State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
2801 Progress Rd.
Madison WI 53716

Scott Walker, Governor
Dan Meyer, Secretary

Dear Mr. Christ,

This summer you requested information regarding a water chemistry and aquatic plant survey that Bureau of Water Quality staff from the Department of Natural Resources conducted on July 27th, 2017 on Lake DeNeveu in Fond du Lac County, WI. The water chemistry, sediment, and plant surveys were conducted as part of the National Lake Assessment, a nationwide survey of the ecological, water quality, and recreational health of America's lakes.

Water Chemistry and Trophic State

Although multiple measurements are necessary for a full assessment, the information provided in the table below (Table 1) can provide context on lake water transparency, chemistry, and trophic state, as well as the presence of *E. coli* bacteria and pesticides. Lake DeNeveu is deep seepage lake with hard water, high transparency, and high alkalinity (McGinley and Sisk, 2015). The high mineral content in the water makes the lake resistant to changes in pH and can promote greater fish and aquatic plant productivity. Moderate to high levels of Sodium, Potassium, Chloride, and Sulfate indicate that the lake may be impacted by road salts and fertilizer in the surrounding watershed.

Table 1. Summary of water quality results. Water samples were taken near the surface at the deepest point of the lake. Result of ND indicates that this variable was Not Detected.

Secchi Depth	5.9 M

Depth at Sampling Station	16.7 M

Chemistry	
pH	8.5 SU
Alkalinity-Total CACO3	207 mg/L
Conductivity	580 uS/cm
Dissolved Organic Carbon	6.29 ppm C
Chloride	51.4 mg/L
Aluminum-Total Recoverable	ND ug/L
Calcium-Total Recoverable	33.2 mg/L
Magnesium-Total Recoverable	45.2 mg/L
Potassium-Total Recoverable	2.95 mg/L
Sodium-Total Recoverable	20.6 mg/L
Hardness-Total Recoverable Calculation	269 mg/L
Color	10 SU
Dissolved Silica (mg/L SiO2)	2.3 mg/L
Dissolved Sulfate-As SO4	29.1 mg/L
Turbidity-Lab Nephelometric NTU	0.894 NTU

Nutrients & Algae	
Dissolved Nitrate Nitrogen (mg/L as NO3)	0.427 mg/L
Nitrogen-NH3-N Dissolved	ND mg/L
Total Nitrogen	0.818 mg/L
Total Phosphorus	0.0107 mg/L
Chlorophyll-*a*, Fluorescence (Welschmayer 1994)	1.65 ug/L
Microcystin via ELISA	ND ug/L
Cylindrospermopsin via ELISA	ND ug/L

Bacteria	
E. Coli Colilert Quantitray MPN	1 /100 mL

Pesticide	
Triazine Screen	ND ppb

Lake DeNeveu has an oligotrophic trophic state based on chlorophyll *a* measurements, despite moderate amounts of dissolved nitrate nitrogen, total nitrogen, and total phosphorus (McGinley and Sisk, 2015). These nutrients enhance aquatic plant growth, but too many nutrients can cause excessive algal growth, leading to impairment of water bodies. Measured total nitrogen, total phosphorus, and chlorophyll *a* levels in Lake DeNeveu were below impairment thresholds (WisCALM, 2018). Microcystin and cylindrospermopsin are toxins produced by freshwater cyanobacteria that are commonly associated with harmful algal blooms in nutrient-rich lakes. In Lake DeNeveu, these toxins were Not Detected and thus did not attain levels that could cause high illness risk according to World Health Organization guidelines (WHO, 2003). Additionally, levels of *E. coli* bacteria were below the Environmental Protection Agency (EPA) standard of 235 cfu/100 mL for a single sample maximum (WisCALM, 2018).

Triazine is the name for a widely used group of agricultural herbicides consisting of atrazine, simazine, and propazine. In Lake DeNeveu, Triazine levels were Not Detected and thus below the threshold considered a risk in EPA Cumulative and Ecological Risk Assessments.

Lake profile measurements (Figure 1) were conducted for specific conductivity, dissolved oxygen, pH, and temperature. These profiles can reveal whether lakes are stratified, with a warmer layer of water near the lake surface, or mixed, with similar water conditions throughout the lake depth. Lake DeNeveu exhibited thermal stratification on the sampling date, with significant decreases in water temperature and dissolved oxygen starting at five meters depth (WisCALM, 2018). Water below seven meters is nearly anoxic (without oxygen) and cold, potentially supporting coldwater fish species.

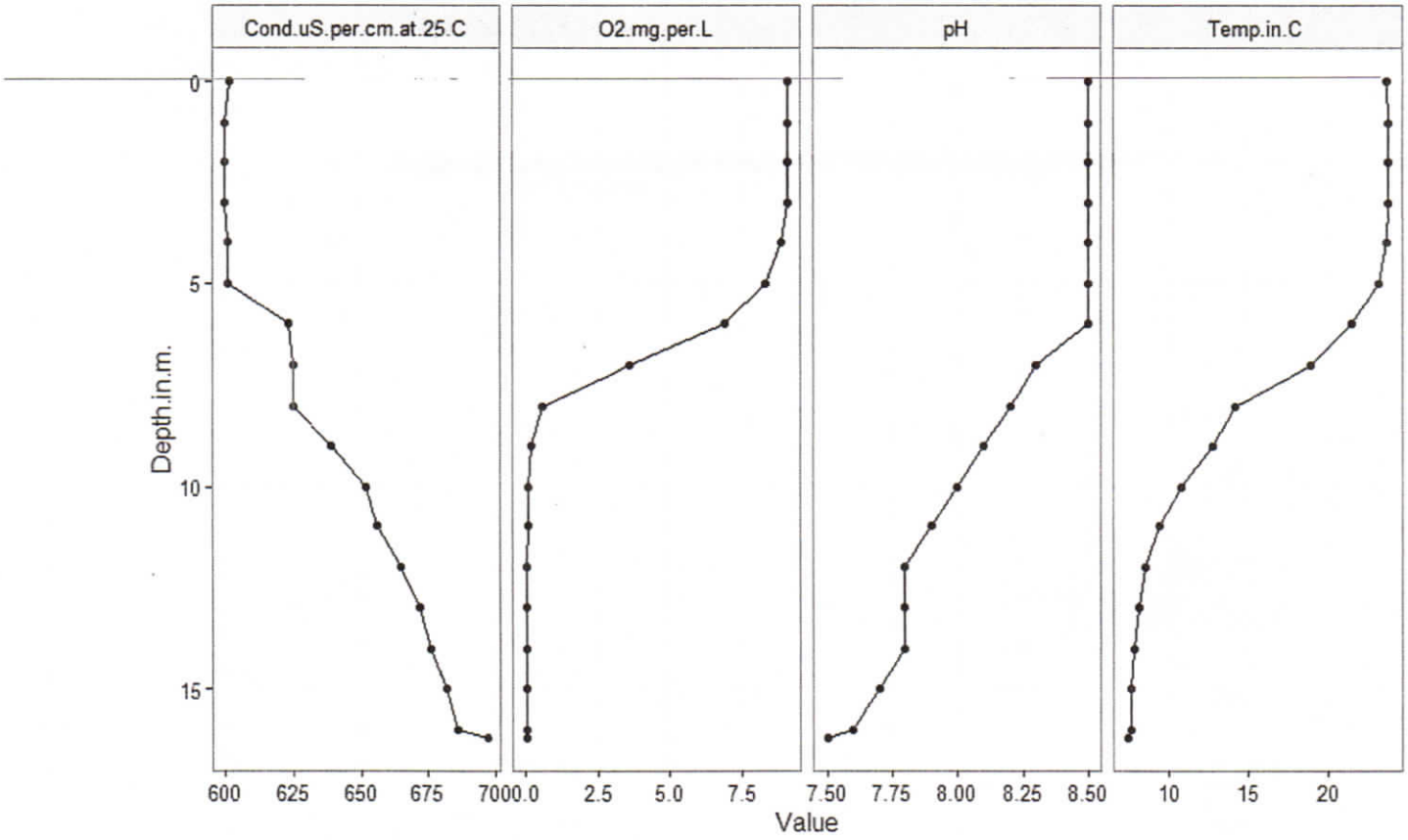

Figure 1. Lake depth (m) profiles for specific conductivity (Cond µS cm^{-1} at 25 °C), dissolved oxygen (mg O_2 L^{-1}), pH, and temperature (Temp in °C) in Lake DeNeveu.

Importance of Aquatic Plants

Aquatic plants form the foundation of healthy lake ecosystems. They not only protect water quality, but also produce life-giving oxygen. Aquatic plants are a lake's own filtering system, helping to clarify the water by absorbing nutrients like phosphorus and nitrogen that could stimulate algal blooms. Plant beds stabilize soft lake bottoms and prevent shoreline erosion by reducing the effect of waves and currents. Aquatic plants provide important habitat for fish, invertebrates, and wildlife. By leaving or restoring a natural buffer area of emergent vegetation along the shoreline, property owners can reduce erosion, help maintain water quality, and provide habitat and travel corridors for wildlife.

Point-Intercept Sampling Method

Based on area and depth specific to Lake DeNeveu, we mapped a 204-point sampling grid over the entire lake surface. Using a GPS, we navigated by boat to each of the pre-determined grid points. At each point we used a two-sided rake to sample aquatic plants from a small area. After pulling the plants to the surface, the overall rake as well as individual species on the rake were assigned a fullness rating of 1, 2 or 3 to estimate density of plant growth (see Figure 2 for descriptions of rake fullness ratings). We also recorded visual sightings of species within six feet of the sample point, as well as any additional species seen in the lake during a general boat survey. We include estimates of how rare or common each species was in the habitable area of the lake using the measure of % Frequency found in Table 2. This measure expresses the percentage of habitable points at which each species was observed. For more detailed information on the point-intercept sampling method and how data were collected please visit: http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic%20Plants/PI-Protocol-2010.pdf

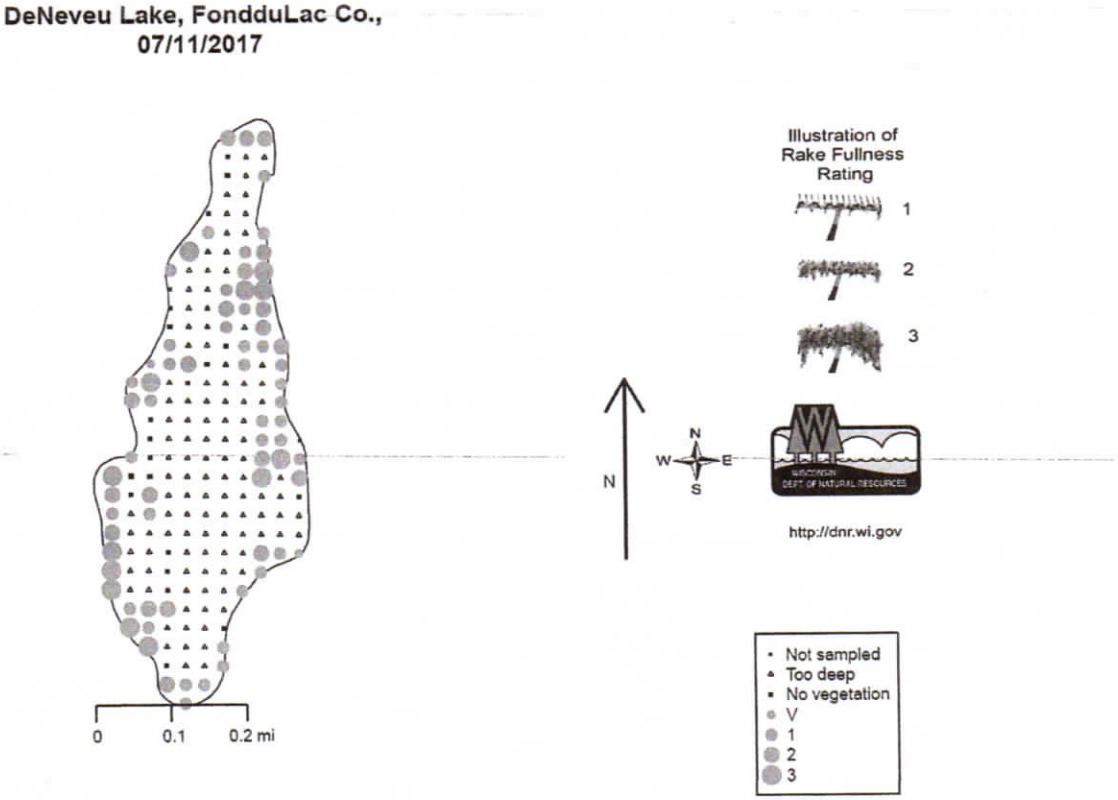

Figure 2. A map of the approximate location and abundance of total aquatic vegetation in Lake DeNeveu. Sampling points labeled "Too deep" were deeper than the maximum colonization depth for aquatic plants in this lake. The size of the colored dot over each sampling point indicates the rake fullness (1, 2, or 3) of aquatic vegetation at that point.

Table 2. Species present in the aquatic plant survey. Frequency of occurrence is calculated by taking the total number of times a species is detected in a lake divided by the total number of points in a lake at which the growth of plants is possible. Voucher specimens have been sent to the UW-Madison Herbarium, therefore all species identifications are subject to change pending verification.

Common Name	Scientific Name	Growth Form	% Frequency of
Muskgrass	*Chara spp.*	Submerged	65.17
Filamentous algae	Various	Free-floating	25.84
Sago pondweed	*Stuckenia pectinata*	Submerged	11.24
Common waterweed	*Elodea canadensis*	Submerged	7.87
Stiff pondweed	*Potamogeton strictifolius*	Submerged	7.87
Northern water-milfoil	*Myriophyllum sibiricum*	Submerged	5.62
Coontail	*Ceratophyllum demersum*	Submerged	4.49
Water star-grass	*Heteranthera dubia*	Submerged	4.49
Slender naiad	*Najas flexilis*	Submerged	2.25
Wild celery	*Vallisneria americana*	Submerged	1.12

Figure 3. Images of the most common species found in Lake DeNeveu: muskgrass, sago pondweed, and common waterweed. Photos by Paul Skawinski (Skawinski, 2014).

We calculated lake-wide aquatic plant statistics to compare to region and statewide averages. Littoral zone percent vegetated (given in Table 3) indicates how often vegetation was observed considering only areas of the lake that are capable of supporting plant growth (known as the "littoral zone"). The maximum depth of plant growth is the deepest depth at which plants were found in the lake. Species richness is a count of the total number of different plant species found in a lake. The Floristic Quality Index (FQI) is a metric that evaluates the closeness of the flora in a lake to that of an undisturbed condition. The higher a FQI value, the closer that plant community is to an undisturbed ecosystem. Statewide and regional averages are calculated from a subset of approximately 735 lakes across Wisconsin.

Table 3. Summary metrics of the aquatic plant community in Lake DeNeveu compared to state and region by lake type averages.

	Lake	Statewide Average	Southern Seepage Average
Littoral Zone % Vegetated	**75.3**	**74.0**	**82.0**
Maximum Depth of Plant Growth (ft)	**22.0**	**15.8**	**16.6**
Species Richness	**9.0**	**16.5**	**14.9**
Floristic Quality Index (FQI)	**16.3**	**26.0**	**21.7**

Invasive Aquatic Species

Invasive species are nonindigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health as defined by Wisconsin Statue section 23.22. Ecological impacts of introduced aquatic invasive species can range in severity depending on differing ecosystem variables and are difficult to predict. Some industries such as sport and commercial fishing and raw water users (power companies and utilities) are also negatively affected by aquatic invasive species. Invasive aquatic plants are problematic because they can grow to nuisance levels. These dense populations of non-native plants often have a negative impact on native plant communities because they are able to out-compete them for available resources needed for survival. Changes in the native plant community have far-reaching effects on fish, birds and invertebrates that need native plants to survive. Nuisance levels of non-native aquatic plants may also inhibit recreational activities (such as fishing, swimming, boating, etc.), decrease aesthetic value, and negatively affect water quality. Many times aquatic invasive species are spread to new waters by hitching a ride on boats, trailers, and other recreational equipment. It is important that everyone utilizing Wisconsin's lake resources do their part to help prevent and stop the spread of aquatic invasive species.

In Lake DeNeveu, the aquatic invasive species Zebra Mussel was identified.

Figure 4. Image of the observed aquatic invasive species in Lake DeNeveu: Zebra Mussel. Photo by Amy Benson, USGS.

References

McGinley, P., and D. Sisk. 2015. Interpreting your Wisconsin lake chemistry. Water & Environmental Analysis Laboratory, University of Wisconsin-Stevens Point.

Skawinski, P. M. 2014. *Aquatic Plants of the Upper Midwest, 2nd Edition.* Wausau, Wisconsin. 225pp.

WDNR. 2018. Wisconsin 2018 Consolidated Assessment and Listing Methodology (WisCALM). April 17th, 2017.

WHO. 2003. Atrazine in drinking water. World Health Organization, Geneva, Switzerland.

Additional Resources

Wisconsin's Lakes
http://dnr.wi.gov/lakes/