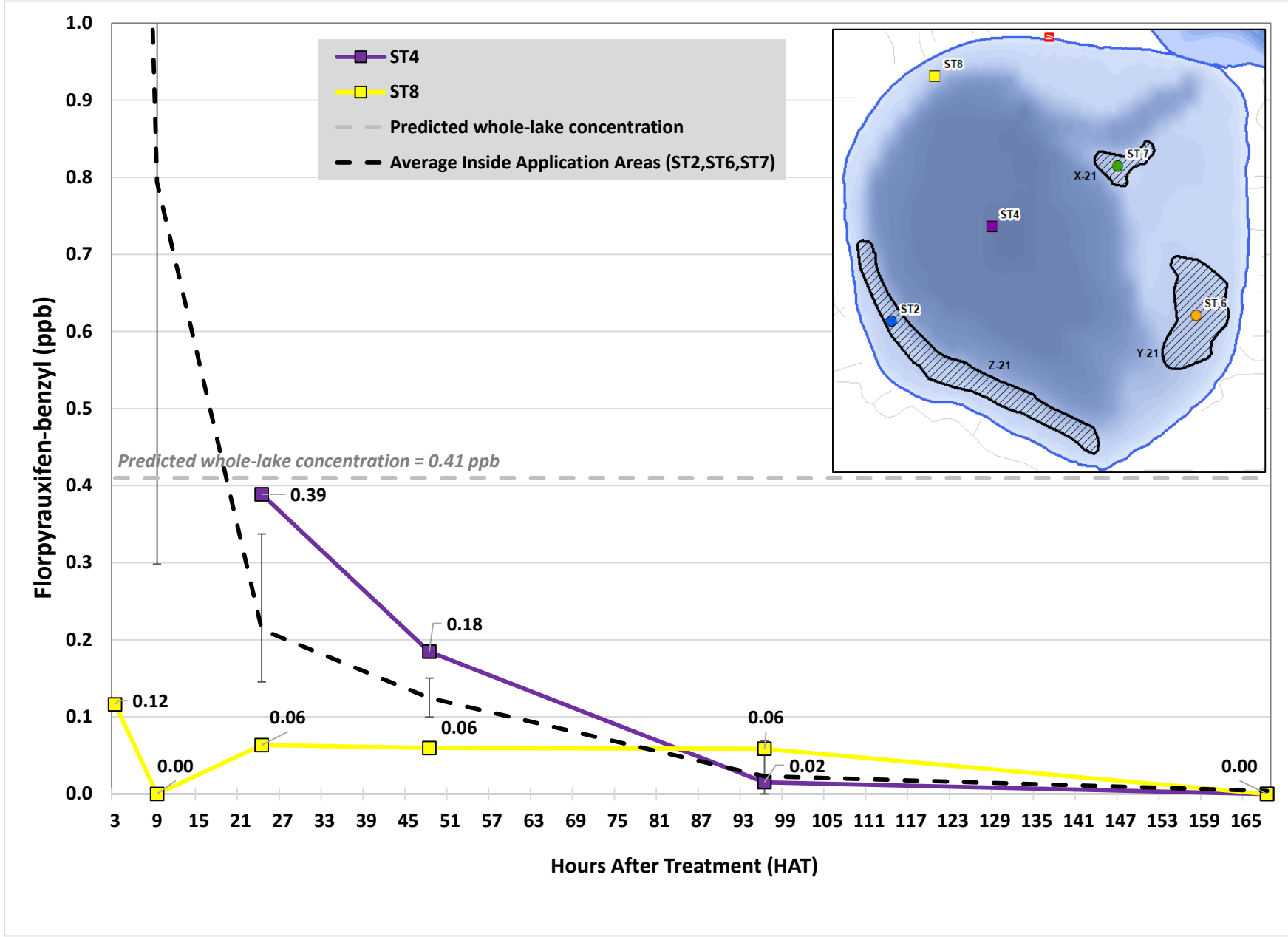
Lake-wide (633 acres) Calculation: 0.41 ppb

EWM *South Twin Lake 2021– Concentration Monitoring*

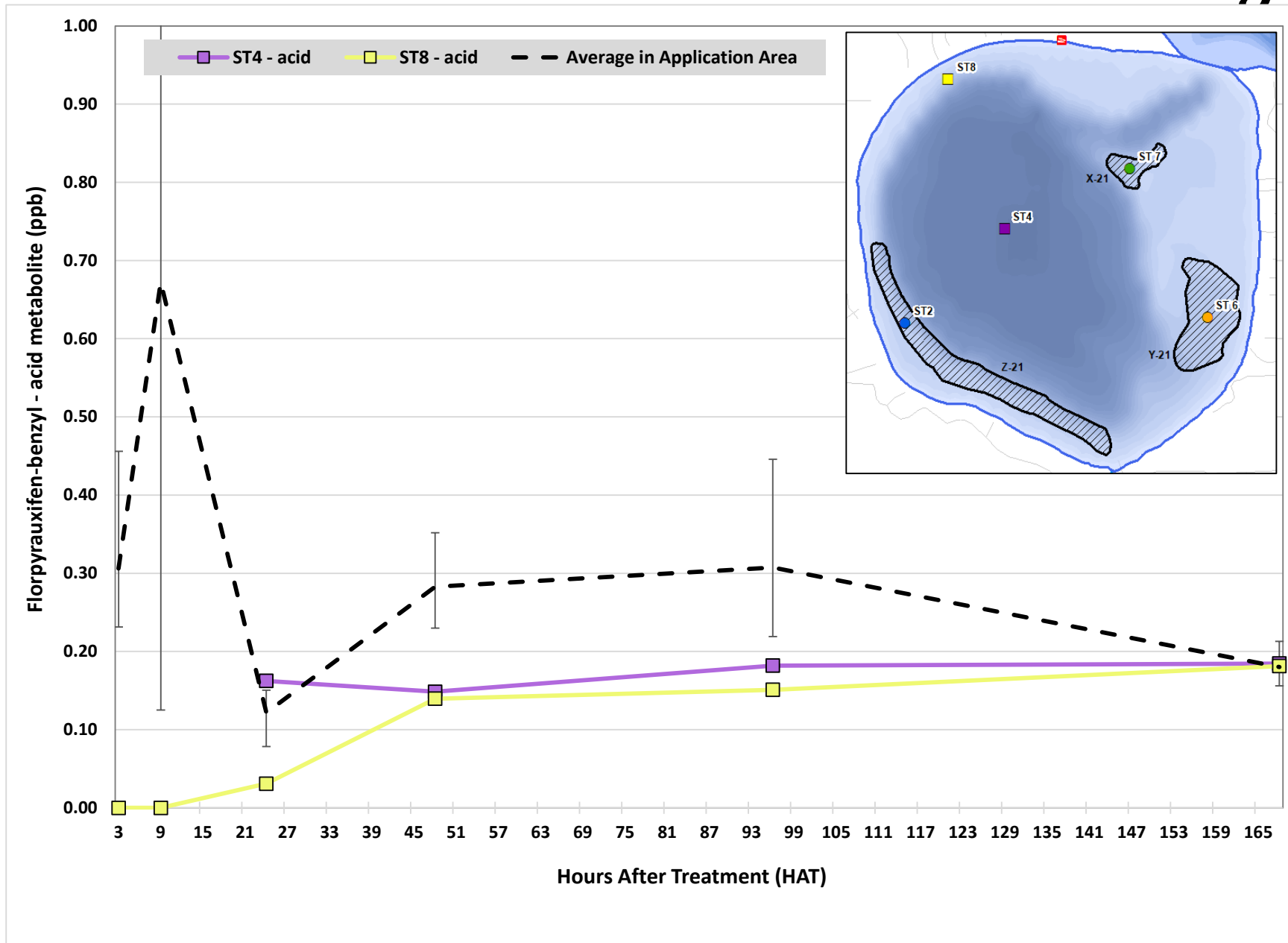
Sampling Interval Matrix (X indicates sample to be collected) (X) indicates sample collection contingent on funding					
Interval	Application Areas			Untreated NW end	Deep Hole
	ST 7	ST 6	ST 2	ST 8	ST 4
Pre-Treatment					X
3 HAT	X	X	X	X	
9 HAT	X	X	X	X	
24 HAT	X	X	X	X	X
48 HAT	(X)	(X)	(X)	(X)	X
96 HAT	(X)	(X)	(X)	(X)	X
7 DAT	(X)	(X)	(X)	(X)	X
HAT = Hours After Treatment, DAT = Days After Treatment					



South Twin Lake 2021- Concentration Monitoring



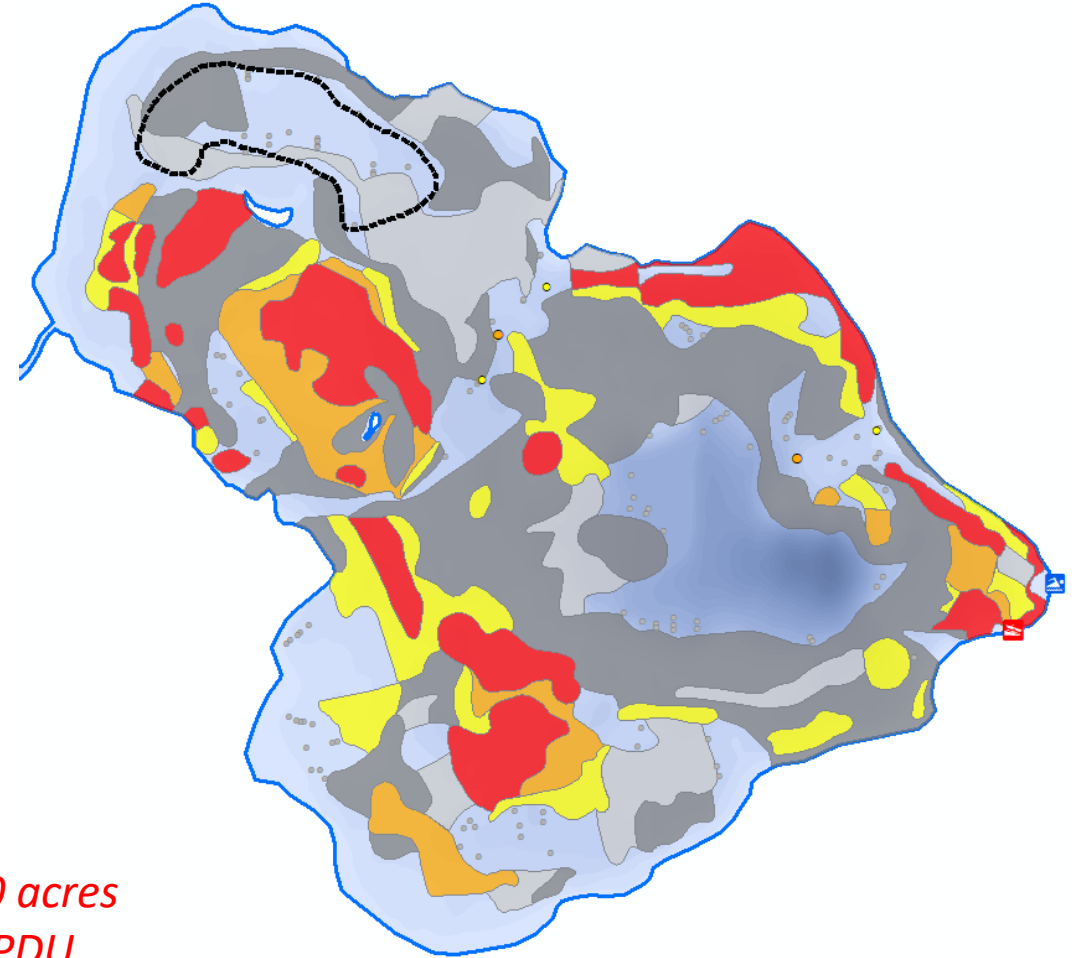
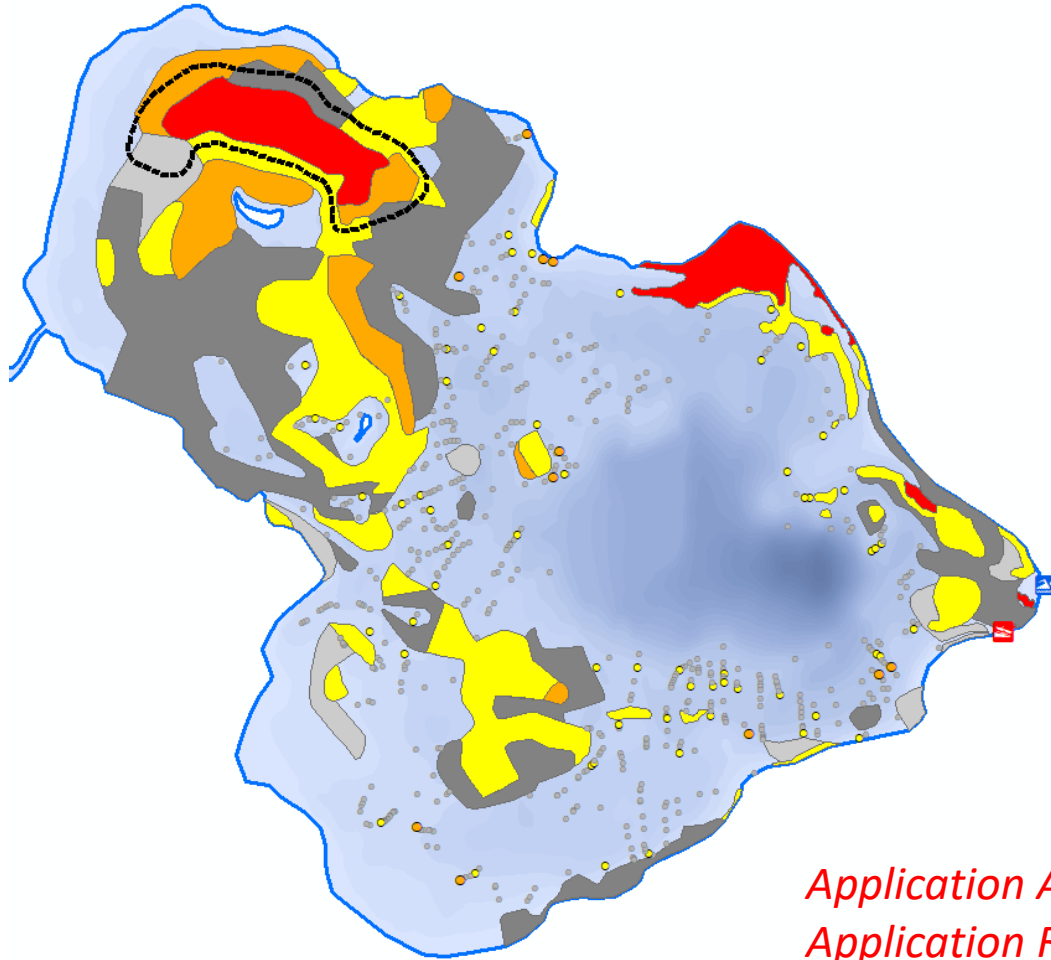
EWM *South Twin Lake 2021- Concentration Monitoring - acid*



Kettle Moraine Lake (Fond du Lac Co.)

2020 (Year prior to treatment)

2021 (Year of treatment)



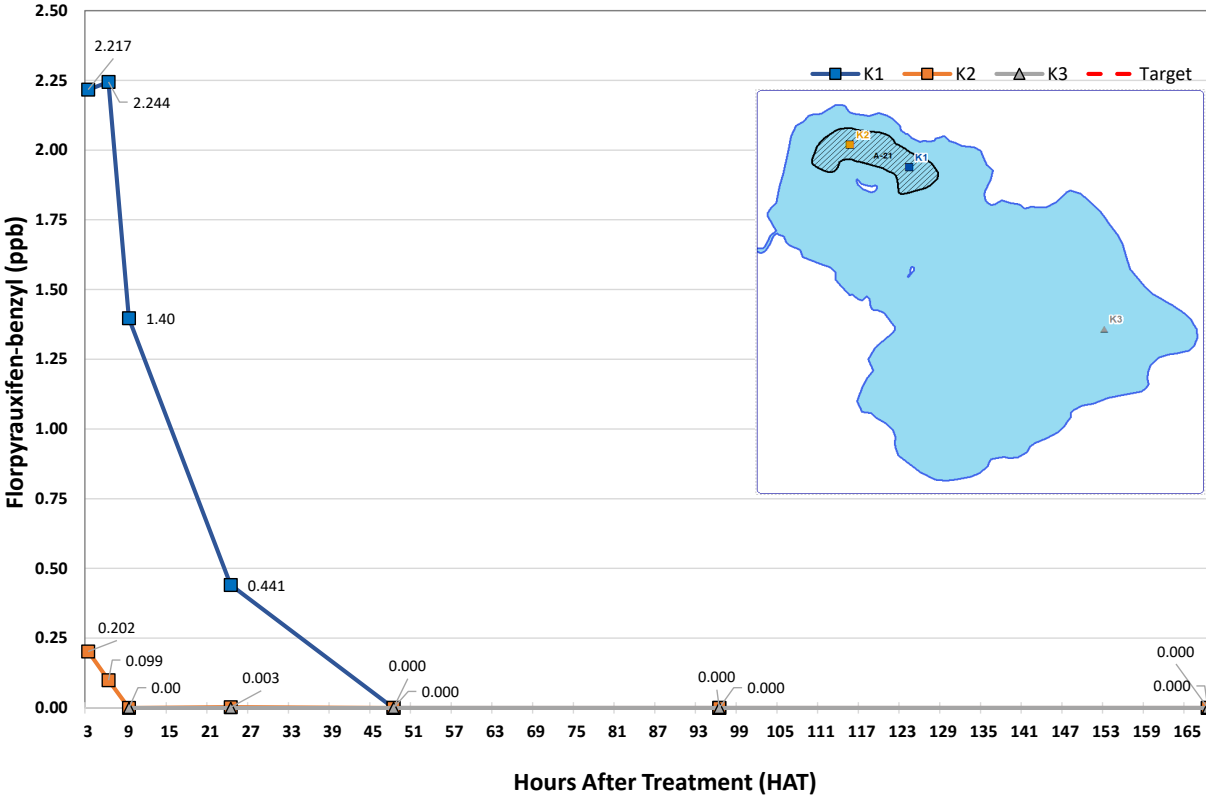
Application Area: 10.0 acres

Application Rate: 4.0 PDU

Lake-wide (209 acres) Calculation: 0.20 ppb

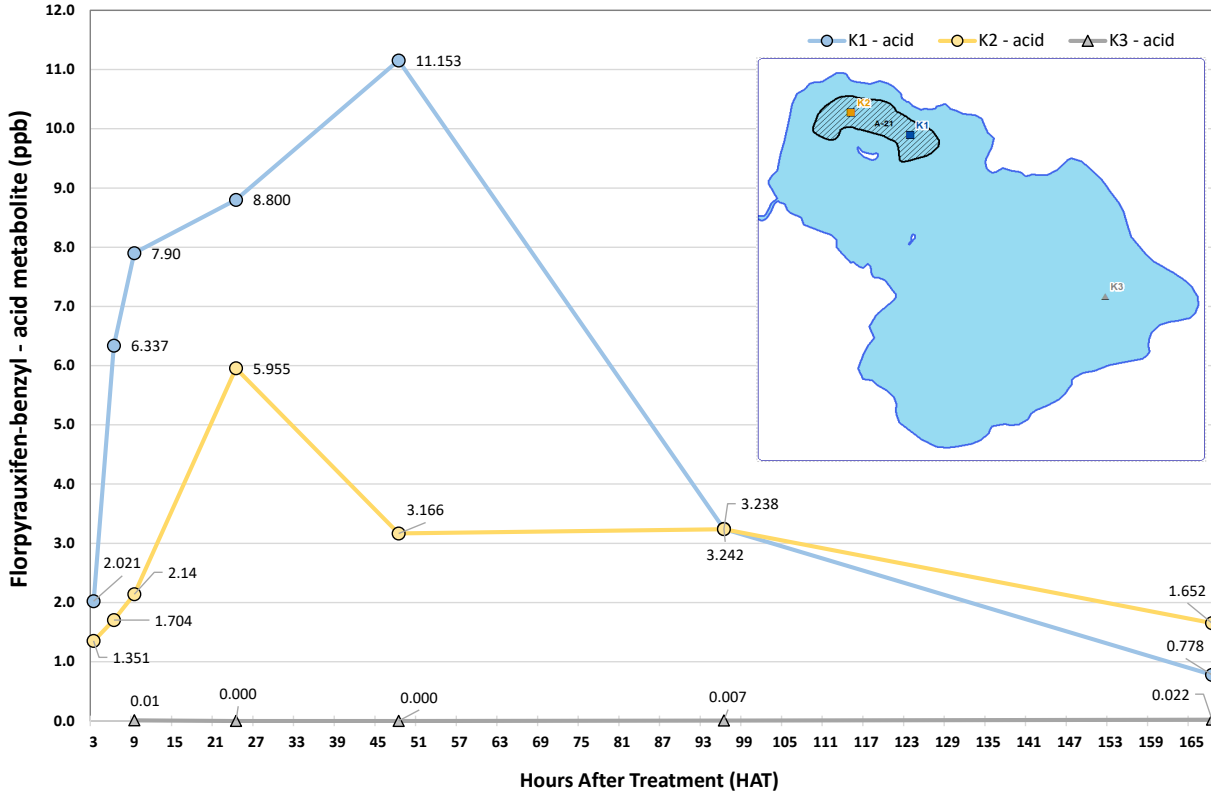
Florpyrauxifen-benzyl

Kettle Moraine Lake, Fond du Lac County



Acid metabolite

Kettle Moraine Lake, Fond du Lac County



Quantitative Aquatic Plant Monitoring -2020

-continued monitoring in 2021 (year-after-treatment)

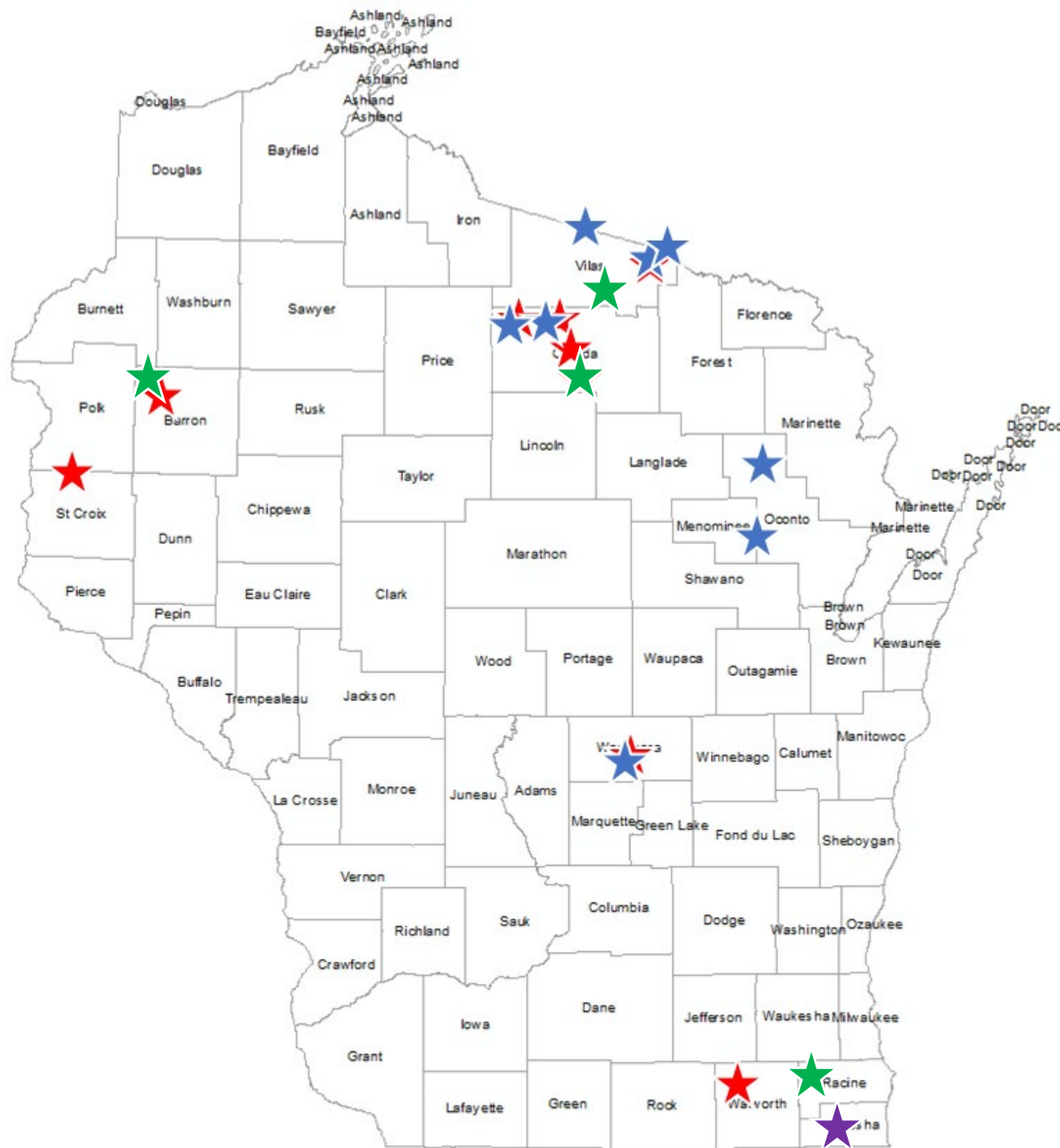
Separate Treatment sites

Due to differences between lakes, treatment timing, and other factors, looking at each treatment site on its own is the most straight-forward way to investigate changes in aquatic plant frequencies (Table 2).

		Summer '19 to Summer '20										Mid June '20 to Late-Summer '20			
		Berry Eastern Basin	North Twin C-20	LSG A-20	LSG C-20	LSG D-20	LongV B-20	Big Silver A-20	Minoc B-20	Minoc C-20	Minoc D-20	Crooked A-20	Minoc G-20	Kawa E-20	Kawa F-20
Myriophyllum spicatum	Eurasian watermilfoil	↓↓↓	↓	↓↓↓	↓	↓↓↓	↓	↓	↓↓↓	↓↓↓	↓↓↓	↓↓↓	↓	↓	↓↓↓
Bidens beckii	Water marigold	-	ns	↓	ns	-	ns	ns	↓	-	↓	-	ns	ns	-
Brasenia schreberi	Watershield	ns	-	-	-	-	-	-	-	-	-	-	-	ns	-
Ceratophyllum demersum	Coontail	ns	ns	↓↓↓	↓	↓↓↓	ns	ns	↓↓↓	↓↓↓	↓↓↓	ns	ns	↓	ns
Charaphytes	Muskgrasses & Stoneworts	ns	ns	↓↓↓	↓	ns	ns	ns	ns	-	ns	ns	ns	ns	ns
Eleocharis acicularis	Needle spikerush	ns	-	ns	ns	-	ns	-	ns	ns	ns	ns	ns	ns	ns
Elodea canadensis	Common waterweed	-	ns	ns	ns	ns	ns	↑	↓	↓	↓↓↓	↓	ns	ns	ns
Heteranthera dubia	Water stargrass	-	ns	ns	ns	ns	ns	↓↓↓	↓	ns	-	-	ns	ns	ns
Isoetes spp.	Quillwort spp.	ns	-	ns	ns	ns	ns	-	-	-	-	-	ns	ns	ns
Lemna trisulca	Forked duckweed	-	-	-	-	↑	-	-	ns	ns	↑↑	ns	ns	ns	ns
Myriophyllum sibiricum	Northern watermilfoil	-	-	↓↓↓	ns	ns	ns	-	↓↓↓	↓↓↓	↓↓↓	-	ns	↓	↓↓↓
Myriophyllum tenellum	Dwarf watermilfoil	ns	-	-	ns	-	-	-	↓	↓	↓	-	-	-	-
Najas flexilis	Slender naiad	ns	ns	-	ns	ns	ns	ns	ns	-	-	ns	-	ns	ns
Najas guadalupensis	Southern naiad	↑↑	-	ns	ns	ns	ns	ns	ns	↓	ns	↑↑↑	ns	↑↑↑	↑
Nuphar variegata	Spatterdock	-	-	ns	-	ns	-	-	-	-	-	ns	-	-	-
Nymphaea odorata	White water lily	ns	-	-	-	ns	-	ns	-	-	-	↓	ns	-	-
Potamogeton amplifolius	Large-leaf pondweed	ns	-	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	↑
Potamogeton friesii	Fries' pondweed	-	ns	-	-	-	-	ns	ns	-	-	-	-	-	ns
Potamogeton gramineus	Variable-leaf pondweed	ns	ns	ns	ns	ns	↑	ns	ns	ns	ns	ns	ns	ns	ns
Potamogeton illinoensis	Illinois pondweed	↑	-	↓	-	-	-	ns	ns	-	ns	-	-	-	-
Potamogeton natans	Floating-leaf pondweed	ns	-	-	-	-	-	ns	-	-	-	↑	-	-	-
Potamogeton praelongus	White-stem pondweed	ns	ns	↓	-	ns	ns	ns	↑↑	ns	ns	ns	ns	-	ns
P. pusillus & P. berchtoldii	Small pw & Slender pw	ns	↑↑	↓	ns	↓	-	ns	ns	↓↓↓	↓	↑	ns	ns	ns
Potamogeton richardsonii	Clasping-leaf pondweed	ns	ns	ns	↑	ns	↓↓↓	-	ns	ns	ns	-	↑	ns	↑
Potamogeton robbinsii	Fern-leaf pondweed	ns	-	ns	ns	↑↑	ns	-	↓↓↓	ns	ns	ns	↑	↑	↑
Potamogeton strictifolius	Stiff pondweed	ns	-	-	-	↑	-	ns	ns	-	-	↑	-	-	-
Potamogeton zosteriformis	Flat-stem pondweed	ns	ns	ns	-	ns	-	↑↑↑	ns	ns	ns	ns	ns	ns	ns
Ranunculus aquatilis	White water crowfoot	ns	ns	ns	-	-	-	ns	↓	ns	ns	-	ns	ns	↓↓↓
Schoenoplectus subterminalis	Water bulrush	-	-	-	-	-	-	-	-	-	-	ns	-	-	-
Stuckenia pectinata	Sago pondweed	-	-	-	-	-	-	ns	-	-	-	-	-	-	-
Utricularia gibba	Creeping bladderwort	ns	-	-	-	-	-	-	-	-	-	↑↑	-	-	-
Utricularia intermedia	Flat-leaf bladderwort	ns	-	-	-	-	-	-	-	-	-	ns	-	-	-
Utricularia resupinata	Northeastern bladderwort	ns	-	-	-	-	-	-	-	-	-	-	-	-	-
Utricularia vulgaris	Common bladderwort	ns	-	-	-	ns	-	-	-	-	ns	ns	-	ns	-
Vallisneria americana	Wild celery	ns	ns	ns	ns	↓	ns	ns	ns	ns	ns	ns	↑↑	↑↑↑	↑

*Table displays species that exhibited a frequency of occurrence of at least above 2% in any one survey.
 *Table splits to separate survey timing schemes
 *Arrow Represents statistically valid direction of change, ↑ = p<0.05, ↑↑ = p<0.01, ↑↑↑ = p<0.001

*Preliminary Results
Michelle Nault, WDNR*

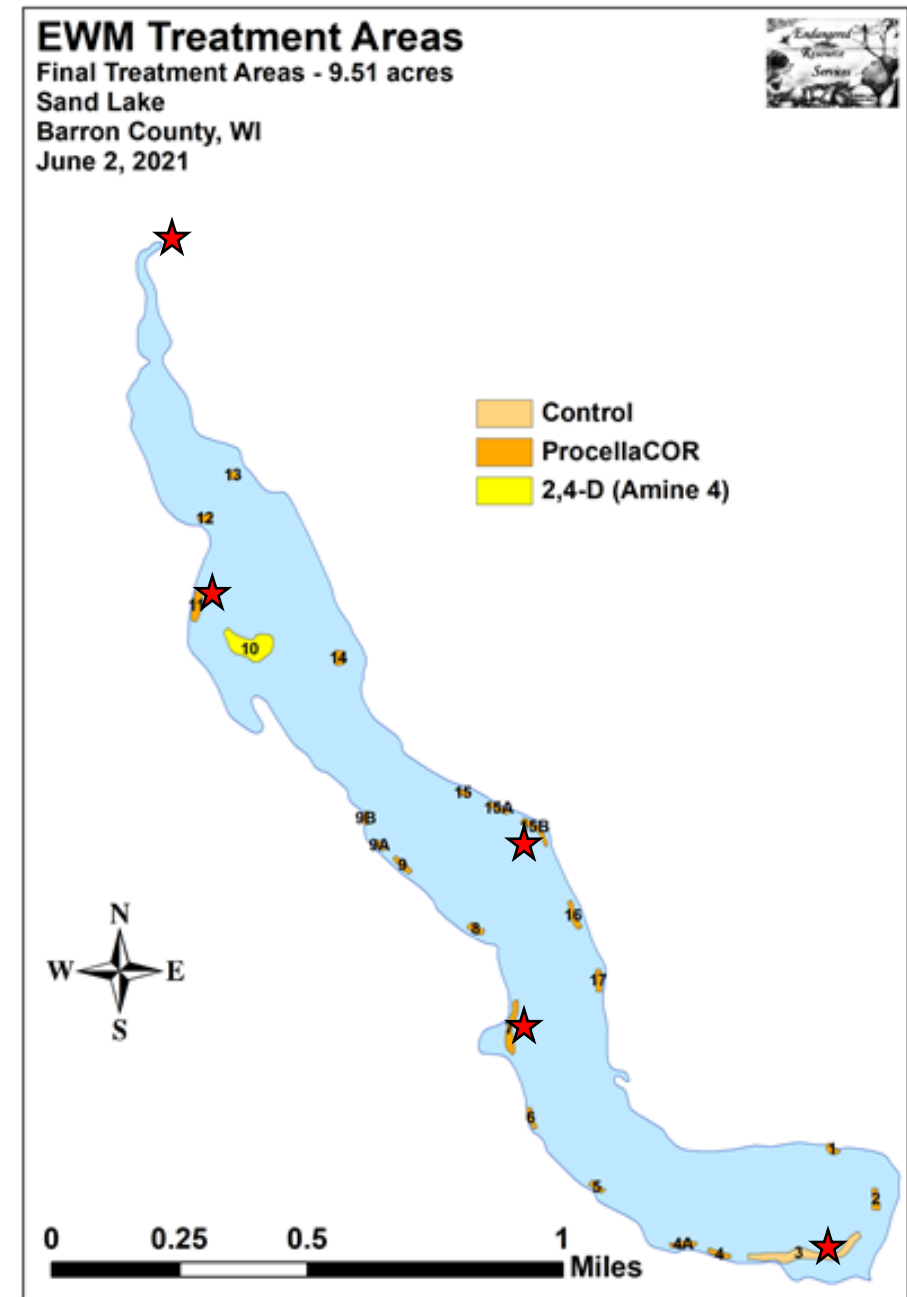


Case Studies (2021)

Lake	County	Lake Acreage	Date Treated	Treatment Area (acres)	Total acreage	% Surface Area Treated	Application Rate (PDU/ac-ft)	Application Rate (ppb)	Milfoil Genetics
Sand	Barron	318	6/2/2021	20 'spots': 0.15-0.85 ac	6.4	2%	5.0-8.0	9.6-15.4	EWM
Muskellunge	Vilas	270	6/23/2021	11.6, 7.1 & 1.1	19.8	7%	3.0-4.0	5.8-7.7	EWM
Buena	Racine	53.7	6/8/2021	53.6	53.6	100%	3.5	6.7	UNK
Crescent	Oneida	616	6/15/2021	16.0 & 5.0	21	3%	4.0-4.5	7.7-8.7	EWM

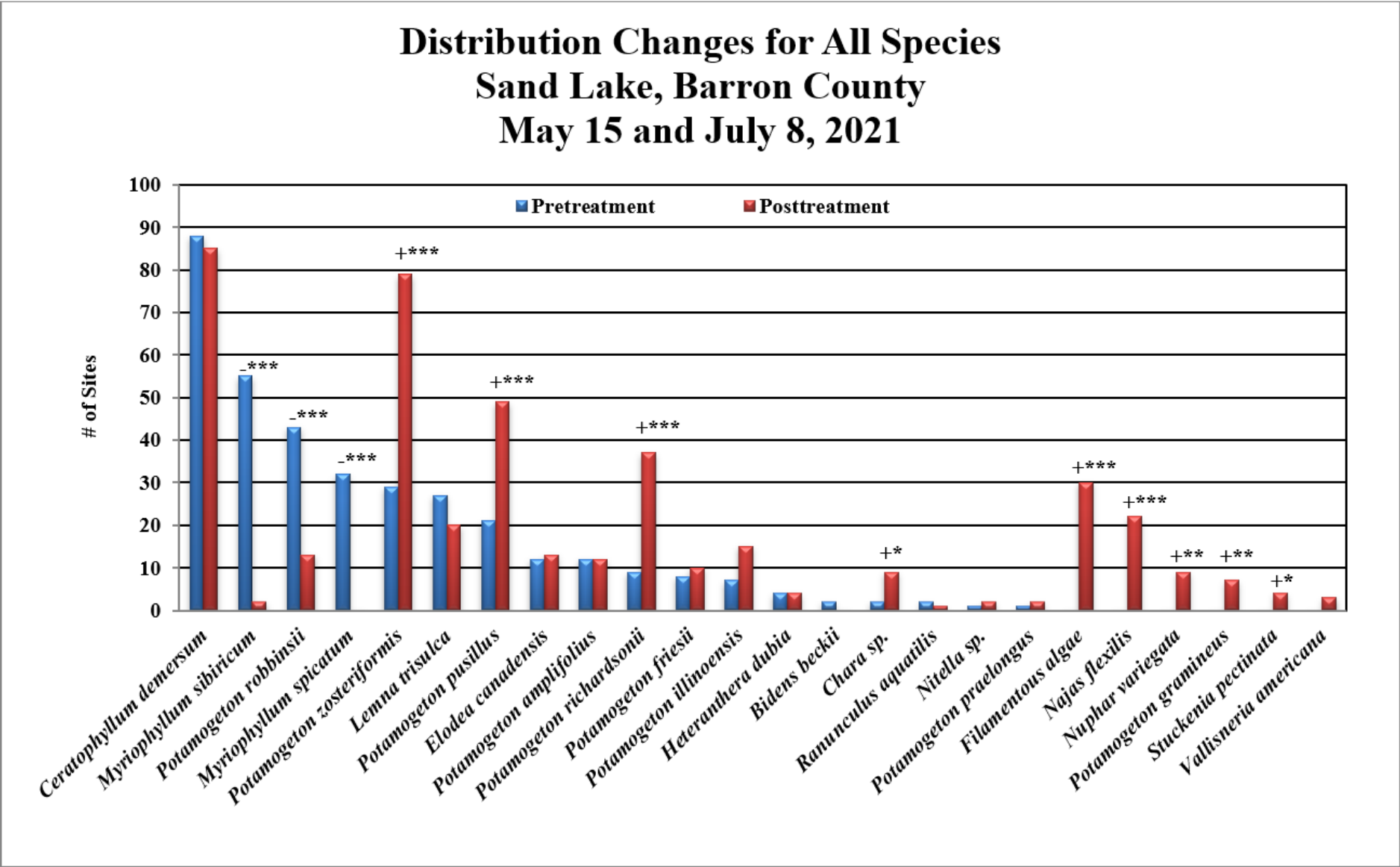
Sand Lake, Barron Co.

- 318 acres; max depth = 57 feet; mesotrophic
- Treatment date: June 2, 2021
- Acreage: 20 'spots' ranging from 0.15 – 0.85 ac
- Total: 6.4 ac (ProcellaCOR) + 3.12 ac (2,4-D @ 4 ppm)
- Applied Rate: 5.0-8.0 PDU/ac-ft
- Herbicide monitoring at 3 largest sites, in addition to untreated reference sites (Bed 3 & outlet)
- Pre (mid-May) & Post (July) Sub-PI (n=160 combined)
- Lakewide PI in 2015 & 2021



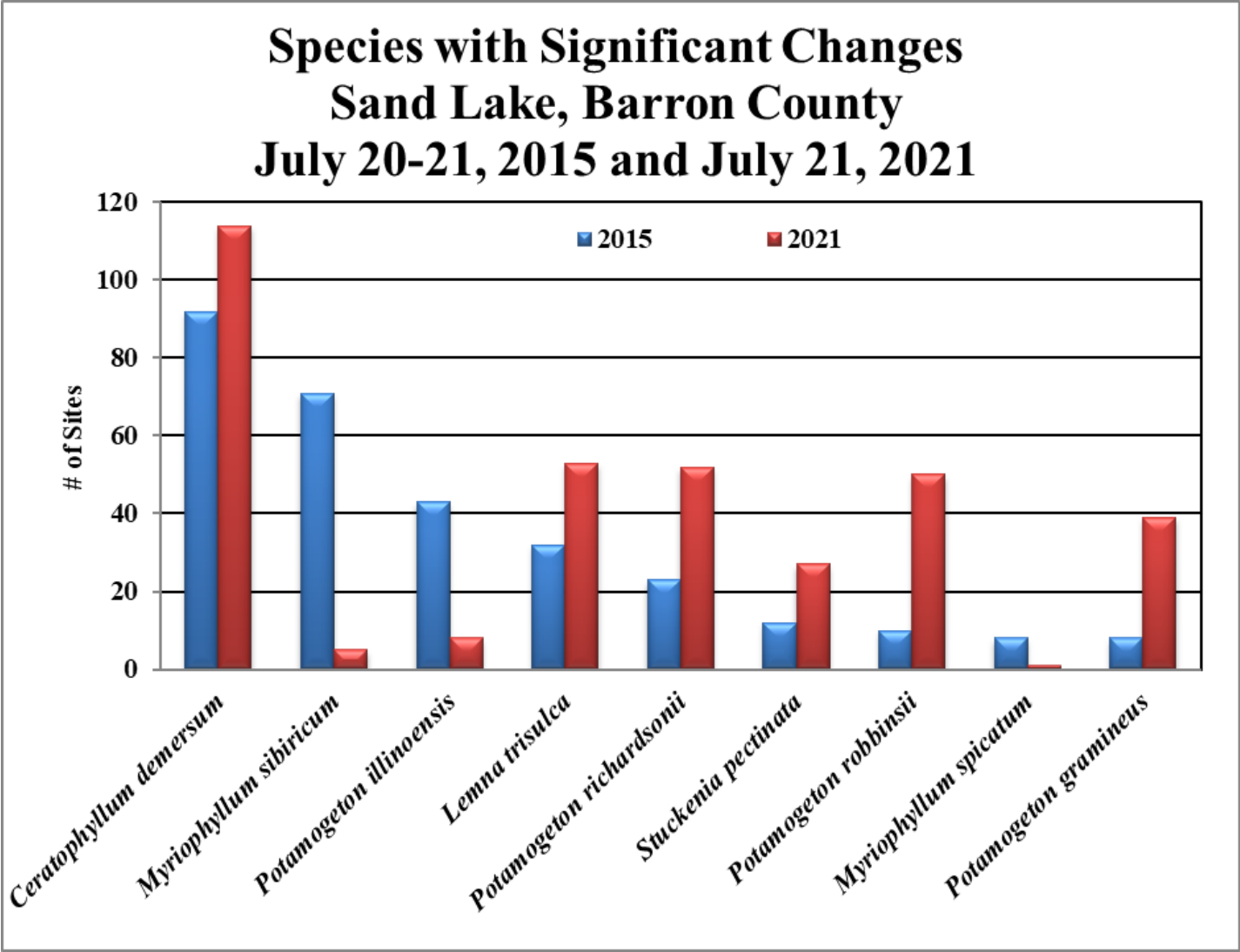
Data: Endangered Resource Services & LEAPS

Sand Lake, Barron Co. – Sub-PI

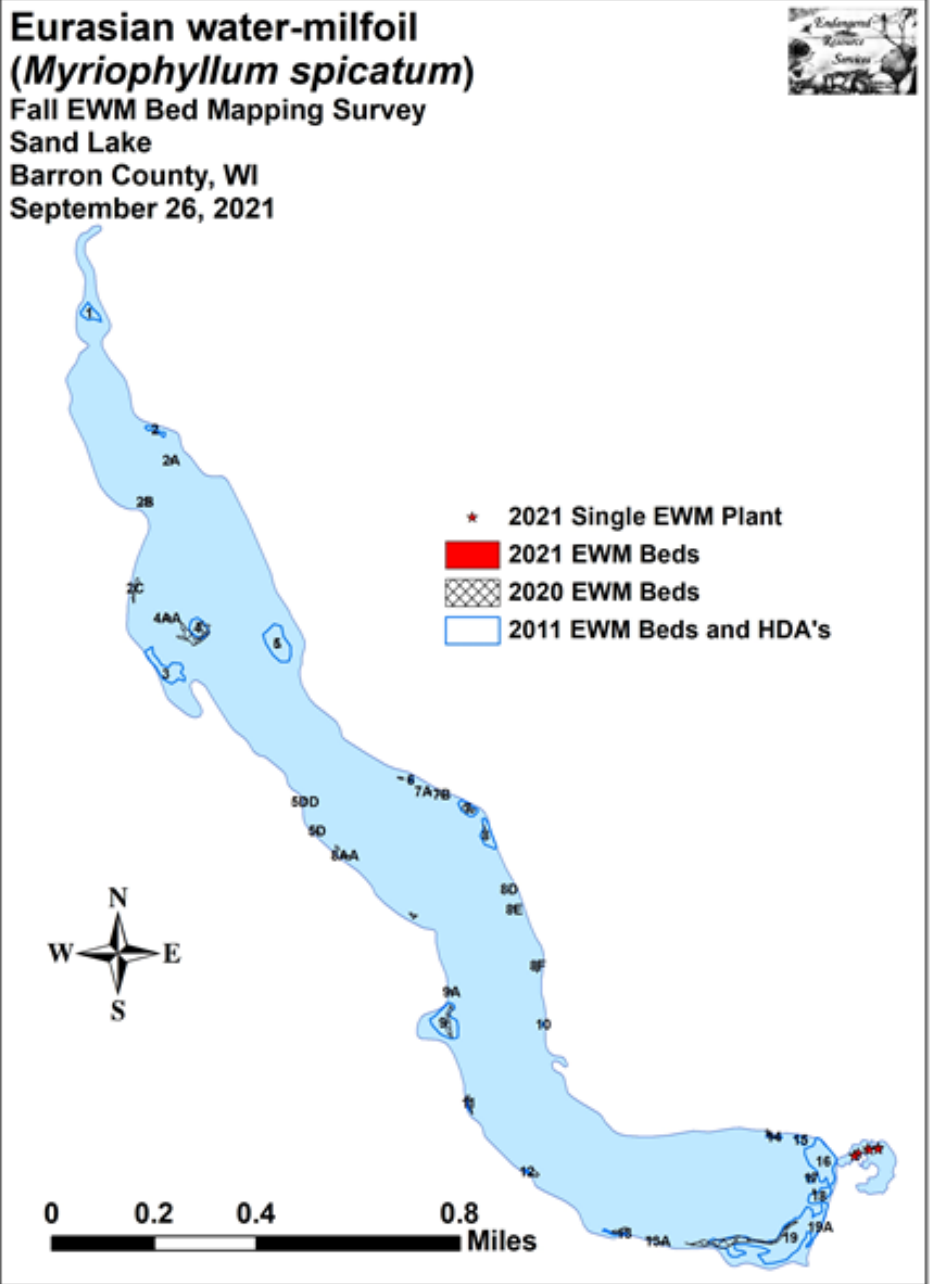
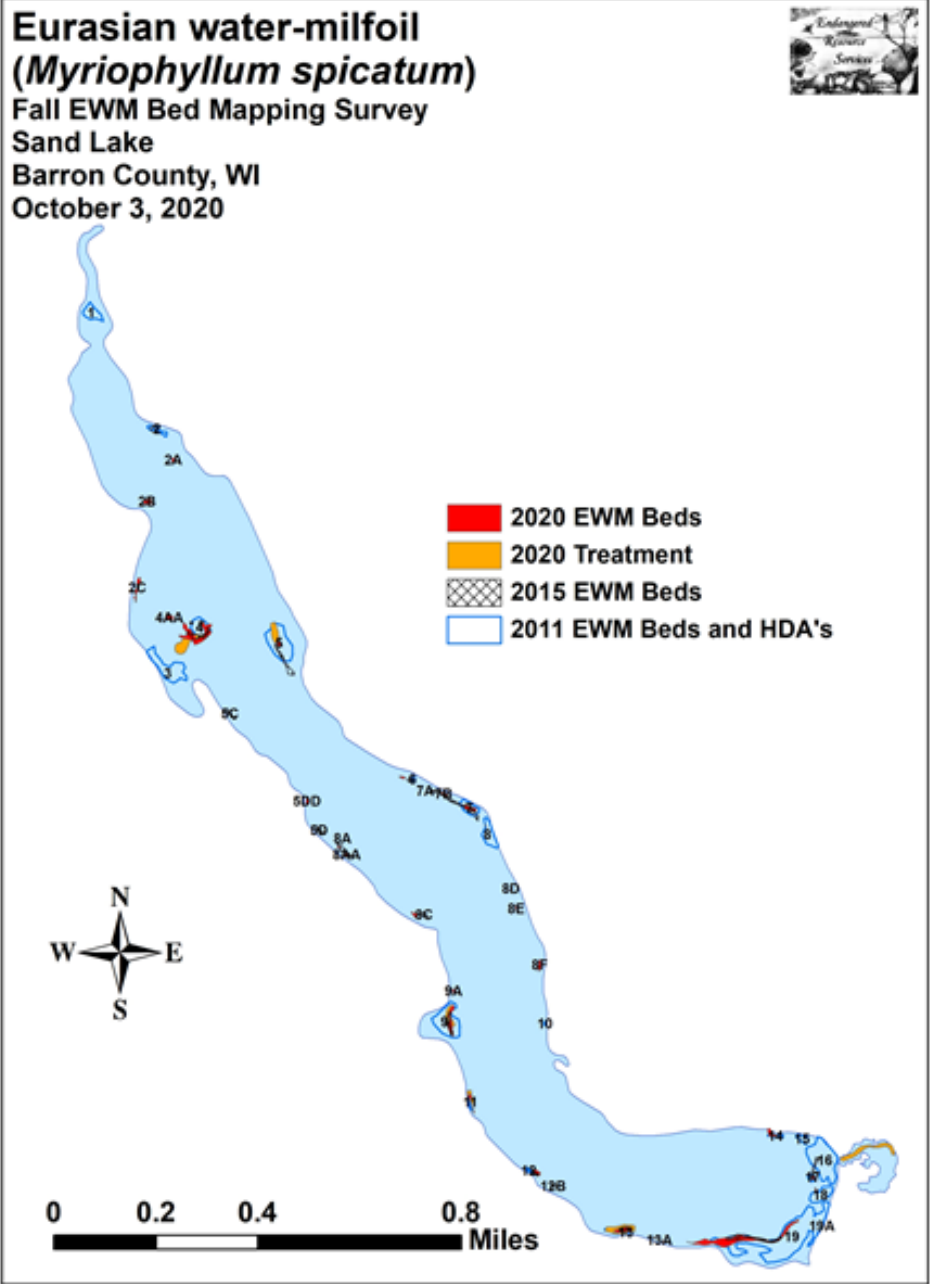


Significant differences = * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

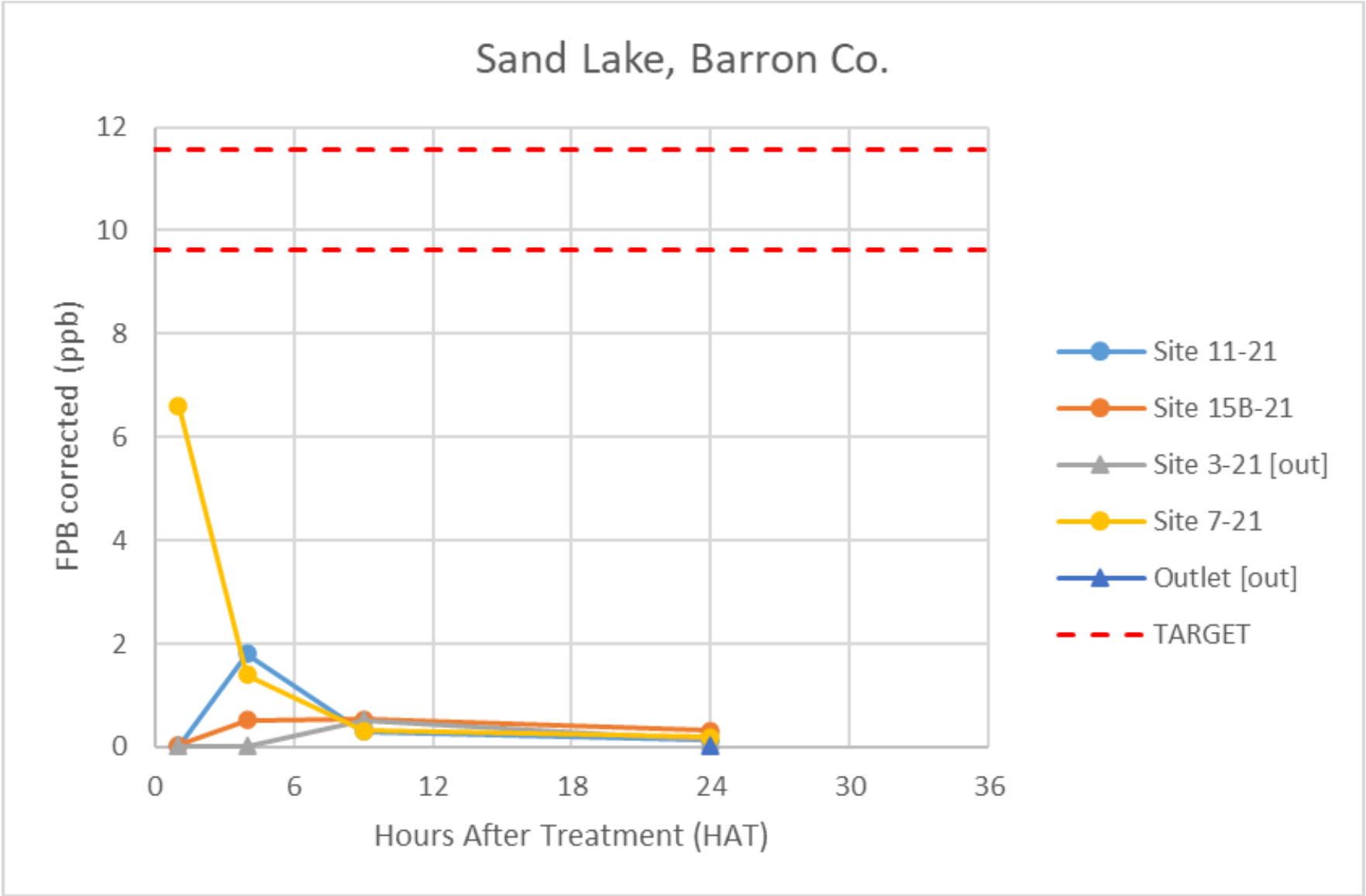
Sand Lake, Barron Co. – Lakewide (sig. changes)



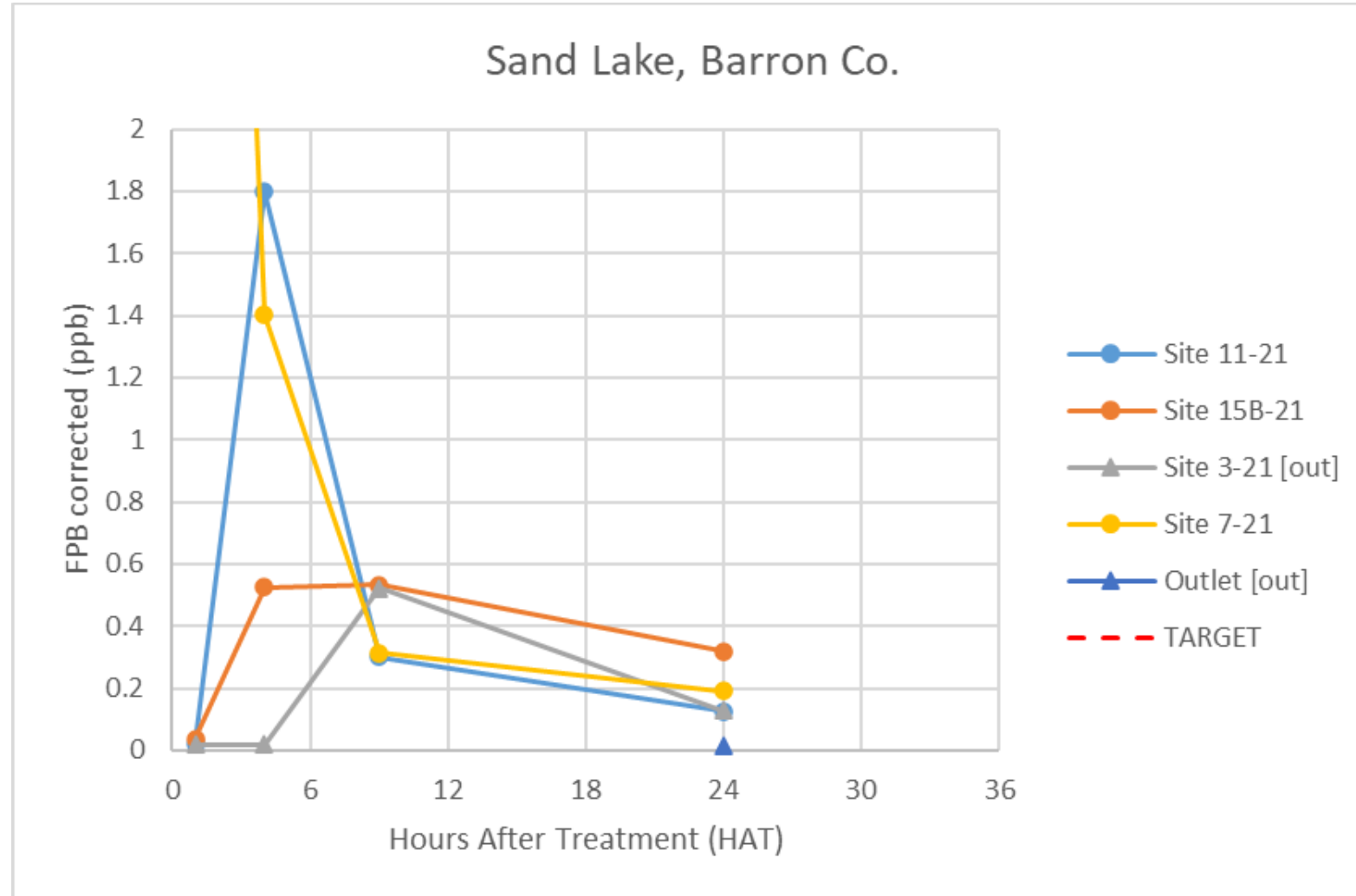
Sand Lake, Barron Co. – EWM Bed Mapping



Sand Lake, Barron Co.



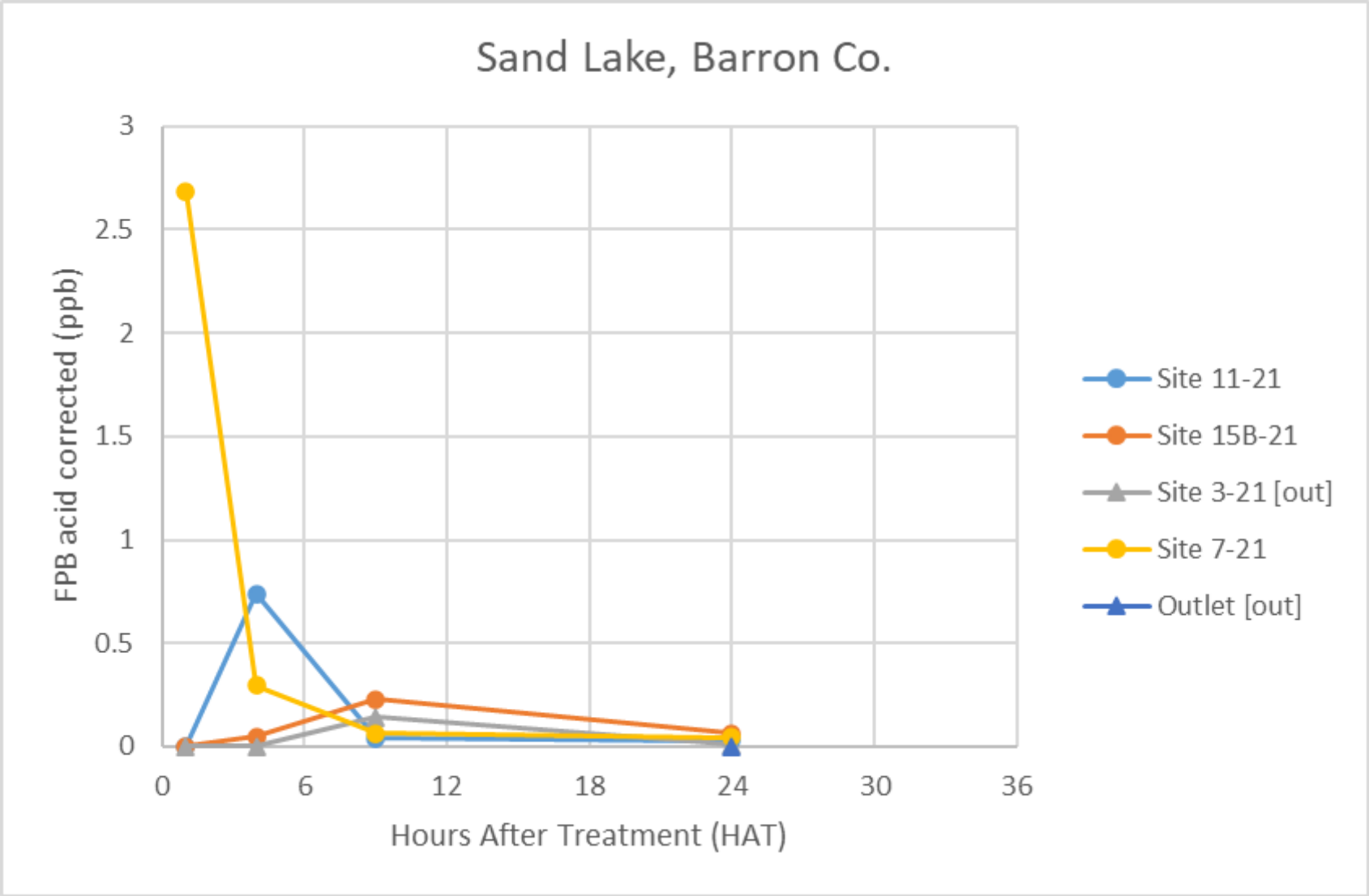
Sand Lake, Barron Co.



Average calculated rate @ 9 HAT = 0.42 ppb

Average calculated rate @ 24 HAT (excluding outlet) = 0.19 ppb

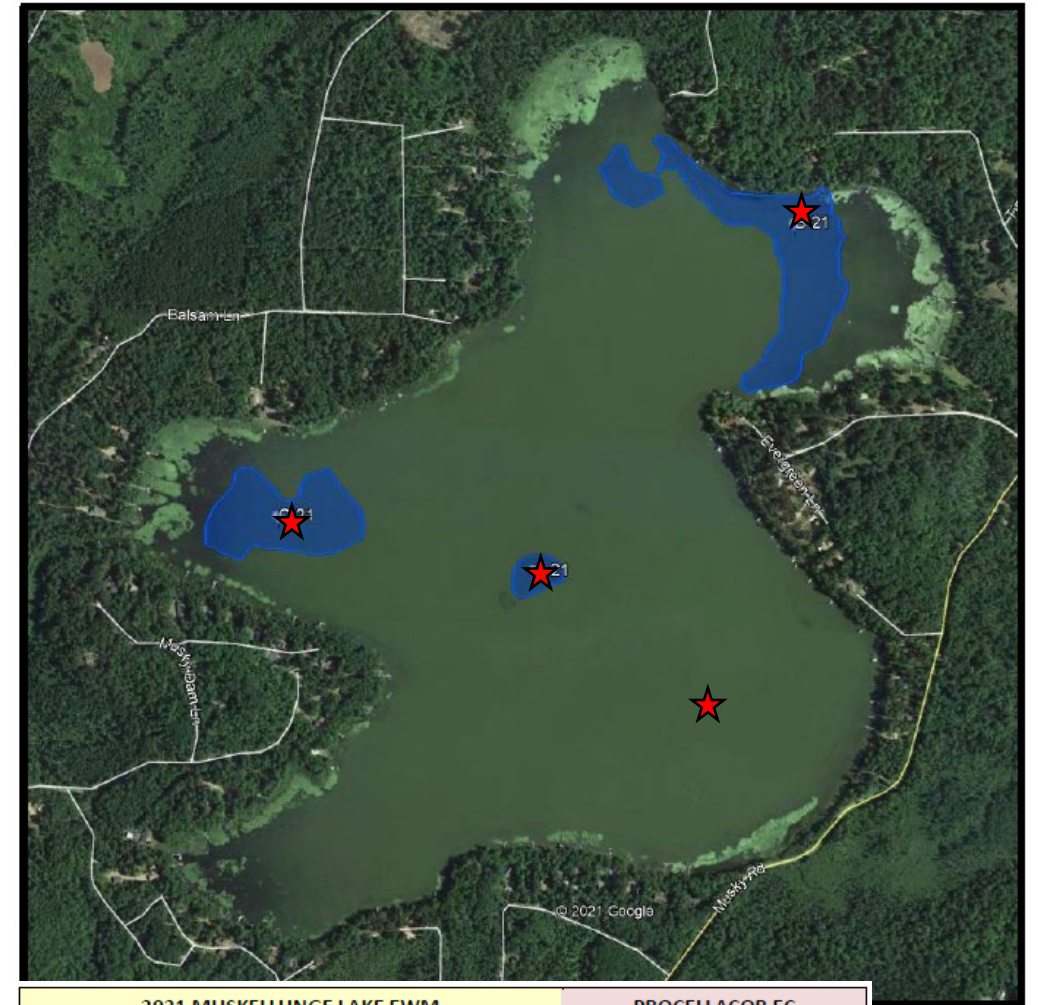
Sand Lake, Barron Co. – FPB Acid



Muskellunge Lake, Vilas Co.

- 270 acres; max depth = 19 feet; eutrophic
- Treatment date: June 23, 2021
- Acreage: 3 'spots': 11.6, 7.1, & 1.1 ac
- Total acreage: 19.8 ac (ProcellaCOR)
- Applied Rate: 3.0-4.0 PDU/ac-ft
- Herbicide monitoring at 3 treatment sites, in addition to untreated reference (deep hole)
- Pre (June) & Post (Aug) Sub-PI (n=132 combined)
- Lakewide PI in 2020 & 2021

MUSKELLUNGE LAKE 2021 EWM CONTROL PROJECT
VILAS COUNTY, WISCONSIN



2021 MUSKELLUNGE LAKE EWM Treatment Site/Herbicide Rate Data				PROCELLACOR EC (liquid flörpyrauxifen-benzyl)		
EWM SITES	SURFACE ACRES	MEAN DEPTH ESTIMATE	VOLUME	RATE PDU	PDU PER ACRE	TOTAL PDU
A-21	1.1	6.0	6.6	4.0	24.0	26.4
B-21	11.6	4.6	53.4	3.0	13.8	160.2
C-21	7.1	4.2	29.8	3.0	12.6	89.4
TOTALS	19.8		89.8			276.0

Data: EOR

Muskellunge Lake, Vilas Co. – Sub-PI

June 14 2021 Aug. 15 2021

Common Name	Scientific Name	PRE present	POST present	p	Significant change	Increase/ Decrease
Eurasian water-milfoil	<i>Myriophyllum spicatum</i>	95	0	0.0000	***	-
Watershield	<i>Brasenia schreberi</i>	4	7	0.5202	No	+
Coontail	<i>Ceratophyllum demersum</i>	32	54	0.0794	No	+
Muskgrasses	<i>Chara sp.</i>	3	10	0.0945	No	+
Common waterweed	<i>Elodea canadensis</i>	25	41	0.1639	No	+
Slender naiad	<i>Najas flexilis</i>	10	14	0.6684	No	+
Spatterdock	<i>Nuphar variegata</i>	2	8	0.0970	No	+
White water lily	<i>Nymphaea odorata</i>	2	7	0.1503	No	+
Large-leaf pondweed	<i>Potamogeton amplifolius</i>	10	19	0.2046	No	+
Leafy pondweed	<i>Potamogeton foliosus</i>	8	7	0.5605	No	-
White-stem pondweed	<i>Potamogeton praelongus</i>	38	45	0.9758	No	+
Small pondweed	<i>Potamogeton pusillus</i>	6	17	0.0514	No	+
Fern pondweed	<i>Potamogeton robbinsii</i>	25	45	0.0679	No	+
Flat-stem pondweed	<i>Potamogeton zosteriformis</i>	8	26	0.0070	**	+
Wild celery	<i>Vallisneria americana</i>	8	25	0.0101	*	+
Softstem bulrush	<i>Schoenoplectus tabernaemontani</i>	1	1	0.9081	n.s.	-

Data: EOR

Muskellunge Lake, Vilas Co. – Lakewide

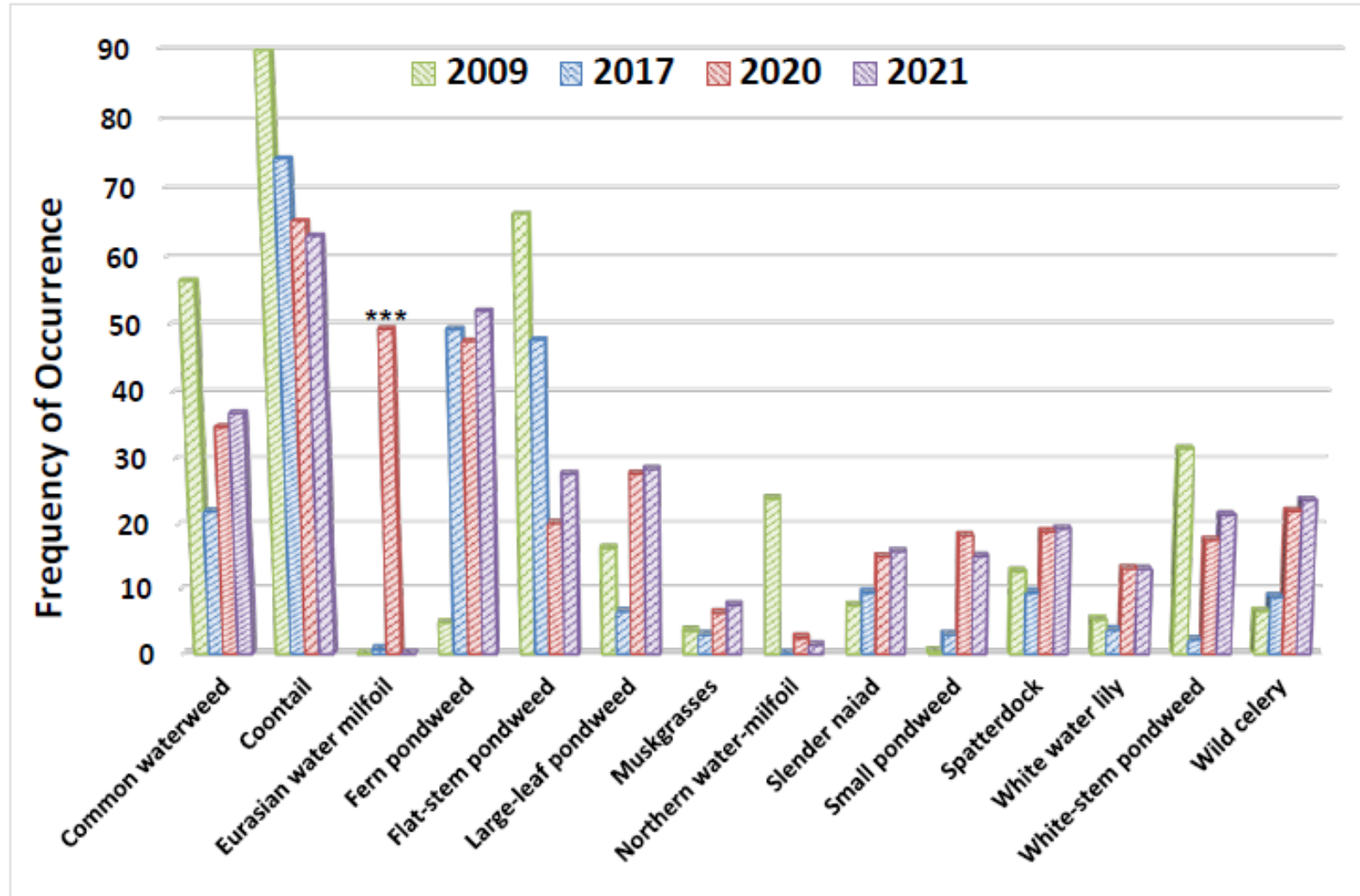
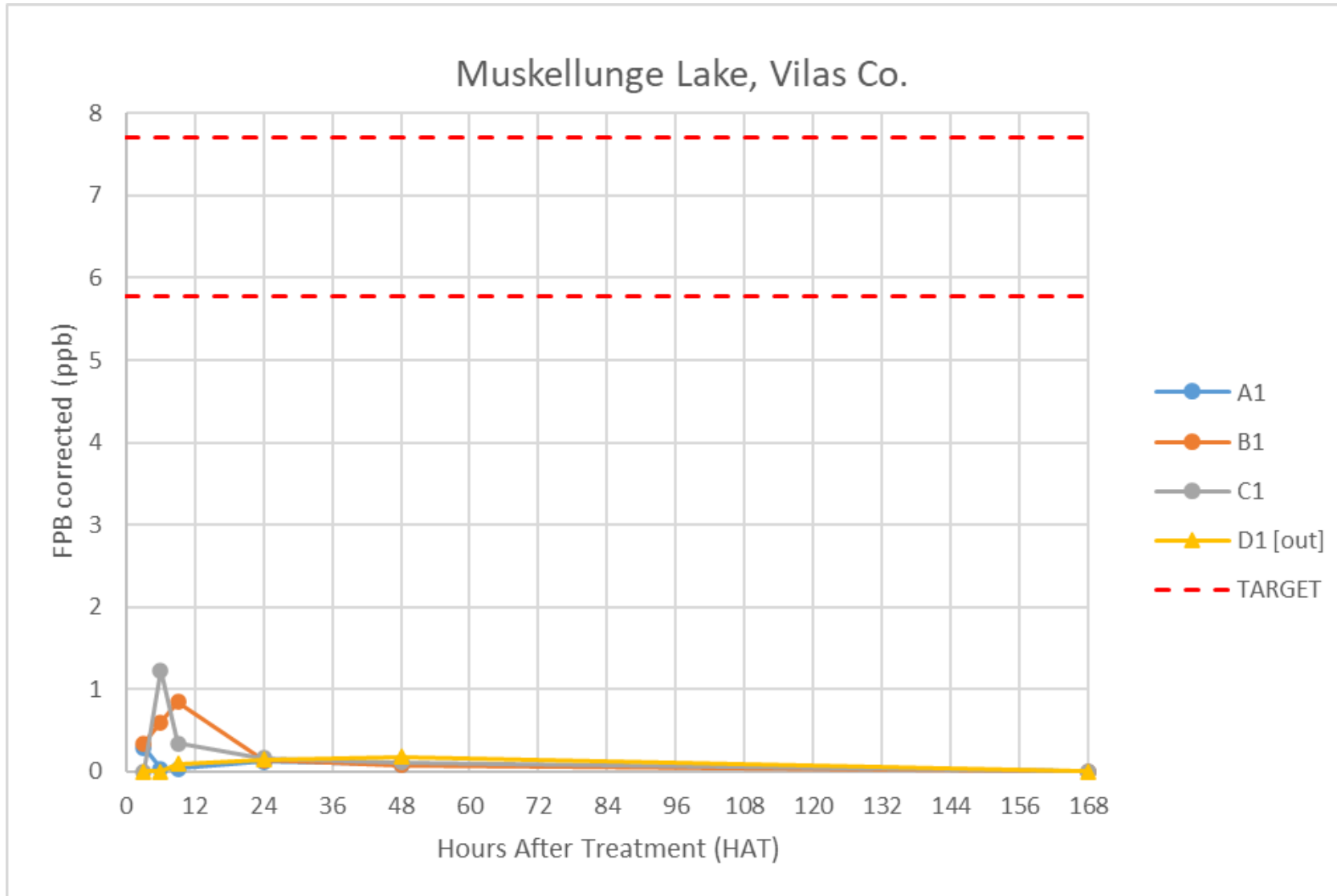
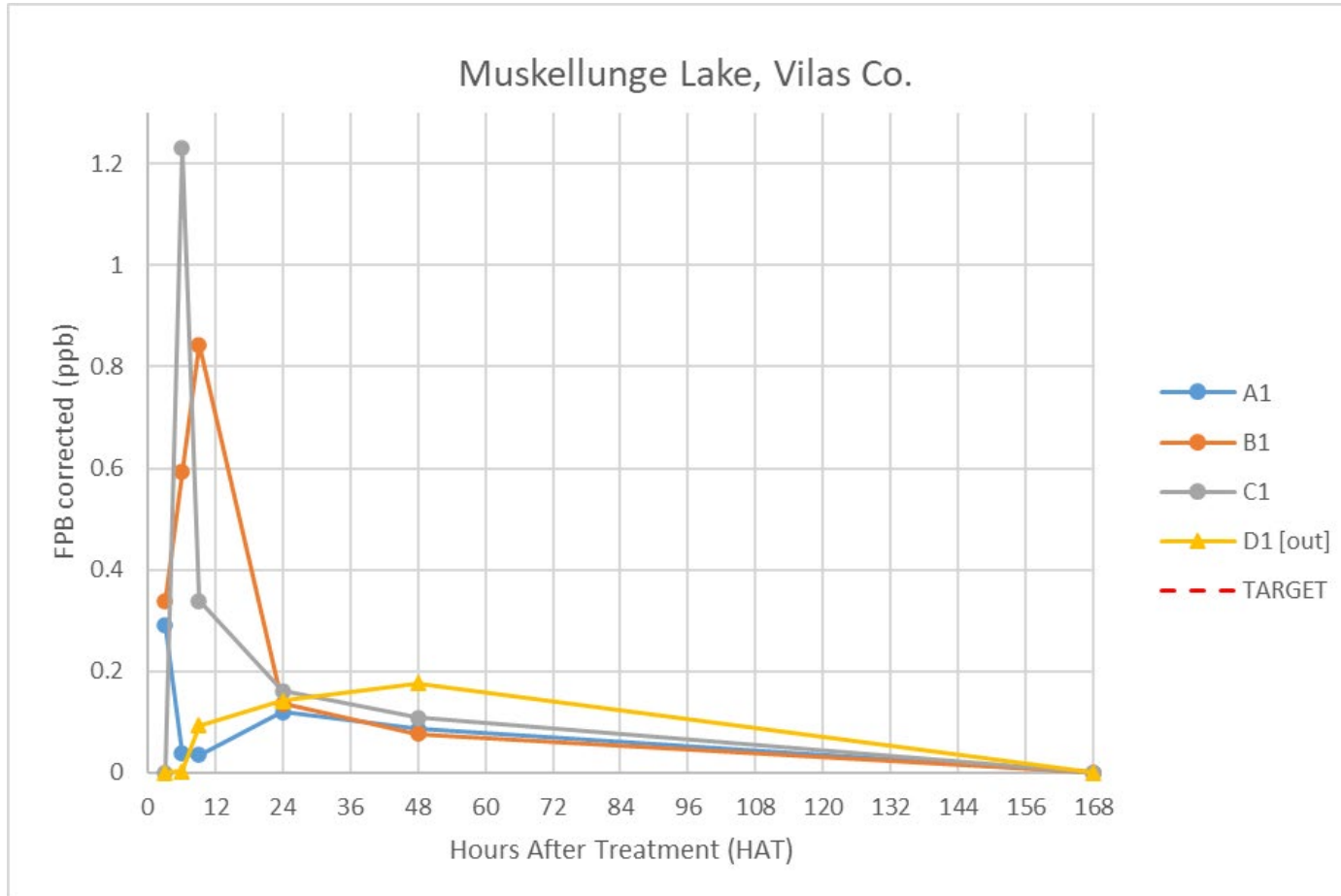


Figure 4. Frequency of Occurrence of aquatic plants from 2009, 2017, 2020, and 2021 Lake-wide Point Intercept Surveys.

Muskellunge Lake, Vilas Co.



Muskellunge Lake, Vilas Co.

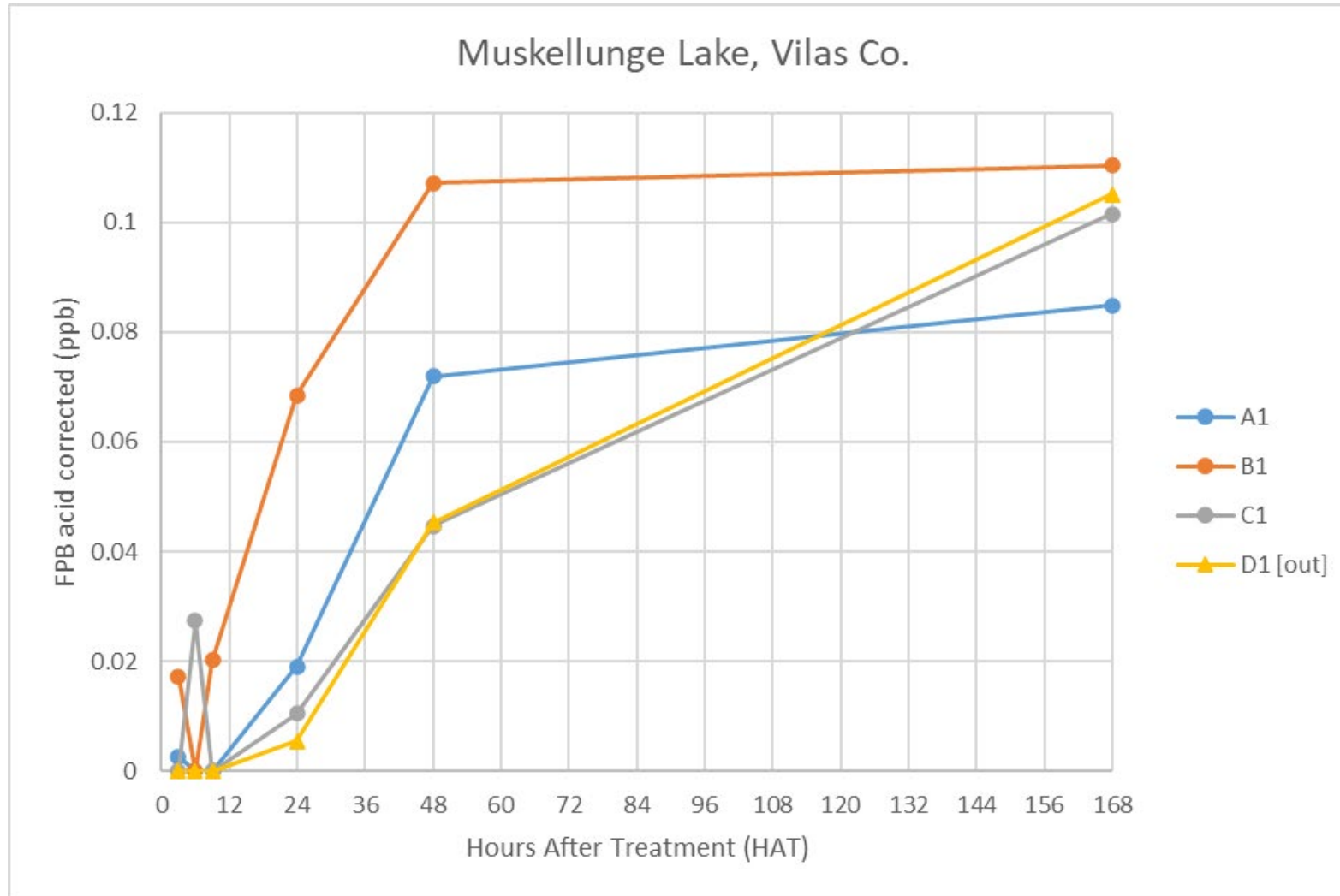


Average calculated rate @ 9 HAT = 0.33 ppb

Average calculated rate @ 24 HAT = 0.14 ppb

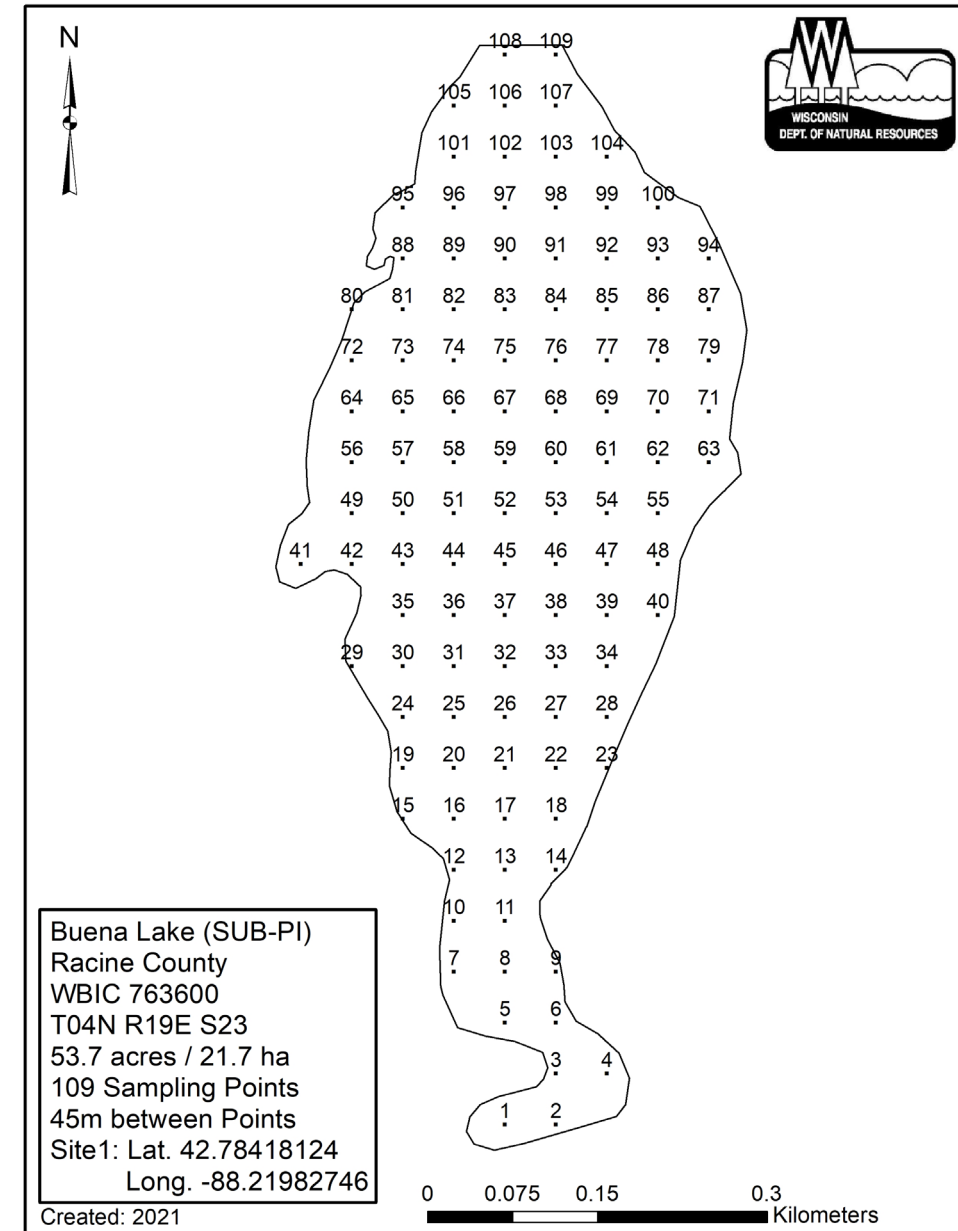
Average calculated rate @ 48 HAT = 0.11 ppb

Muskellunge Lake, Vilas Co. – FPB Acid



Buena Lake, Racine Co.

- 53.7 acres; max depth = 4.5 feet; eutrophic
- Treatment date: June 8, 2021
- Acreage: 53.6 acres
- Total: 53.6 ac (ProcellaCOR) + 6.9 ac (Captain + Clipper SC + Tribune)
- Applied Rate: 3.5 PDU/ac-ft
- Pre (May) & Post (Sept) Sub-PI (n=109)



Data: WDNR [Craig Helker]

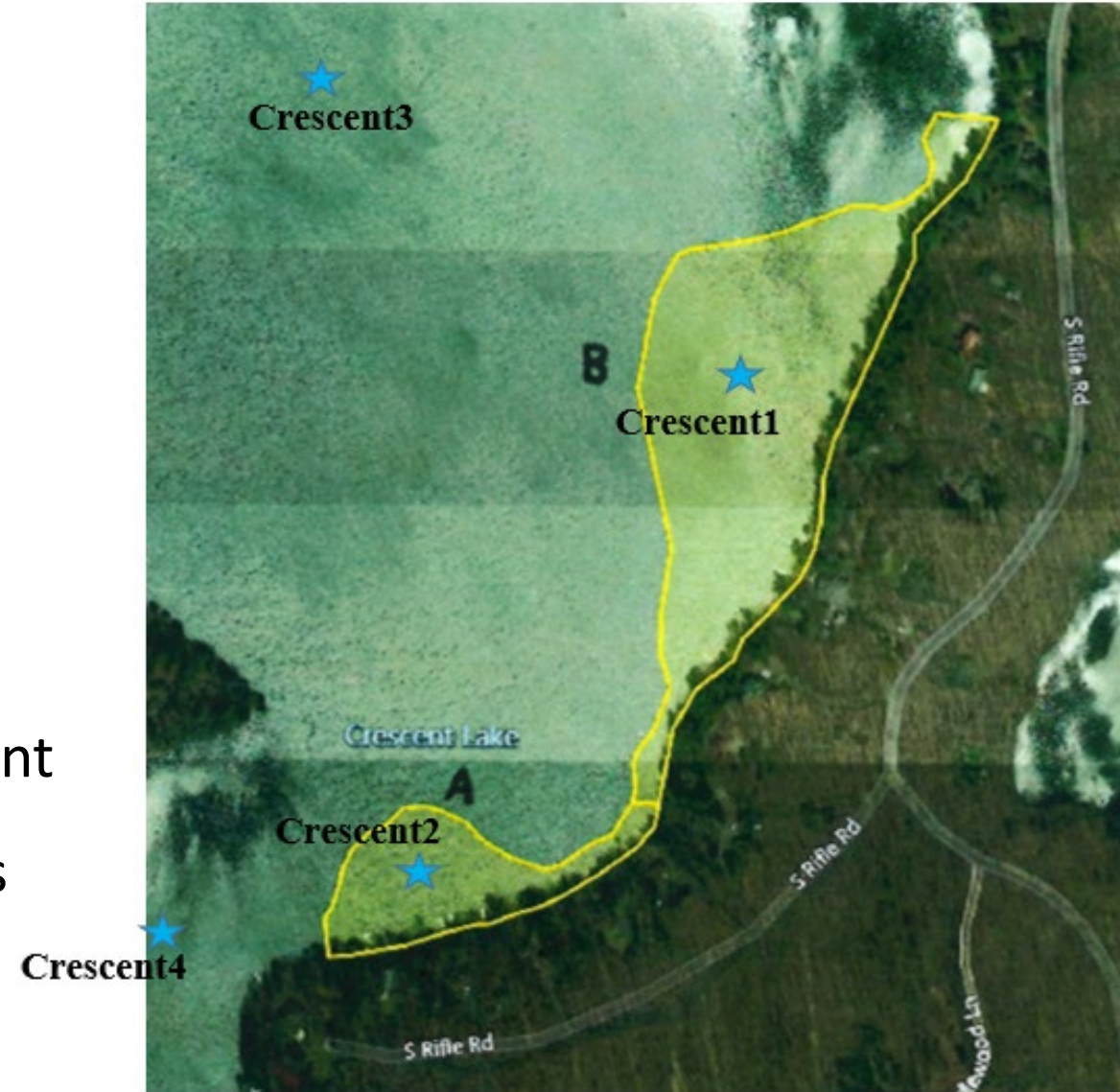
Buena Lake, Racine

Buena Lake					
pre-treatment survey total points	109				
post-treatment survey total points	109				
	May 2021 present	Sept 2021 present	p	Significant change	Increase/Decrease
Myriophyllum spicatum	87	5	2.44848E-29	***	-
Potamogeton crispus	58	3	1.05832E-16	***	-
Ceratophyllum demersum	62	65	0.680318751	n.s.	+
Elodea canadensis	80	29	4.90455E-12	***	-
Heteranthera dubia	0	6	0.012994847	*	+
Lemna minor	0	31	1.83729E-09	***	+
Lemna trisulca	0	4	0.043528286	*	+
Nymphaea odorata	8	17	0.055744033	n.s.	+
Potamogeton zosteriformis	2	0	0.155390684	n.s.	-
Ranunculus aquatilis	11	0	0.000665023	***	-
Spirodela polyrhiza	51	0	3.36857E-16	***	-
Stuckenia pectinata	1	8	0.017170186	*	+
Wolffia columbiana	12	16	0.418103741	n.s.	+
Filamentous algae	43	14	7.83388E-06	***	-

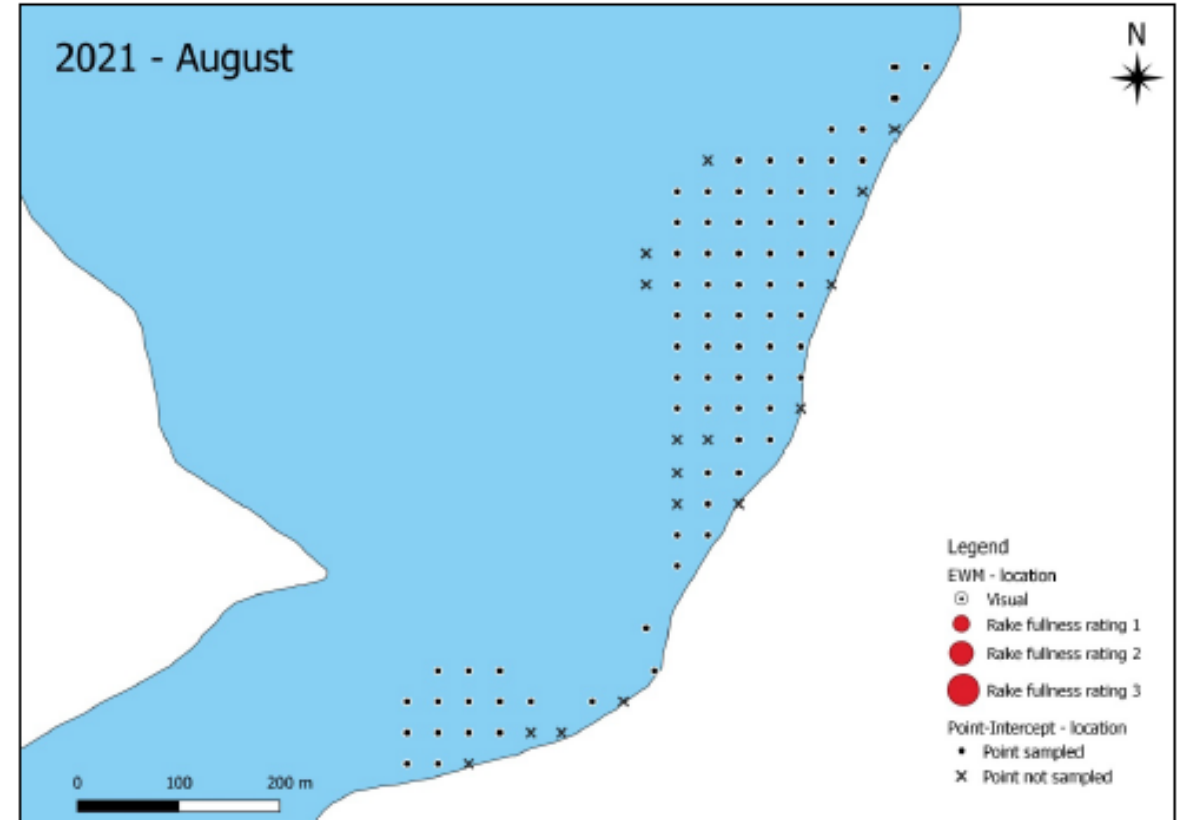
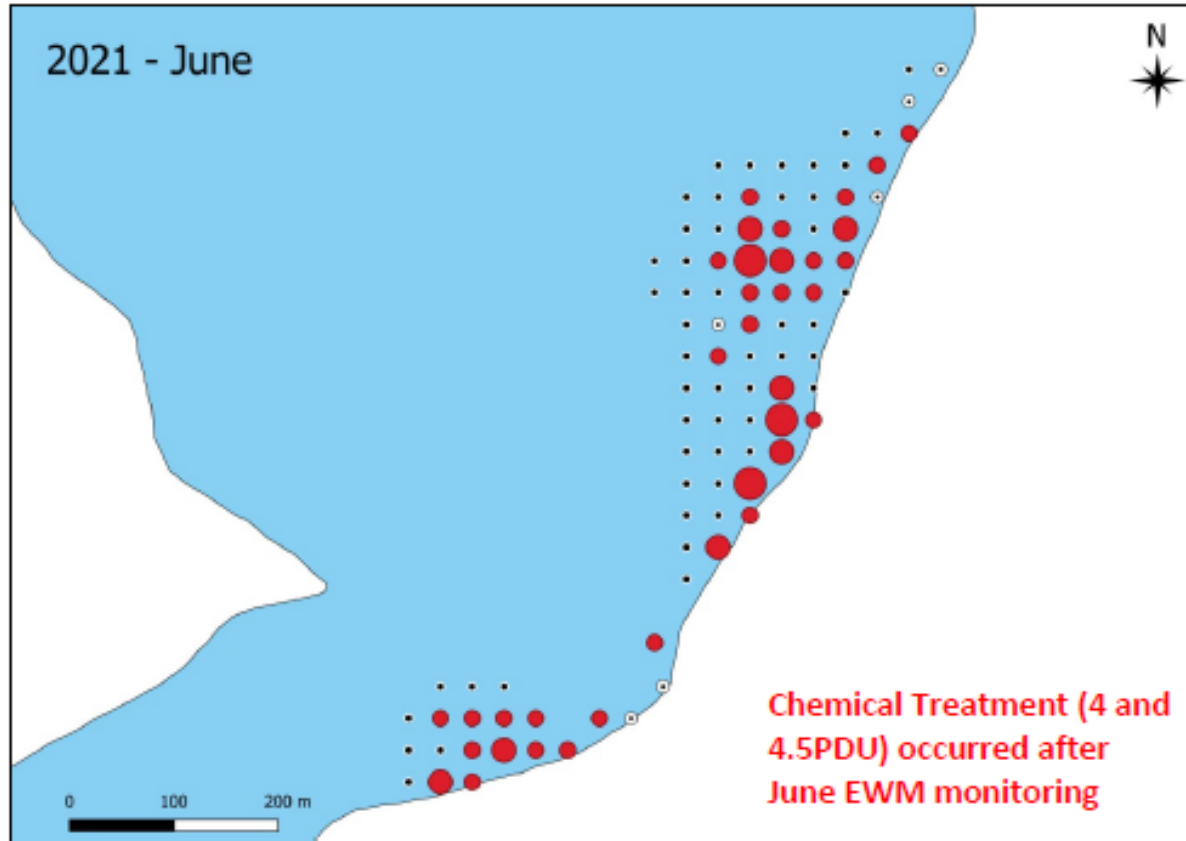
Data: WDNR [Craig Helker]

Crescent Lake, Oneida Co.

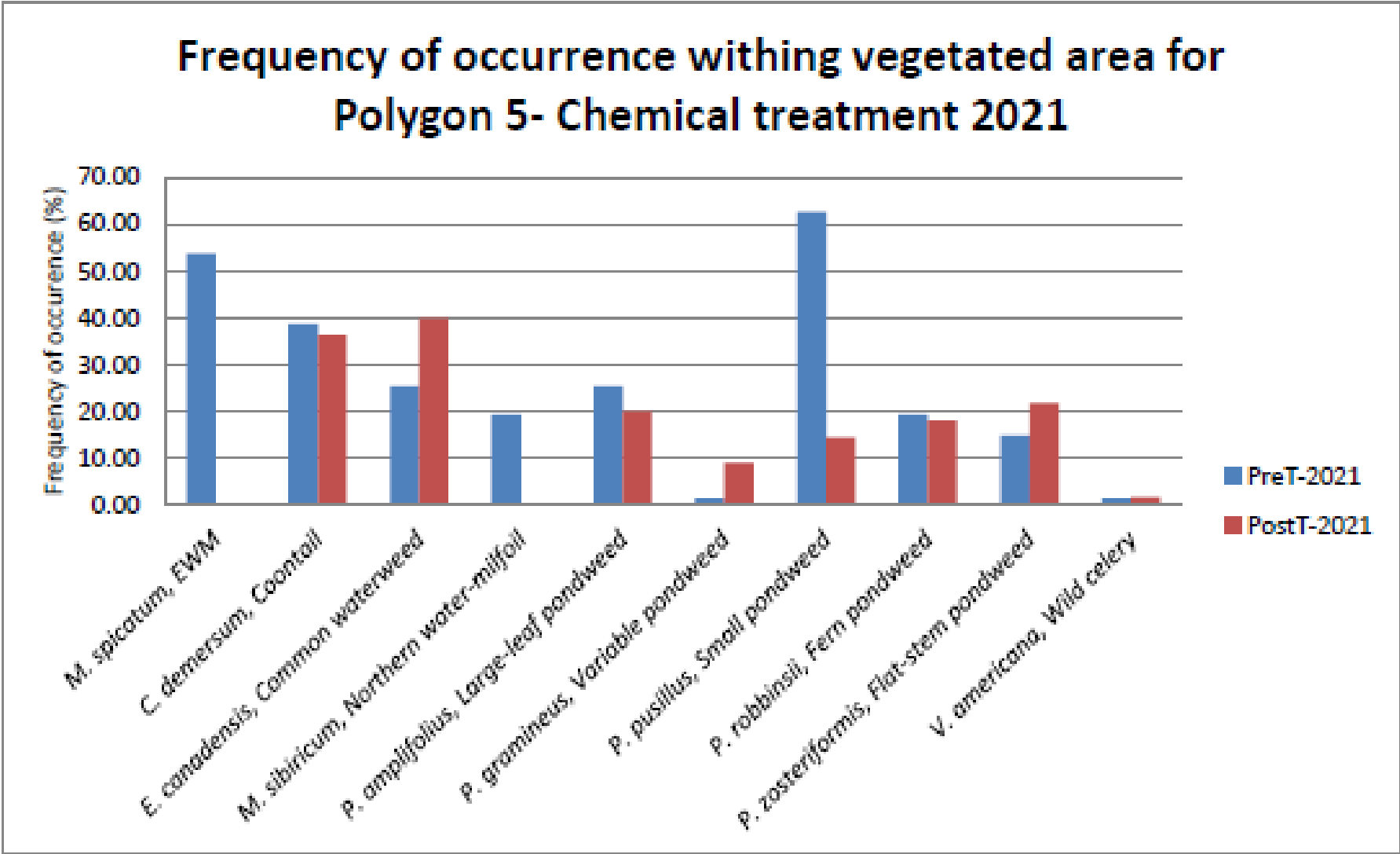
- 616 acres; max depth = 32 feet; mesotrophic
- Treatment date: June 15, 2021
- Acreage: 2 'spots': 16.0 & 5.0 acres
- Total: 21.0 ac (ProcellaCOR)
- Applied Rate: 4.0-4.5 PDU/ac-ft
- Herbicide monitoring at 2 sites within treatment area, in addition to 2 untreated reference sites
- Pre (June) & Post (Aug) Sub-PI (n=93)



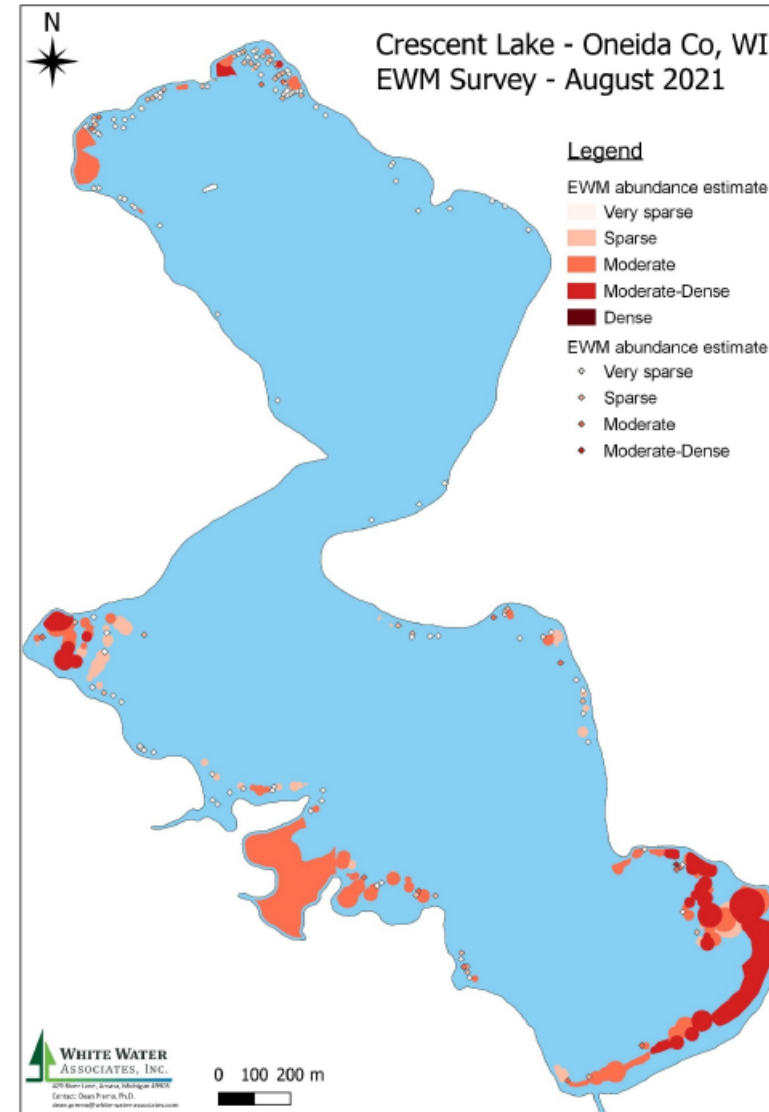
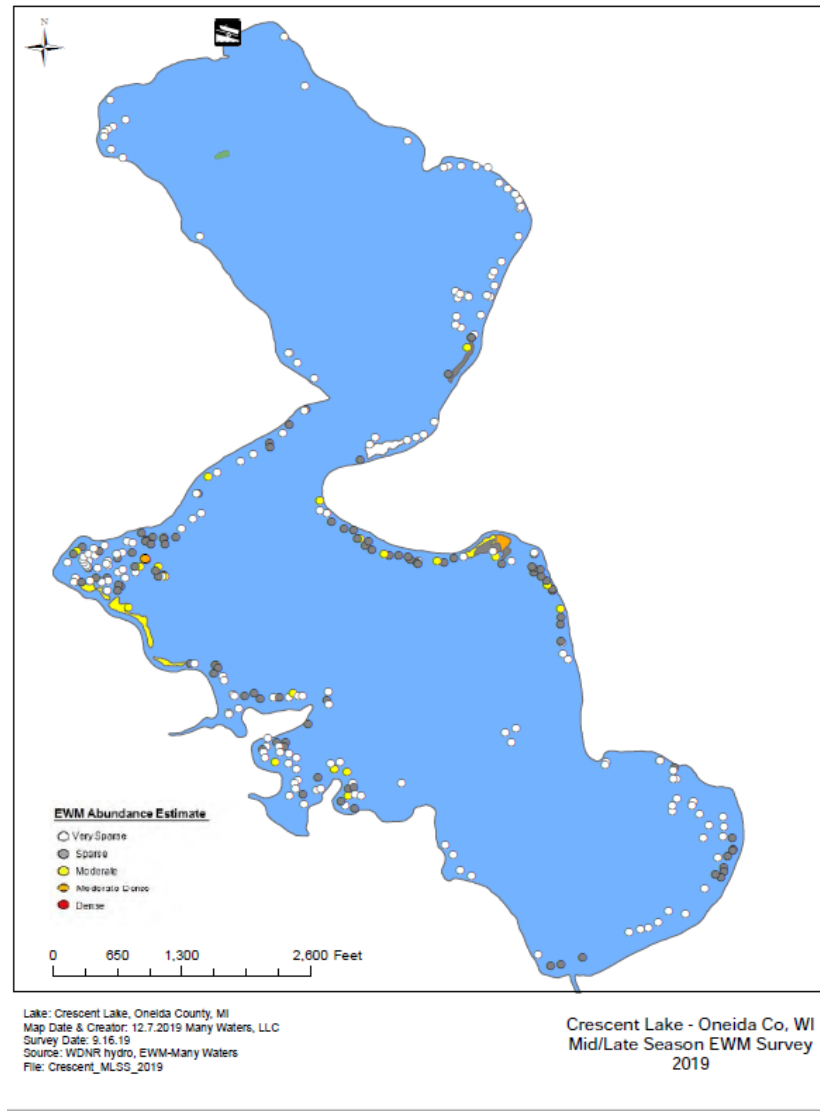
Crescent Lake, Oneida Co.



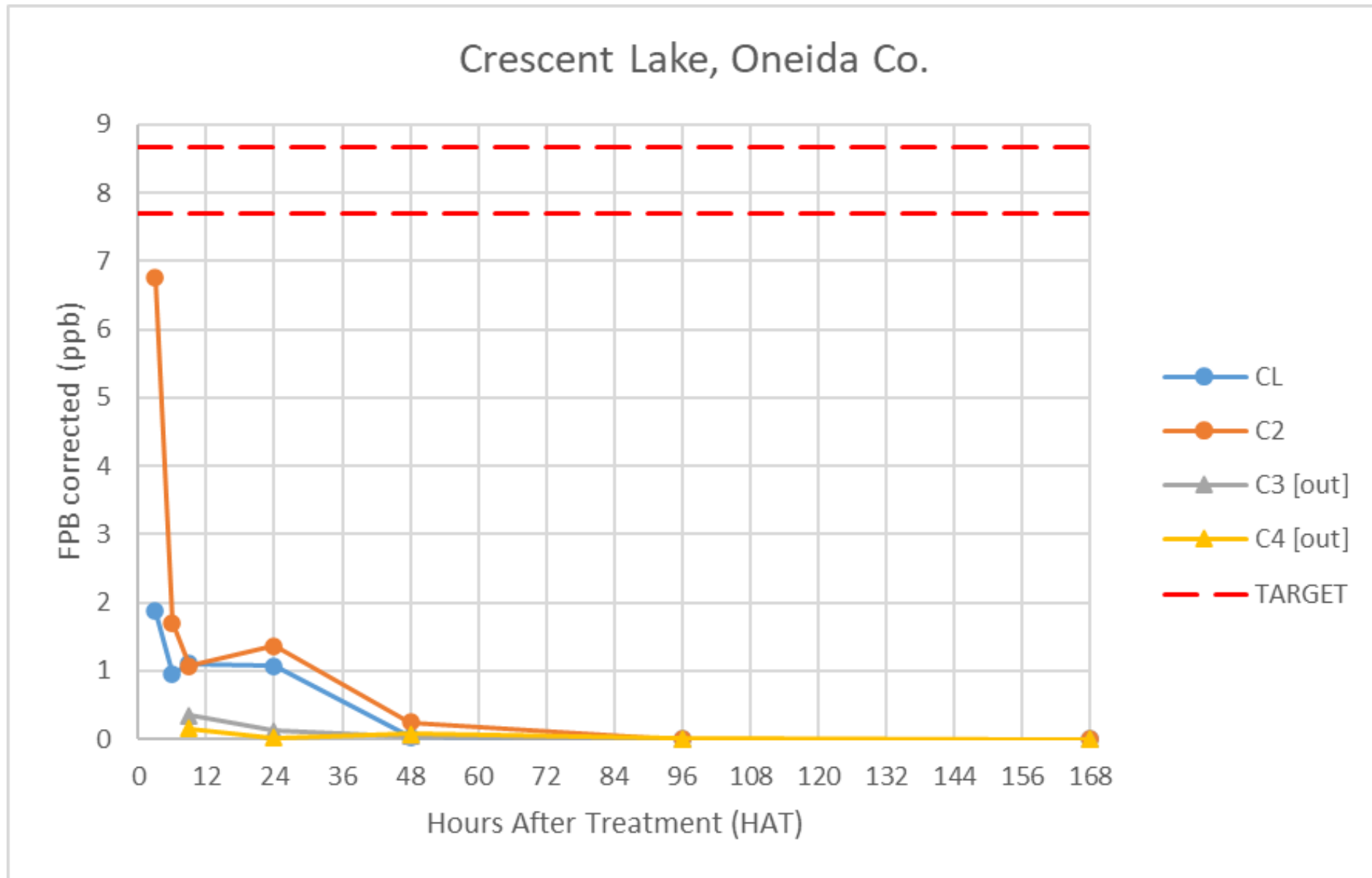
Crescent Lake, Oneida Co.



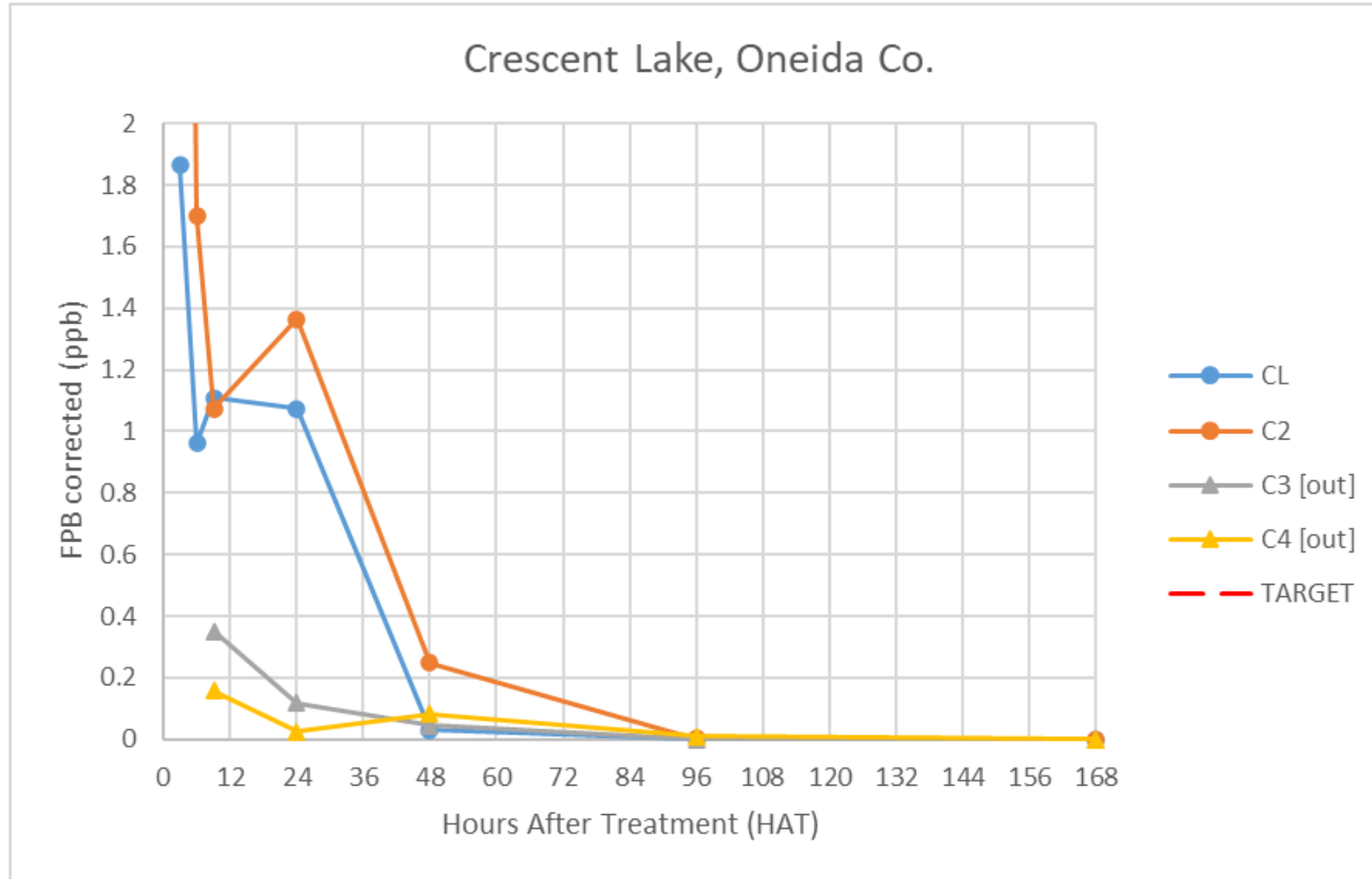
Crescent Lake, Oneida Co.



Crescent Lake, Oneida Co.



Crescent Lake, Oneida Co.

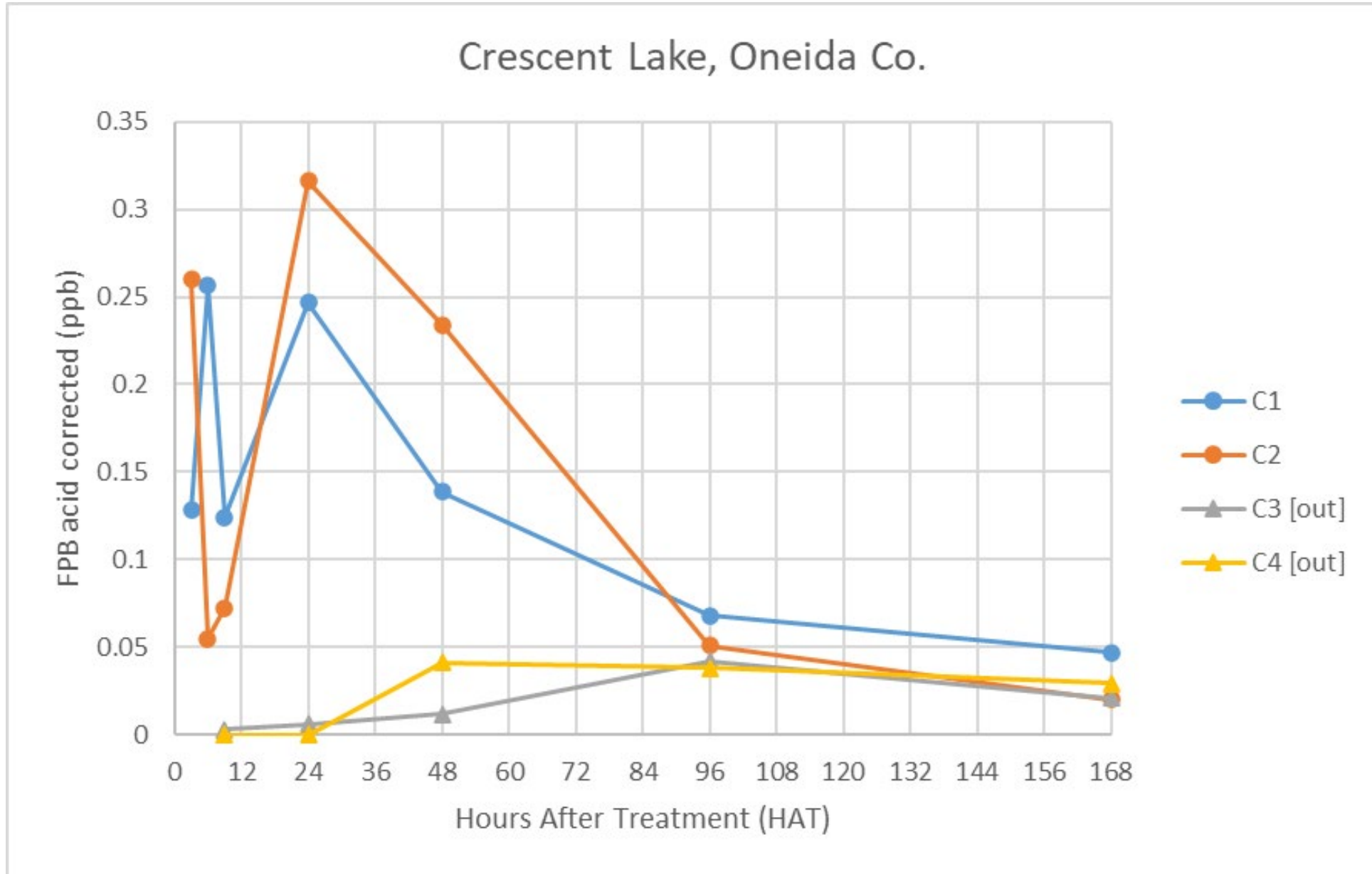


Average calculated rate @ 9 HAT = 0.83 ppb

Average calculated rate @ 24 HAT = 0.64 ppb

Average calculated rate @ 48 HAT = 0.10 ppb

Crescent Lake, Oneida Co. – FPB Acid



Preliminary Conclusions

- Statistically significant non-native watermilfoil control has been achieved during year of treatment in many, but not all ProcellaCOR case studies monitored to date.
- Additional data on milfoil control efficacy collected at one YAT on a small sub-set of lakes observed sustained reductions in non-native milfoil on many waterbodies, with some limited milfoil re-growth observed.
- Field evaluation efforts in 2020 & 2021 also provided evidence which suggests that the observed impacts following some of these localized ProcellaCOR treatments are extending to areas beyond the immediate treatment areas. This observation supports conducting additional research to better understand the variables which influence scale of treatment and associated impacts.
- Statistically significant declines were observed with some native plant species, particularly several dicots (i.e., northern watermilfoil, water marigold, white water crowfoot, etc.), while other native plant species did not exhibit any statistical changes.
- Additional data on native plant selectivity collected at one YAT on a small sub-set of lakes observed sustained reductions in the native plant species which exhibited initial declines following treatment.