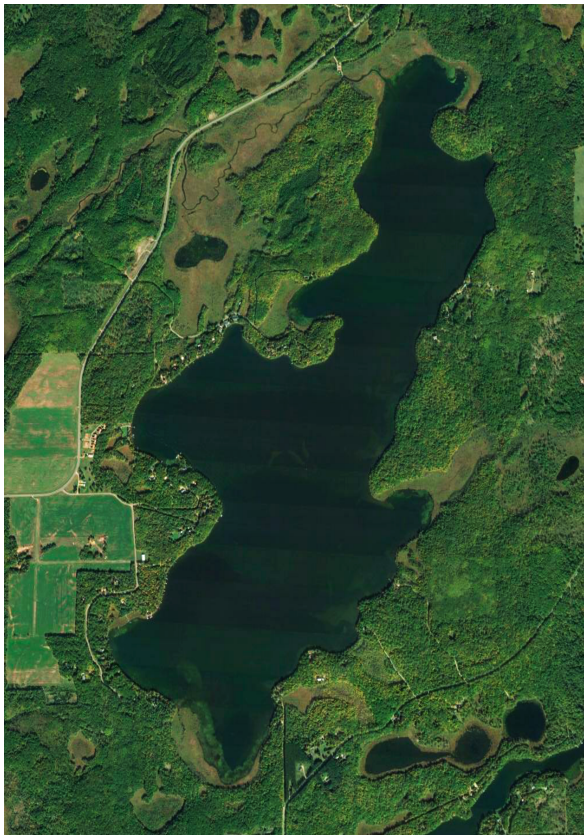


Analysis of Lake-Wide 2,4-D Herbicide Concentration in Clearwater Lake, MN following 2,4-D Spot Treatments

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Clearwater Lake (# 18-0038-00)
Crow Wing County, MN



Analysis and Reporting by:

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Context

Over the past decade, lakeshore homeowners on Clearwater Lake have reported a lake-wide reduction in the abundance of native plants. This perceived reduction of plant cover has been of particular concern due to its potential impact to the fish population in the lake.

The lake association has been spot-treating isolated patches of invasive Eurasian watermilfoil (EWM) for several years using 2,4-D herbicide. The lake is also infested with rusty crayfish, which are known to uproot and destroy aquatic plants. Over the past several years, the lake group has been debating internally whether the perceived reduction of plant abundance in the lake was due to herbicide treatments or rusty crayfish. Specifically, they wondered if the herbicide treatments to control EWM were having unintended lake-wide impacts on native plants. Such lake-wide impacts were reported in Wisconsin study lakes (Nault et al. 2014). In this Wisconsin study, two lakes were treated with 2,4-D to purposefully achieve lake-wide concentrations of 275 and 500 ppb. In these study lakes, the lake-wide 2,4-D concentrations persisted much longer than expected (months instead of weeks), and resulted in unintended impacts to native plants.

Given the results of this Wisconsin study, lake residents expressed interest in determining the potential for such lake-wide effects of 2,4-D herbicide on native plants in Clearwater Lake.

Analysis and Results

Estimate of Lake Volume

To calculate the potential lake-wide concentration of herbicide in Clearwater Lake, we need to have information on the amount and type of herbicide applied, as well as an accurate estimate of the total lake volume and epilimnetic volume (portion above the thermocline). We used lake bathymetric data from the MDNR and desktop GIS software to calculate the cross-sectional area of the lake at 10-ft depth intervals. We then used these cross-sectional areas to calculate the volume in each 10-ft layer of the lake using a formula for partial cone volumes. These calculated volumes for each 10-ft layer were summed to determine the total lake volume (22,383 acre-ft). This estimate of total lake volume was similar to the lake volume reported by the MDNR (21,678 acre-ft), indicating that our layer estimates were accurate (3% difference between the two volume estimates). We then used our calculated lake layer volumes to develop a hypsographic curve for Clearwater Lake that allowed us to estimate water volumes above and below any given stratified depth (Fig. 1).

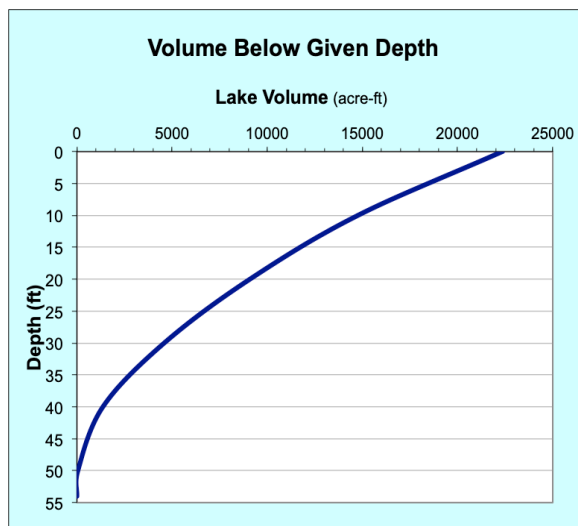


Figure 1. Hypsographic Volume Curve

Using this relationship, we calculated the volume above the reported typical thermocline depth (18 ft) in the lake to be 12,883 acre-ft.

Now that we have created this lake volume model, we can easily estimate the maximum lake-wide concentration of herbicides for any past or future treatments.

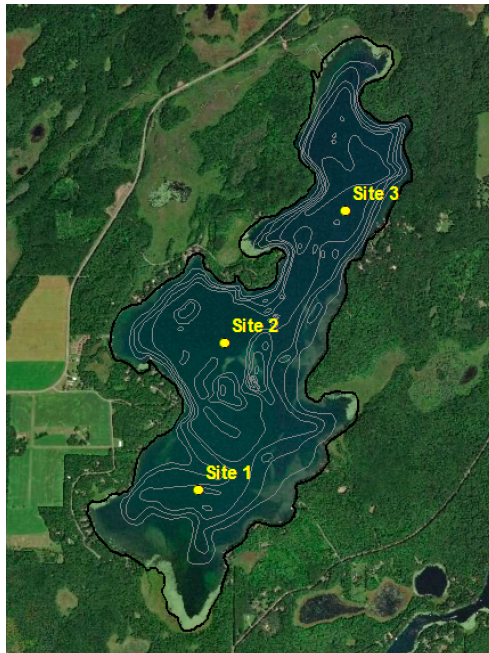
Clearwater Lake 2,4-D Treatment Analysis		
Analysis by: JA Johnson – Freshwater Scientific Services		
Herbicide Product	Navigate DMA	
Treatment Date	10/20/2019	
Applicator	Central MN Aquatics	
		Information Source
Area Treated	14 acres	Central MN Aquatics
Mean Depth Treated	4.4 ft	Calculated by FWSS
Treated Volume	61.2 ac-ft	Central MN Aquatics
Total Product Applied to Lake		
Total Mass Applied	2400 lbs	Central MN Aquatics
% Mass that is 2,4-D →	22.70% % ae	Herbicide Manufacturer
Mass of 2,4-D Applied →	544.8 lbs ae	Calculated by FWSS
Plot Dosing (per acre-ft)		
Total Mass Applied	39.22 lbs/ac-ft	Central MN Aquatics
% Mass that is 2,4-D →	22.70% % ae	Herbicide Manufacturer
Mass of 2,4-D Applied →	8.90 lbs ae/ac-ft	Calculated by FWSS
Target Conc in Plots	3.27 ppm 2,4-D	Calculated by FWSS
	3273 ppb	Unit conversion
	↑	
This target concentration is between the manufacturer's recommended dosing for typical (2 ppm) and difficult (4 ppm) treatment conditions.		

Surface Area	Average Depth	For typical conditions 2 ppm 2,4-D ae/acre-foot	For difficult conditions* 4 ppm 2,4-D ae/acre-foot
		Lbs of Product (2,4-D lbs ae)	Lbs of Product (2,4-D lbs ae)
1 Acre	1 Foot	23.8 (5.4 ae)	47.6 (10.8 ae)
	2 Feet	48 (10.8 ae)	95 (21.6 ae)
	3 Feet	71 (16.2 ae)	143 (32.4 ae)
	4 Feet	95 (21.6 ae)	190 (43.2 ae)
	5 Feet	119 (27.0 ae)	238 (54.0 ae)

* Examples include spot treatment of pioneer colonies of Eurasian Water Milfoil and certain difficult to control aquatic species.

Estimated Maximum Lake-Wide 2,4-D Concentration in Clearwater Lake					
Lake Area	907	acres	MDNR		
Max Depth	54	ft	MDNR		
Mean Depth	24	ft	MDNR		
Thermocline Depth	18	ft	RMB Env Labs		
Whole Lake Volume	22,383	acre-ft	Calculated by FWSS using MDNR bathymetric contours		
	21,678	acre-ft	MDNR		
Vol Above Thermocline	12,883	acre-ft	Calculated by FWSS using MDNR bathymetric contours		
Total 2,4-D Applied	544.8	lbs ae	Central MN Aquatics		
Max Lake-Wide Conc	8.9	ppb	Assumes mixing throughout entire lake volume and no degradation of 2,4-D		
	0.009	ppm	Unit conversion		
Max Epilimnetic Conc	15.5	ppb	Assumes mixing throughout epilimnion and no degradation of 2,4-D		
	0.016	ppm	Unit conversion		

Measured Herbicide Concentration					
Water Sample Lab Results (2,4-D concentration in ppb)					
	North	Center	South	Mean	Std Error
Pretreatment	0	0	0	0	0
24 Hours	0	0	0	0	0
72 Hours	0	1.5	3.2	1.6	0.92



Sampled locations for measurement of lake-wide herbicide concentration in Clearwater Lake in 2019. Samples collected by Lance Baumann (lake volunteer) and analyzed by SePRO SRTC–Whitakers, NC.

Summary of Evidence

(1) Very low concentration of 2,4-D in Clearwater

Based upon the total amount of 2,4-D applied to Clearwater Lake in 2019, the maximum lake-wide concentration (assuming no degradation of 2,4-D) would be 9 ppb if mixed into the entire lake volume, or 16 ppb if the lake was stratified at 18ft and the herbicide only mixed into the epilimnion (above the thermocline). In addition, water samples collected at 1 and 3 days after treatment showed that the concentration of 2,4-D (1.6 ± 0.92 ppb) was even lower than the estimated maximum lake-wide concentration.

(2) Both the estimated and measured lake-wide 2,4-D concentration in Clearwater were much lower than normally used to kill plants and much lower than observed in the Wisconsin study (Nault et al. 2014)

The estimated maximum lake-wide 2,4-D concentration in Clearwater Lake for 2019 was 9 to 16 ppb. This is only 0.5% to 1% of the lowest concentration used to kill targeted plants in lakes (2000 ppb). Furthermore, at this concentration (2000 ppb), 2,4-D selectively kills dicots (Eurasian watermilfoil, lilies, Elodea, naiads), but most of the aquatic plant species in MN (including all pondweeds) are monocots. These monocots are not killed by 2,4-D at typical concentrations unless the herbicide persists at moderate concentrations for a long period of time.

In the Wisconsin study lakes, the lake-wide 2,4-D concentration was initially 275 ppb to 500 ppb. Although these initial concentrations dropped over time in the WI lakes, the lake-wide concentration of 2,4-D in those lakes remained >100 ppb for 2 to 4 months. Despite this persistence, native plants remained in the lake dosed at 275 ppb. By comparison, this 275 ppb concentration is ~30 times greater than the estimated maximum lake-wide concentration in Clearwater Lake, and ~150 times greater than the 2,4-D concentration measured in water samples after the 2019 treatment.

Conclusion

Given the extremely low lake-wide 2,4-D concentration in Clearwater Lake (estimated and measured), it is my professional opinion that there is no potential for lake-wide impacts on native plants from the amount of 2,4-D applied in 2019.

References

Nault, M. E., et al. (2014). Efficacy, selectivity, and herbicide concentrations following a whole-lake 2,4-D application targeting Eurasian watermilfoil in two adjacent northern Wisconsin lakes. Lake and Reservoir Management 30(1): 1-10.