

Water Quality of Mule Lake

Since 1991, citizen volunteers from Mule Lake have participated in the Minnesota Pollution Control Agency's (MPCA) Citizen Lake Monitoring Program (CLMP), recording secchi disc transparency – a measure of water clarity. Clarence Wachter, Marjorie R. Dahlager and Roger Hermanutz have been the primary volunteers recording these data for Mule Lake.

On the MPCA's web-site link, "Lake Water Quality Database," additional water chemistry data are commonly reported, although none is listed for Mule Lake. The MPCA's "Environmental Database Access" system also provides additional water chemistry data which includes total phosphorus concentrations, as well as other data, although only the secchi measurements present.

One application of secchi disc transparency data is to convert the clarity measurements into a Carlson Trophic Status Index (TSI) score. The Carlson Trophic Status Index (TSI) is a tool used to summarize several measurements of water quality into one index value, which can be used to compare a lake to other lakes, or to historic/future data as a measure of degradation or improvement. In many ways, the index can be viewed as a measure of the potential for algal productivity. Since most people value lakes with low algae productivity, the lower the TSI value the healthier the lake. Specifically:

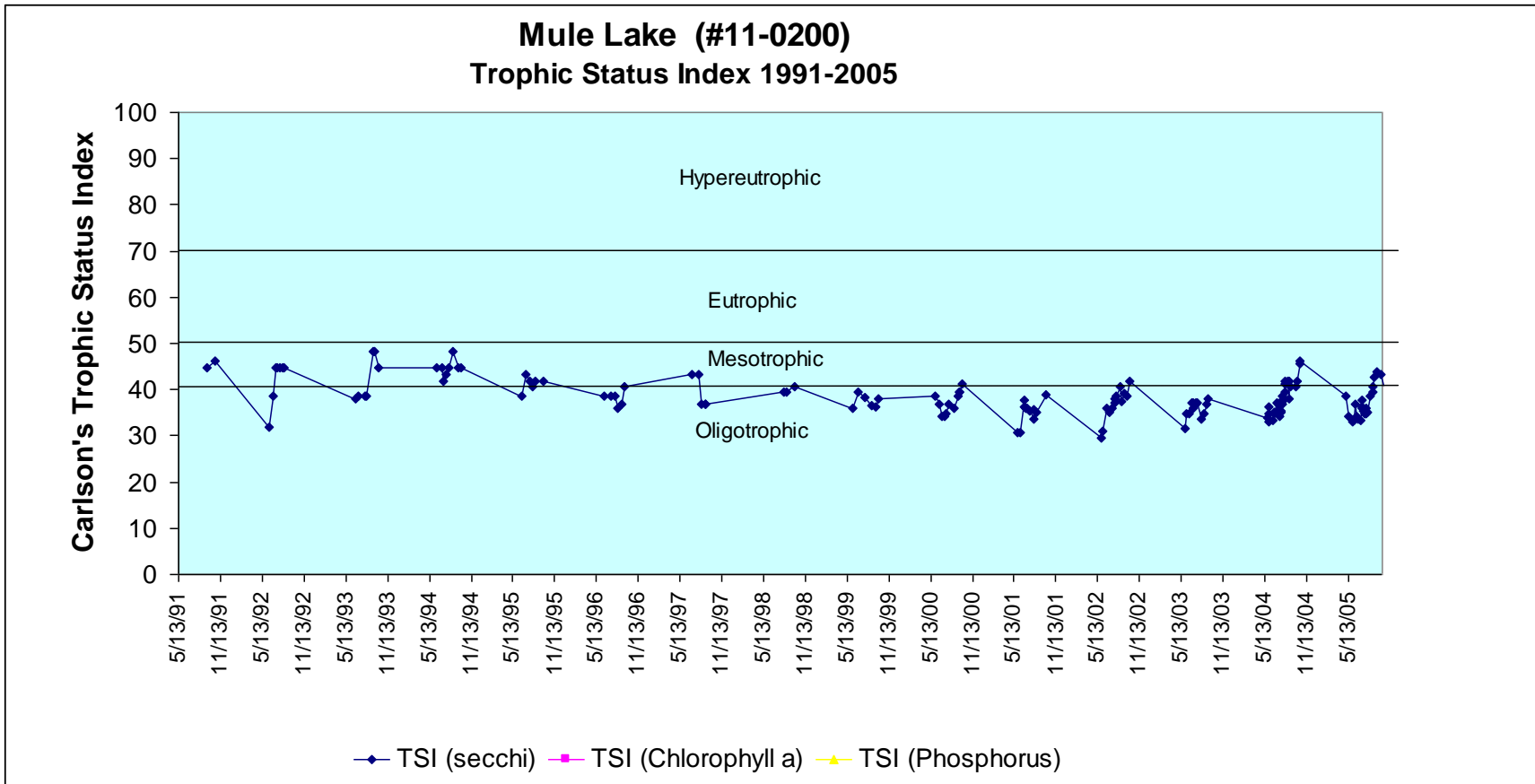
| TSI Range | Trophic Status | Characteristics |
|------------------|-----------------------|---|
| 0-40 | Oligotrophic | Clean Lake |
| 41-50 | Mesotrophic | Temporary algae & aquatic plant problems |
| 50-70 | Eutrophic | Persistent algae & aquatic plant problems |
| Greater than 70 | Hypereutrophic | Extreme algae & aquatic plant problems |

Based on the data provided on the MPCA website, an average concentration (or depth) for the key TSI parameters can be determined, and the associated TSI score calculated.

Average TSI Measurements for Mule Lake

| Year | Chlorophyll a ($\mu\text{g/L}$) | Total Phosphorus ($\mu\text{g/L}$) | Secchi Depth (feet) | Average TSI |
|------|--------------------------------------|---|------------------------|-------------|
| 1991 | --- | --- | 9.0 | 45.5 |
| 1992 | --- | --- | 12.2 | 42.0 |
| 1993 | --- | --- | 11.9 | 42.1 |
| 1994 | --- | --- | 9.6 | 44.6 |
| 1995 | --- | --- | 12.0 | 41.4 |
| 1996 | --- | --- | 15.0 | 38.2 |
| 1997 | --- | --- | 14.1 | 39.3 |
| 1998 | --- | --- | 13.2 | 40.0 |
| 1999 | --- | --- | 15.7 | 37.5 |
| 2000 | --- | --- | 16.0 | 37.3 |
| 2001 | --- | --- | 18.8 | 35.1 |
| 2002 | --- | --- | 16.9 | 36.8 |
| 2003 | --- | --- | 17.7 | 35.8 |
| 2004 | --- | --- | 15.6 | 38.0 |
| 2005 | --- | --- | 16.7 | 36.9 |

These data suggest that water quality in Mule Lake has exhibited conditions in the lower “mesotrophic” (a score above 40 but below 50) or upper “oligotrophic” conditions (a TSI score below 40) during the period of record.



The table above shows the long-term trend in Trophic Status Index values for the years for which data are available for **Mule Lake**. The variation observed within a single year reflects naturally occurring impacts of temperature, precipitation and water level; the important ‘take home message’ of these graphs is that the data suggests a fairly stable range within the lower mesotrophic/upper oligotrophic conditions since data were first collected in 1991.

A second method of assessing water quality and determining whether your water body is the “best that it can be” is to compare it to other lakes of similar morphology, geology, and land uses. Listed below are ranges of common measures of water quality based on many years and locations of water quality. The tables below are adapted from the MN Pollution Control Agency “Environmental Data Access” database, and compare observe results in Mule Lake to common water quality ranges for lakes within the Northern Lakes and Forests Eco-region.

Average Summer Water Quality and Trophic Status Indicators

| Parameter | Typical Range: Northern Lakes & Forest Eco-region | Mule Lake Average + St. Dev. |
|---|---|------------------------------------|
| Total Phosphorus (µg/L) | 14 – 27 | 19 |
| Chlorophyll a (µg/L) mean | 4 – 10 | 3.39 |
| Chlorophyll a (µg/L) maximum | <15 | ND |
| Secchi disc (feet) | 8 – 15 | 15.3 + 3.9 |
| Total Kjeldahl Nitrogen (mg/L) | 0.4 – 0.75 | ND |
| Nitrite + Nitrate Nitrogen (mg/L) | <0.01 | ND |
| Alkalinity (mg/L) | 40-140 | 67 |
| Color (Pt-Color units) | 10 – 35 | ND |
| pH | 7.2 – 8.3 | 8.1 + 0.6 |
| Chloride (mg/L) | 0.6 – 1.2 | ND |
| Total Suspended Solids (mg/L) | <1 – 2 | ND |
| Total Suspended Inorganic Solids (mg/L) | <2 | ND |
| Conductivity (µmhos/cm) | 50 – 250 | 160.8 + 33.9 |
| Total Nitrogen/Total Phosphorus ratio | 25:1 – 35:1 | ND |

ND = No Data

Data listed without standard deviation represent a single sample collected by DNR Fisheries Biologists on July 16, 2001.

A third application of these data is to compare phosphorus concentrations to the Minnesota Pollution Control Agency water quality criterion for swimming and other recreational contact. The Northern Lakes and Forests Ecoregion phosphorus criteria level of 30 micrograms per liter (µg/L) serves as the upper threshold for full-support for swimmable use. This concentration corresponds to Carlson's TSI values of 54 or lower.

For the Northern Lakes and Forests ecoregion, summer-mean total phosphorus concentrations above 35 µg/L were associated with nonsupport of aquatic recreational use. At concentrations above about 35 µg/L mild blooms occur over 50 percent of the summer, nuisance blooms (> 20 µg/L of chlorophyll a) about 15 percent of the summer.

Phosphorus concentrations above criteria levels would result in greater frequencies of nuisance algal blooms and increased frequencies of "impaired swimming."

| Name | Mean Total Phosphorus (µg/l) | Carlson's Trophic Stratus Index (secchi) | MPCA Swimming Criterion ¹ |
|-----------|------------------------------|--|--------------------------------------|
| Mule Lake | No data | 38.3 | Full Support |

Based on the phosphorus concentration (estimated using secchi depth) presented above, Mule Lake “fully supports” recreational use and contact.

Detail comparison results for 2006 on the chemistry dimensions from the water sampling conducted by Outdoor Corp from the University of Minnesota Extension Office and the Initiative Foundation are as follows:

Total Phosphorous

Phosphorous (P) concentrations are important to measure in lakes because P concentrations affect plant growth. As P concentrations increase, plant growth also increases and overall lake quality decreases. Some of the effects of P enrichment include loss of clarity and low dissolved oxygen which stresses fish and other organisms. Total phosphorus concentrations averaged 25 µg/l (0.025 mg/L) over the summer, which correlates to a TSI value of 50 for Mule Lake. Typical values range from .014 to .027 with a TSI of 41.

Chlorophyll-a

Measuring chlorophyll-a provides a reasonable estimate of how much algae is in the water. Chlorophyll-a is a measure of the green pigment that is responsible for a plant's ability to photosynthesize. Chlorophyll-a levels averaged 5 µg/l, which when transformed, provided a TSI value of 46 for Mule Lake. Typical values would be less than 10 with a TSI of 53.

Water Transparency

Water transparency is measured using a Secchi disk. Light absorption and attenuation are important factors in controlling temperature and potential photosynthesis. Photosynthesis provides food that supports much of the food web as well as much of the dissolved oxygen in the water. Transparency values from Mule Lake averaged 4 m (13 feet) which yielded a TSI value of 40. Typical values would be 7.9 to 15.1 feet with a TSI of 42.

TSI Classification

Based on total phosphorous, chlorophyll-a, and water transparency TSI values, Mule Lake is on the higher end of the moderate nutrient lakes range due partly to the comparatively higher level of phosphorous to other ecoregion lakes.

Dissolved Oxygen

Dissolved oxygen stratifies with temperature. In general cooler water holds more oxygen. Healthy oxygen levels (> 4.0 mg/L) were maintained to a depth of 6 m in June, 5 m in July, and to maximum sampling depth in September and October. Low oxygen conditions are common in many lakes during the summer. As fall turnover occurs,

oxygen is restored throughout the lake to healthy levels as was the case with September and October sampling results for Mule Lake.

pH

Acidity in lakes is measured by recording the water's pH on a scale from 0 to 14. A pH of 7 is considered neutral where results below 7 reflect acidity while those above reflect the water's basic state. pH levels are influenced by surrounding geology, land use, and climate. The aquatic environment will remain healthy as long as a lake is neither too basic nor too acidic. Observed levels in Mule Lake ranged from 7.2 to 8.9 pH values in lakes in the same ecoregion which typically range from 7.2 to 8.3.

Conductivity

Conductivity is a measure of dissolved ions in the water, and like pH, is affected by the geology of the region and land use around the lake and within its watershed. Conductivity values for Mule Lake do not show unusually high levels of dissolved ions present in the lake compared to lakes in the same ecoregion. Typical ranges are .050 to .250 and Mule Lake ranged .126 to .145.

Preliminary results from the 2007 testing illustrate a trend consistent with the findings of 2006.