State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
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This report provides information regarding a water chemistry survey that Bureau of Water Quality staff from the Department of Natural Resources conducted on June 28, 2022 on Lake DeNeveu in Fond du Lac County, WI. This survey was 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 clarity, chemistry, and trophic state. DeNeveu Lake is a drainage lake with high hardness and alkalinity (McGinley and Sisk, 2015). Levels of sodium, potassium, chloride, and sulfate indicate there is no major impact by road salts or fertilizer in the surrounding watershed.

Water clarity measures the ability of light to pass through water and can be lowered by algae, sediment like silt and clay, or dissolved substances that often give a tea color to lakes. The water clarity on DeNeveu Lake is clear. Chlorophyll a, a measure of algal pigments, was moderate. Turbidity, a measure of all particles that cloud the water, is moderate on this lake. DeNeveu Lake also has little staining from dissolved substances. The color scale goes from crystal clear water at 0 to the darkest brown at 500. Highly stained lakes have a lot of tannins and other natural organic matter.

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.

Chemistry

Alkalinity-Total $CaCO_3$	220	mg/L
Conductivity	570	uS/cm
Dissolved Aluminum	ND	mg/L
Dissolved Calcium	30.6	mg/L
Dissolved Chloride	46.1	mg/L
Dissolved Magnesium	46.8	mg/L
Dissolved Potassium	3.26	mg/L
Dissolved Sodium	21.8	mg/L
Dissolved Sulfate	27.7	mg/L
Dissolved Iron	ND	mg/L
Dissolved Silica	4.15	mg/L
Hardness	269	mg/L
pH	8.78	SU
Color	5	SU
Dissolved Organic Carbon	6.39	ppm C
Turbidity	5.33	NTU

Clarity

Deep Hole Depth	21.3	m
Secchi Depth	1.2	m

Nutrients and Algae

Dissolved Nitrite (NO_2^-)	0.02	mg/L
Dissolved Nitrate (NO_3^-)	0.11	mg/L
Dissolved Ammonia (NH_3)	ND	mg/L
Dissolved Total Nitrogen	0.73	mg/L
Total Nitrogen	1.05	mg/L
Dissolved Phosphorous	ND	mg/L
Total Phosphorus	0.02	mg/L
Chlorophyll-*a*	28.6	ug/L
Mycrocystin	0.1	ug/L
Cylindrospermopsin	ND	ug/L

Pesticide

Triazine	ND	ppb

DeNeveu Lake is eutrophic, meaning that nutrients are high with abundant plants, algae, and fish. Although dissolved phosphorus and ammonia were not detected, the concentrations of total phosphorus and nitrogen were high (McGinley and Sisk, 2015). These nutrients enhance aquatic plant and fish growth, but too many nutrients can cause excessive algal growth, leading to poor water quality. At least six measurements over two years are needed to complete a water quality assessment for lakes. This single sample event indicates that DeNeveu Lake could be impaired for chlorophyll *a*, and is at the threshold for total phosphorus. To protect aquatic life on deep drainage lakes, total phosphorus must be < 30 ug/L and chlorophyll *a* must be below 27 ug/L. To protect recreational uses, chlorophyll *a* must be below 20 ug/L at least 95% of summer days. (WisCALM, 2022).

Microcystin and cylindrospermopsin are toxins produced by freshwater cyanobacteria that are commonly associated with harmful algal blooms in nutrient-rich lakes. The EPA recommends swimming advisories take effect if microcystins are ≥ 8 ug/L or cylindrospermopsins are >15 ug/L. In DeNeveu Lake, these toxins were detected but did not attain levels that could be hazardous to human health through recreation according to the EPA.

Triazine is the name for a widely used group of agricultural herbicides consisting of atrazine, simazine, and propazine. In DeNeveu Lake, 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 from top to bottom. Lake DeNeveu exhibited thermal stratification on the sampling date, with decreases in dissolved oxygen and water temperature beginning at three meters depth. Water below ten meters is nearly anoxic (without oxygen) and cold. This is a natural phenomenon in deep lakes that stratify and are moderately productive.

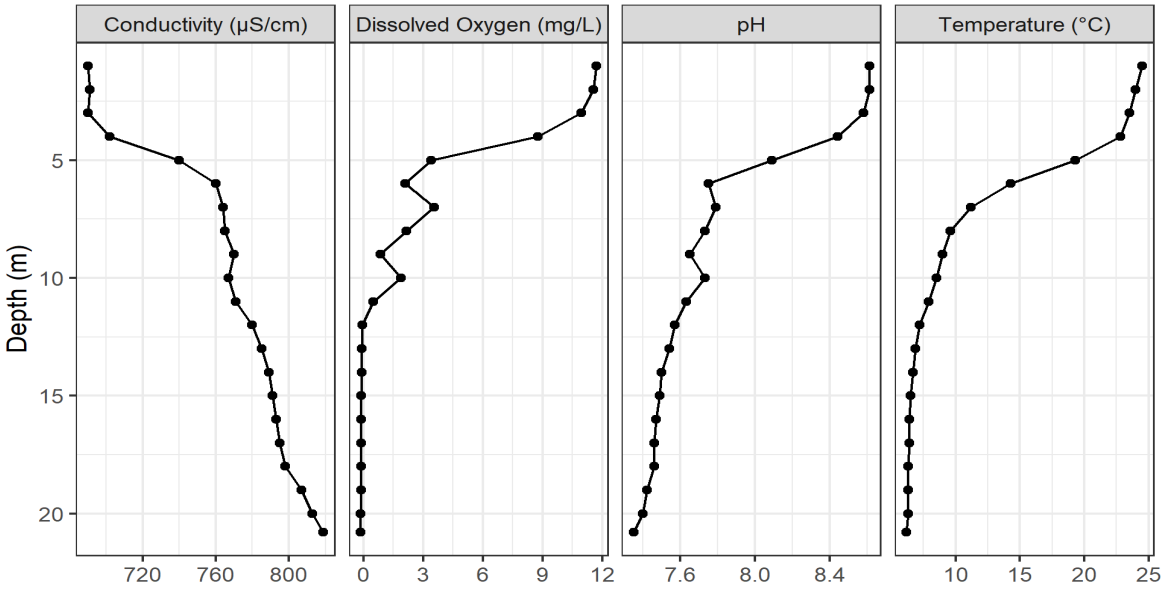

Figure 1. Specific conductivity, dissolved oxygen, pH, and temperature from the surface to the bottom of DeNeveu Lake

PFAS (Per- and Poly-Fluorinated Alkyl Substances) are organic compounds that have been manufactured since the 1940's for fire retardants, non-stick surfaces, water repellants, and other uses. Due to their chemical structure (carbon-fluorine bond), they tend not to degrade naturally and are now pervasive in the environment. They can have negative human health effects. Wisconsin has surface water standards for two types of PFAS: PFOS must be below 8.0 ng/L and PFOA below 95 ng/L. In DeNeveu Lake, both water quality standards were met. Although PFOS and PFOA may be detected in surface water, low concentrations likely come from precipitation as low concentrations of PFAS can be found in WI rainwater (Pfotenhauer et al. 2022).

Table 2. PFOS and PFOA concentrations in the surface water at the deepest point of the lake.

PFOS			**PFOA**		
Perfluoro-n-octanesulfonic acid	0.27	ng/g	Perfluoro-n-octanoic acid	0.71	ng/g

PFOS accumulates in fish, and DNR has fish consumption advisories for the state of Wisconsin. If PFOS is <10 ng/L in fish tissue, no limits on fish consumption exist. Wisconsinites should only eat one meal per week if PFOS is 10-50 ng/L, one meal per month if PFOS is 50-200 ng/L, and no fish if PFOS is > 200 ng/L in fish tissue. Anglers fishing on DeNeveu Lake do not need to limit fish consumption due to PFOS. DNR is monitoring other areas of the state where surface water concentrations are above the PFOS and PFOA standards or where PFOS fish consumption advisories have been issued (see the PFAS DataViewer below).

Mercury is a heavy metal that is released to the atmosphere through coal-fired utility and incinerator emissions, as well as evaporation from water and land. Once mercury enters the environment, it can remain for years as it accumulates. Mercury accumulates in the body over time and incrementally increases at each level of the food chain. Once mercury enters the body of an animal or a person, it can affect the function and development of the central nervous system, as well as cause other adverse health impacts such as reproductive and behavioral problems. The National Lakes Assessment is testing mercury in fish across the nation to update a study done 20 years ago quantifying the extent of mercury contamination in fish. For the National Lakes Assessment study, we collected multiple individuals of similar size from a single species and analyzed the mercury concentration in their combined tissue. This approach gives an overall picture of mercury contamination across the US. The Wisconsin DNR measures mercury in many individual fish to develop fish consumption advisories to protect human health. Although our study did not measure mercury in enough individual fish to assess fish consumption risks, the concentrations of mercury in the samples we collected on DeNeveu Lake were below thresholds that normally trigger a fish consumption advisory to protect human health.

Table 3. Mercury and PFOS concentrations in fish tissue samples combined by species.

Species	**Measurement**	**Result**	**Limit of Detection**
Bluegill	Mercury (Hg)	0.12 ug/g	<0.01 ug/g
Bluegill	PFOS	<1.08 ng/g	1.08 ng/g

Aquatic Invasive Species (AIS)

Aquatic invasive species (AIS) 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 aquatic invasive species can range in severity depending on a variety of factors and are difficult to predict. Aquatic invasive species can grow to nuisance levels, and dense populations of AIS often negatively impact native communities by out-competing them for resources. Nuisance levels of AIS may also inhibit recreational activities (such as fishing, swimming, boating, etc.), decrease aesthetic value, and negatively affect water quality. AIS often spread to new waters by hitching a ride on boats, trailers, and other recreational equipment. Everyone enjoying Wisconsin lakes should help stop the spread of AIS. We observed one AIS on DeNeveu Lake.

Table 4. AIS found during the 2022 NLA survey of DeNeveu Lake

Type	Common Name	Scientific Name
Animal	Zebra Mussel	*Dreissena polymorpha*

Figure 2. Image of the observed aquatic invasive species found on DeNeveu Lake. Photo provided by Amy Benson, USGS.

Aquatic Plant Point Intercept Survey

Based on area and depth specific to DeNeveu Lake, we mapped a 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. 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 5. This measure expresses the percentage of habitable points at which each species was observed.

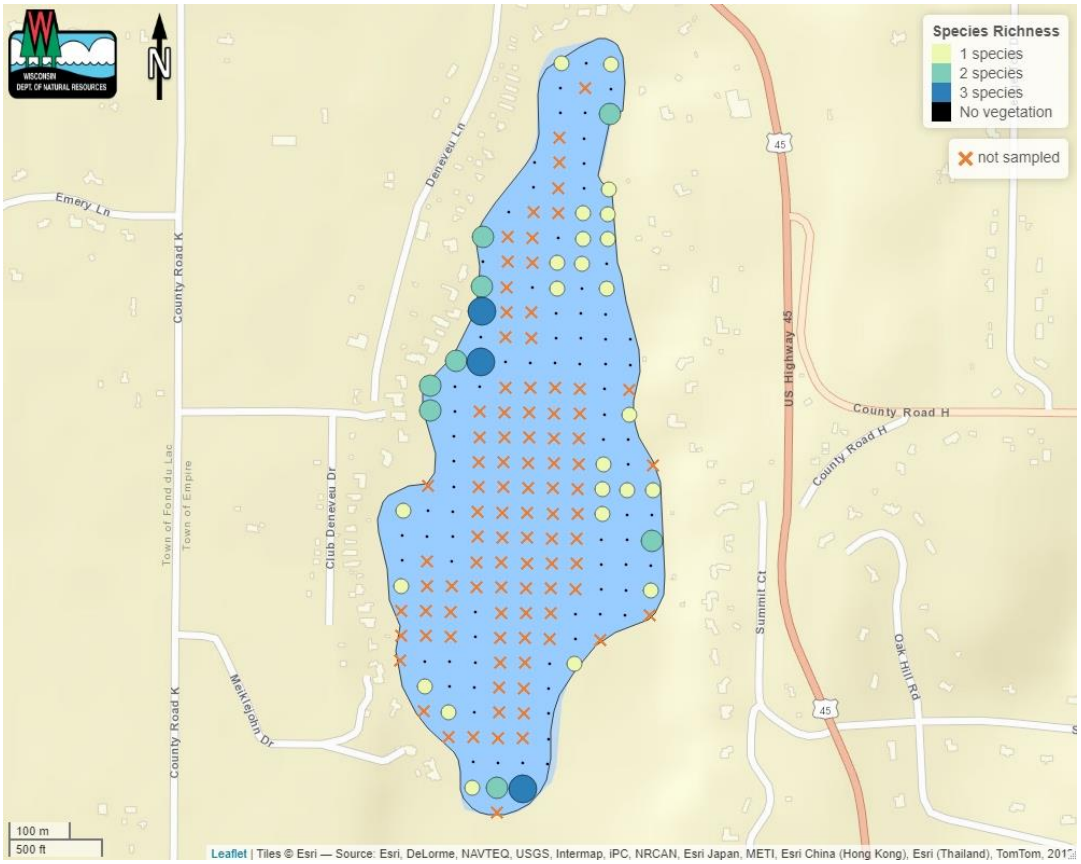

Figure 3. Map of DeNeveu Lake showing the number of aquatic plant species (species richness) found at each sample point. Points not sampled were either too deep or shallow for plant growth or had obstacles in the way.

Table 5. 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, so all species identifications are subject to change pending verification.

Common Name	Scientific Name	Growth Type	% Frequency
Fetid Stonewort	*Chara contraria*	Submersed	42
Filamentous Algae	No scientific name	Submersed	36
Sago Pondweed	*Stuckenia pectinata*	Submersed	16
Water Star-grass	*Heteranthera dubia*	Submersed	6
Coontail	*Ceratophyllum demersum*	Submersed	3
Globular Stonewort	*Chara globularis*	Submersed	3
Horned Pondweed	*Zannichellia palustris*	Submersed	3
Small Pondweed	*Potamogeton pusillus*	Submersed	2
Water Celery	*Vallisneria americana*	Submersed	2

Figure 4. Images of the most common species found in DeNeveu Lake: fetid stonewort (left), filamentous algae (center), and sago pondweed (right). Photos by Paul Skawinski (Skawinski, 2014).

We compare Lake DeNeveu to other lakes of the same type and to all lakes in the state where we have conducted aquatic plant surveys (Table 6). Littoral zone percent vegetated (Table 6) indicates how often vegetation was observed considering only areas of the lake that are shallow enough for aquatic plants (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 counts the total number of plant species found in the lake. The last two metrics describe the quality of the plant community based on "coefficients of conservatism" or "C" values assigned to each species by plant experts. Native species with high C values (scaled from 0 to 10) are more sensitive to disturbance, so a higher Mean C and higher Floristic Quality Index (FQI) indicate a plant community closer to an undisturbed ecosystem. In general, Lake DeNeveu has lower plant abundance, variety, and quality than average.

Table 6. Lake-wide metrics describing the aquatic plant community in DeNeveu Lake compared to all lakes in the state and all southern drainage lakes.

Plant Metric	DeNeveu Lake	Southern Drainage Average	Statewide Average
Littoral Zone % Vegetated	54	78	73
Maximum Depth of Plant Growth (ft)	9	14.1	13.4
Species Richness	8	16.3	19.8
Mean C	4	5.3	6.1
Floristic Quality Index (FQI)	11	19.8	25.7

DNR uses two assessment methods to evaluate the condition of a lake's aquatic plant community. The first assessment method is called the Macrophyte Assessment of Condition-General (MAC-Gen) and describes overall aquatic plant community condition in response to multiple sources of anthropogenic disturbance. The second method, called the Macrophyte Assessment of Condition-Phosphorus (MAC-P), reflects a plant community's response to phosphorus. The plant community in this lake attains both bioassessment criteria. Statewide, 48% of lakes attain the MAC-Gen criterion, and 66% of lakes attain the MAC-P criterion (Table 7).

Table 7. Percent of lakes that fall into each of the four assessment categories listed below for our two assessment methods: MAC-Gen and MAC-P. Percentages are listed for all lakes of the same type and for all lakes statewide. The bottom row in each section gives the assessment result for DeNeveu Lake.

MAC-Gen	Not Attained	Attained	Good	Not Assessed
Southern Drainage Average %	59.6	32.6	-	7.8
Statewide Average %	22.6	47.8	14.1	15.4
DeNeveu Lake		**Attained**		

MAC-P	Not Attained	Attained	Good	Not Assessed
Southern Drainage Average %	24.7	30.3	37.1	7.8
Statewide Average %	18.8	66.2	6.7	8.3
DeNeveu Lake		**Attained**		

References

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

Pfotenhauer, D., E. Sellers, M. Olson, K. Praedel, M. Shafer. 2022. PFAS concentrations and deposition in precipitation: An intensive 5-month study at National Atmospheric Deposition Program – National trends sites (NADP-NTN) across Wisconsin, USA. Atmospheric Environment 291: 1-12.

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

Wisconsin Department of Natural Resources. 2022. Wisconsin 2022 Consolidated Assessment and Listing Methodology (WisCALM) for CWA Section 303(d) and 305(b) Integrated Reporting. January 14, 2021.

Additional Resources

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

Wisconsin Water Search
http://dnr.wi.gov/water/waterSearch.aspx

Wisconsin State Herbarium and Plant Identification
http://www.botany.wisc.edu/wisflora/

Invasive Species in Wisconsin
http://dnr.wi.gov/topic/Invasives/

Aquatic Plant Management in Wisconsin
http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/aquaticplants/default.aspx

EPA National Aquatic Resource Surveys
https://www.epa.gov/national-aquatic-resource-surveys

Please note that while this study conforms to statewide protocol and standards for baseline data collection, it may not be suitable for management purposes. For information as to whether this survey meets requirements for management plans or permitting requirements, please contact your local DNR lake coordinator (copied below).

If you have any additional questions regarding the study, please feel free to contact us.

Sincerely,

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