# Trout Lake 31-0410-00 ITASCA COUNTY

## Lake Water Quality

## Summary

Trout Lake is located 20 miles north of Grand Rapids, MN in Itasca County. It is a long lake covering 1,736 acres (Table 1).

Trout Lake has four inlets and one outlet, which classify it as a groundwater drainage lake. Water enters Trout Lake from ground-fed streams in the north and northwest, and there is also a large groundwater interaction component with the lake itself . Trout Lake Creek exits the lake on the south side of Trout Lake and carries water south to the Mississippi River.

Water quality data have been collected on Trout Lake since 1992 (Tables 2 & 3). These data show that the lake is oligotrophic (TSI = 36) with very clear water conditions all summer. In fact, it is so cold and deep that it supports lake trout.

Trout Lake is part of the Wabana Chain of Lakes Association (WCOLA). The association is involved in activities such as water quality monitoring and education. Trout Lake itself is mostly located in federally-owned land (Figure 16, Table 11).

Table 1. Trout Lake location and key physical characteristics.

| Location Data | | Physical Characteristics | |
|---|---|---|---|
| MN Lake ID: | 31-0410-00 | Surface area (acres): | 1736 |
| County: | Itasca | Littoral area (acres): | 741 |
| Ecoregion: | Northern Lakes and Forests | % Littoral area: | 43 |
| Major Drainage Basin: | Mississippi R. -Grand Rapids | Max depth (ft), (m): | 157, 48 |
| Latitude/Longitude: | 47.460885/ -93.552839 | Inlets: | 4 |
| Invasive Species: | None | Outlets: | 1 |
| | | Public Accesses: | 0 |

Table 2. Availability of primary data types for Trout Lake.

## Data Availability

| | | |
|---|---|---|
| Transparency data |  | Good data set from 1992-2011 through the CLMP. |
| Chemical data |  | Good data set through WCOLA monitoring. |
| Inlet/Outlet data | -- | Not necessary |

**Recommendations** **For recommendations refer to page 19.**

## Lake Map

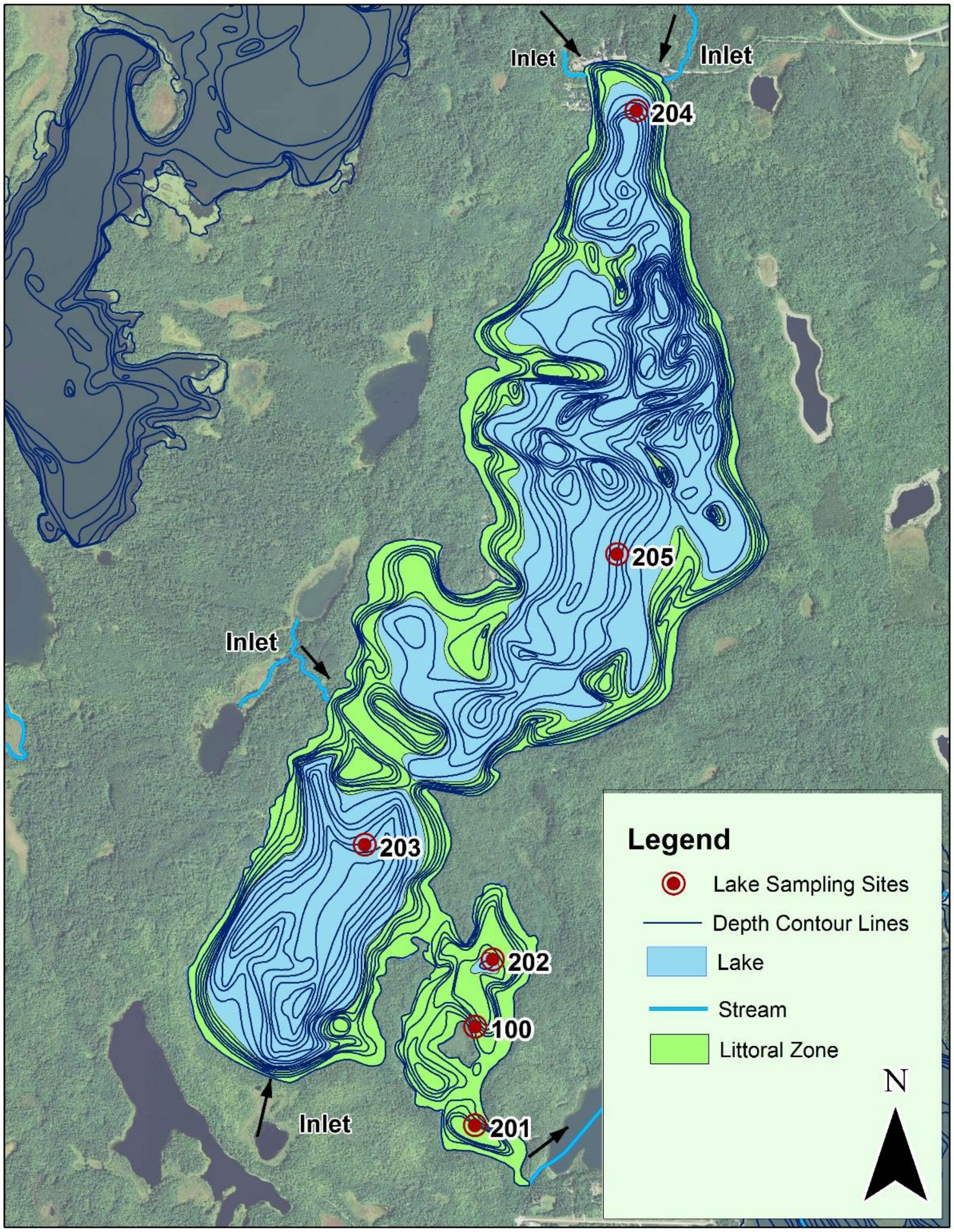



Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), MPCA Lake Monitoring Program Project (LMPP), Lake Monitoring Program (LMP), Itasca County Lake Assessment (ICLA); Wabana Chain of Lakes (WCOLA).

| Lake Site | Depth (ft) | Monitoring Programs |
|---|---|---|
| 100 | NA | ICLA: 2001-2002; LMP: 2000, LMPP: 1988,1991 |
| 201 | 20 | CLMP: 1988,1990,1993-1995,2008-2011 |
| 202 | 40 | CLMP: 1988,1990,1993-2001,2003-2011 |
| 204* Primary site | 80 | CLMP: 1992-2011; WCOLA: 2003, 2005, 2008, 2010-2011, 2014-2015 |
| 205 | 100 | CLMP: 2005-2011 |

# Average Water Quality Statistics

The information below describes available chemical data for Trout Lake through 2015 (Table 4). Data for Secchi depth is from the primary site 204. Data for total phosphorus and chlorophyll *a* are from site 100.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. For more information on ecoregions and expected water quality ranges, see page 11. Trout Lake is in the Northern Lakes and Forests Ecoregion.

Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.

| Parameter | Mean | Ecoregion Range[1] | Impaired Waters Standard[2] | Interpretation |
|---|---|---|---|---|
| Total phosphorus (ug/L) | 9.5 | 14 – 27 | > 30 | Results are better than the expected range for the Northern Lakes and Forests Ecoregion. |
| [3]Chlorophyll *a* (ug/L) | 1.7 | 4 – 10 | > 9 | |
| Chlorophyll *a* max (ug/L) | 4.1 | < 15 | | |
| Secchi depth (ft) | 16.8 | 8 – 15 | < 6.5 | |
| Dissolved oxygen | *See page 8* | | | Dissolved oxygen depth profiles show that the lake mixes in spring and fall (dimictic). |
| Total Kjeldahl Nitrogen (mg/L) | 0.3 | <0.4 – 0.75 | | Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms. |
| Alkalinity (mg/L) | 123.3 | 40 – 140 | | Indicates a low sensitivity to acid rain and a good buffering capacity. |
| Color (Pt-Co Units) | 3.0 | 10 – 35 | | Indicates clear water with little to no tannins (brown stain). |
| pH | 8.3 | 7.2 – 8.3 | | Within the expected range for the ecoregion. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water. |
| Chloride (mg/L) | 0.6 | 0.6 – 1.2 | | Within the expected range for the ecoregion. |
| Total Suspended Solids (mg/L) | 1.8 | <1 – 2 | | Indicates low suspended solids and clear water. |
| Specific Conductance (umhos/cm) | 225.4 | 50 – 250 | | Within the expected range for the ecoregion. |
| TN:TP Ratio | 30:1 | 25:1 - 35:1 | | Within the expected range for the ecoregion, and shows the lake is phosphorus limited. |

[1]The ecoregion range is the 25$^{th}$-75$^{th}$ percentile of summer means from ecoregion reference lakes
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

## Water Quality Characteristics - Historical Means and Ranges

Table 5. Water quality means and ranges for primary sites.

| Parameters | Primary Site 204 | 202 | 205 |
|---|---|---|---|
| **Total Phosphorus Mean (ug/L):** | **9.5** | **NA** | **NA** |
| Total Phosphorus Min: | <5 | NA | NA |
| Total Phosphorus Max: | 17 | NA | NA |
| Number of Observations: | 37 | NA | NA |
| **Chlorophyll *a* Mean (ug/L):** | **1.7** | **NA** | **NA** |
| Chlorophyll-a Min: | <1 | NA | NA |
| Chlorophyll-a Max: | 4.1 | NA | NA |
| Number of Observations: | 34 | NA | NA |
| **Secchi Depth Mean (ft):** | **16.8** | **17.5** | **17.0** |
| Secchi Depth Min: | 9.5 | 11.0 | 10.0 |
| Secchi Depth Max: | 29.5 | 26.0 | 26.0 |
| Number of Observations: | 205 | 205 | 186 |

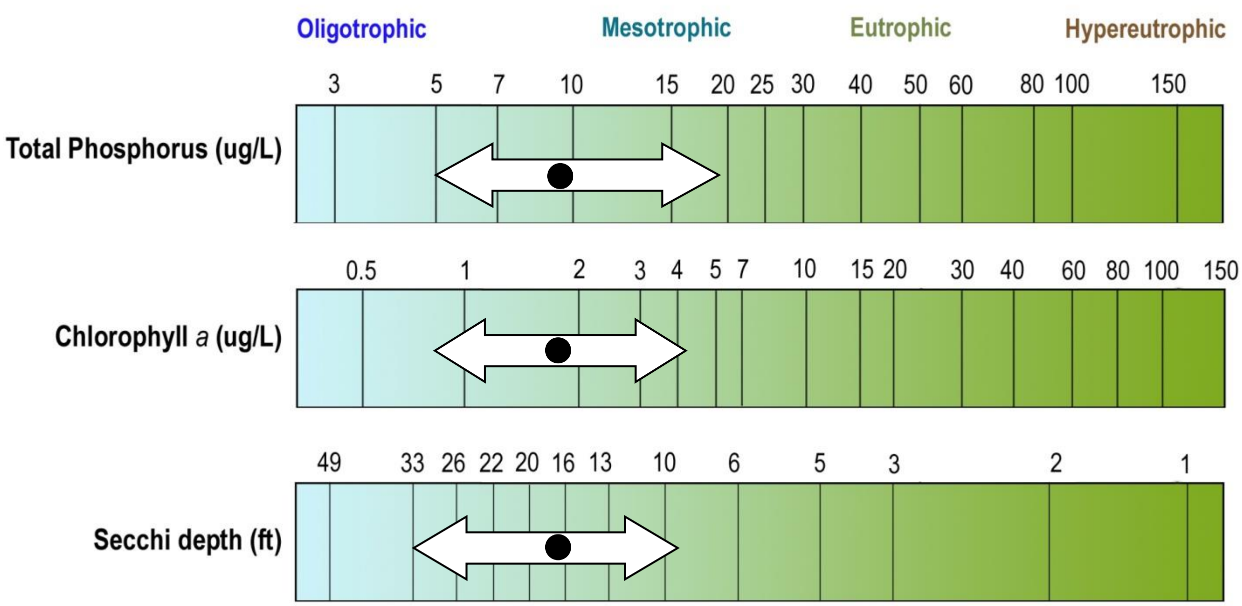



Figure 1. Trout Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 204). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

# Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the amount of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

The annual mean transparency in Trout Lake ranges from 14.6 to 19.1 feet (Figure 3). The annual means hover fairly close to the long-term mean. For trend analysis, see page 10. Transparency monitoring should be continued annually at site 204 in order to track water quality changes.

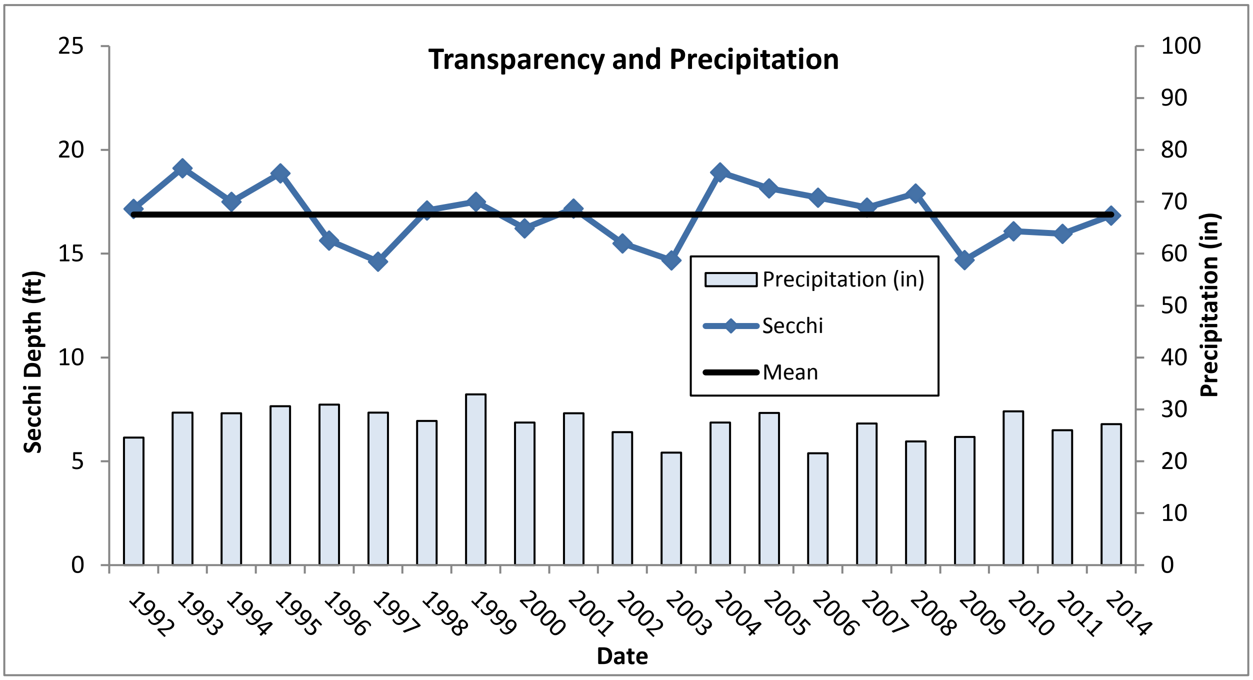



Figure 2. Annual mean transparency compared to long-term mean transparency.

Trout Lake transparency ranges from 9.5 to 29.5 ft at the primary site (204). Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Trout Lake transparency is high in May and June, and then declines through August. The transparency then rebounds in October after fall turnover. This transparency dynamic is typical of a Minnesota lake. The dynamics have to do with algae and zooplankton population dynamics, and lake turnover.

It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not worried about why their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer.

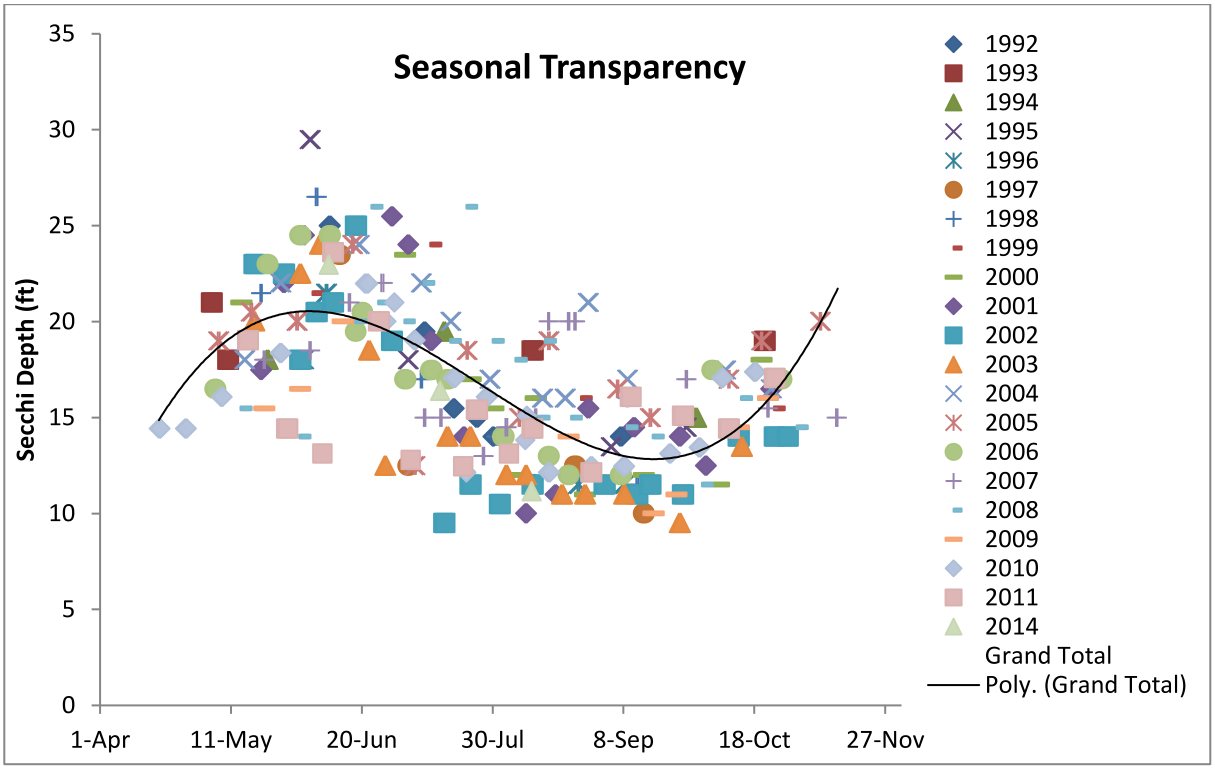



Figure 3. Seasonal transparency dynamics and year to year comparison (Primary Site 204). The black line represents the pattern in the data.

# User Perceptions

When volunteers collect Secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the Secchi depth decreases the perception of the lake's physical appearance rating decreases. Trout Lake was rated as being "not quite crystal clear" 56% of the time by samplers between 1992 and 2014 (Figure 5).

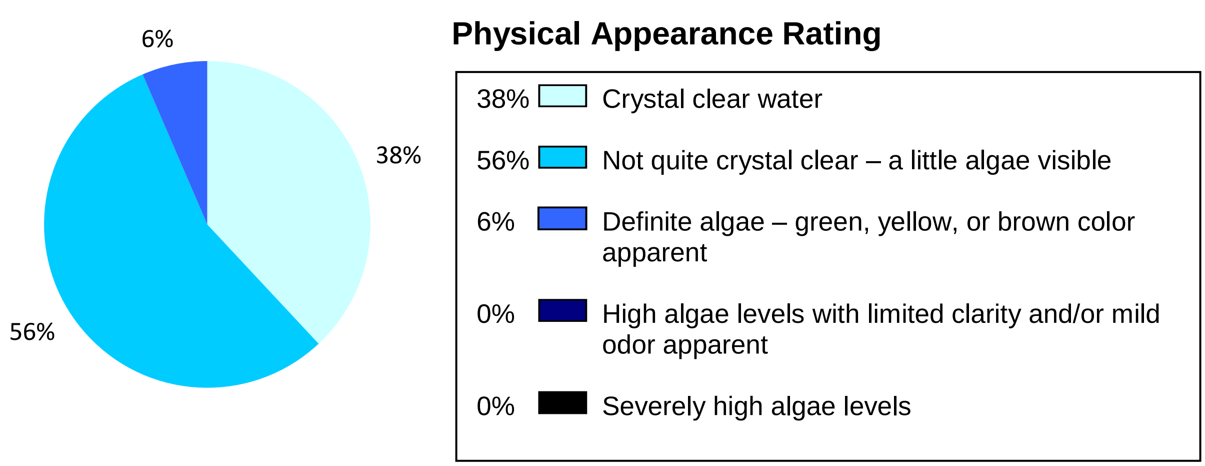



Figure 4. Trout Lake physical appearance ratings by samplers.

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Trout Lake was rated as being "beautiful" 28% of the time from 1994 to 2014 (Figure 6).

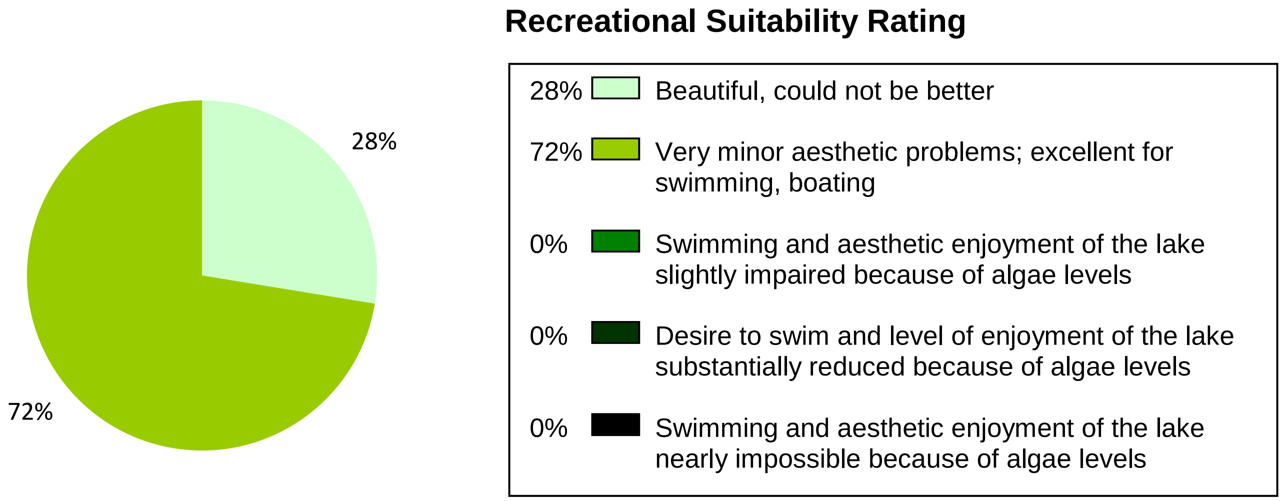



Figure 5. Recreational suitability rating, as rated by the volunteer monitor.

## Total Phosphorus

Trout Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus.

Total phosphorus was evaluated in Trout Lake in 1991, 1999-2000, 2003, 2005, 2008, 2010-2011, 2014-2015. The data do not indicate much seasonal variability. The majority of the data points fall into the oligotrophic range (Figure 7).

Phosphorus should continue to be monitored to track any future changes in water quality.

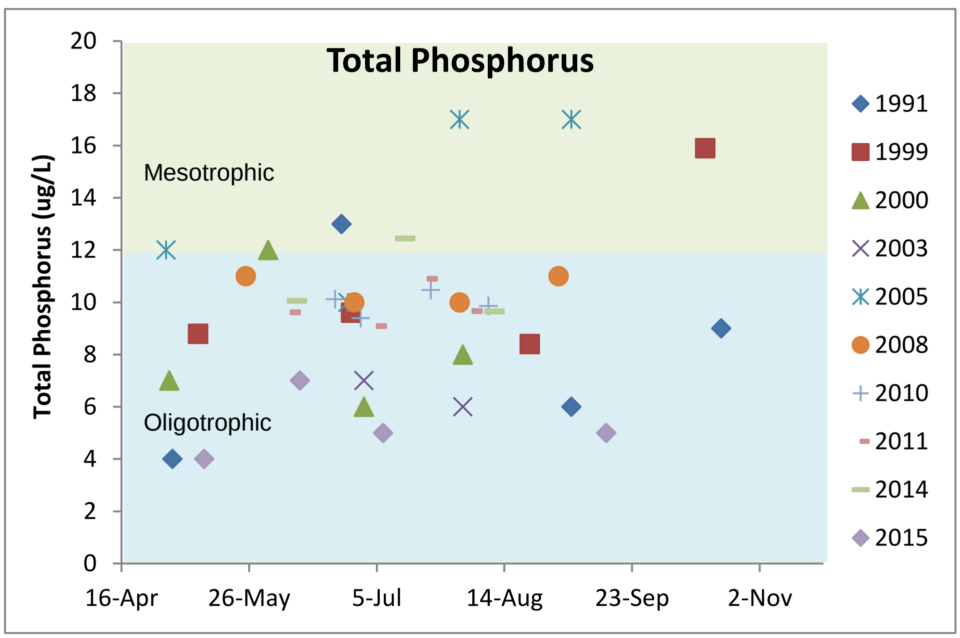



Figure 6. Historical total phosphorus concentrations (ug/L) for Trout Lake site 204.

# Chlorophyll *a*

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is.

Chlorophyll *a* concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

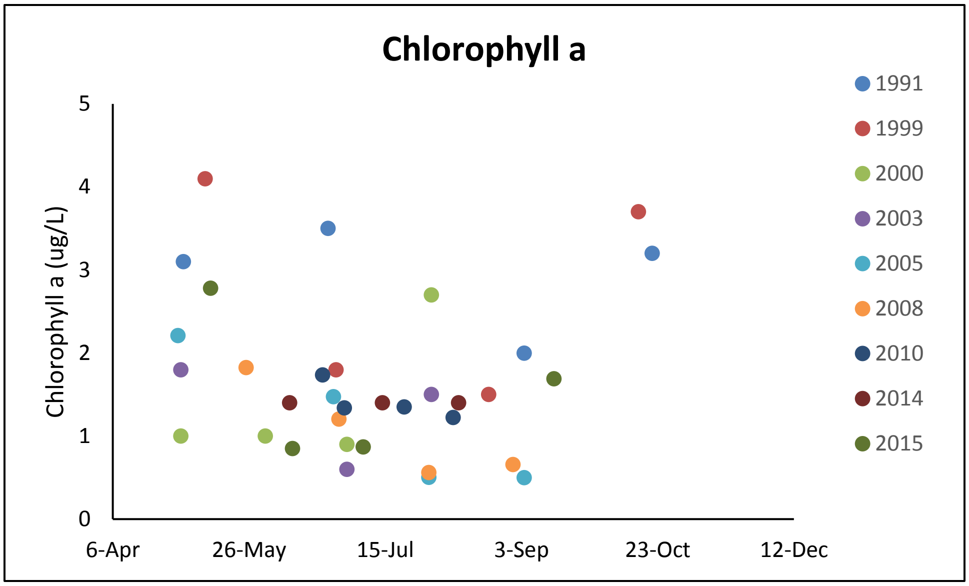



Figure 7. Chlorophyll *a* concentrations (ug/L) for Trout Lake at site 204.

Chlorophyll *a* was evaluated in Trout Lake in 1991, 1999-2000, 2003, 2005, 2008, 2010, 2014-2015 (Figure 8). Chlorophyll *a* concentrations stayed well below 10 ug/L, indicating no algae blooms.

# Dissolved Oxygen

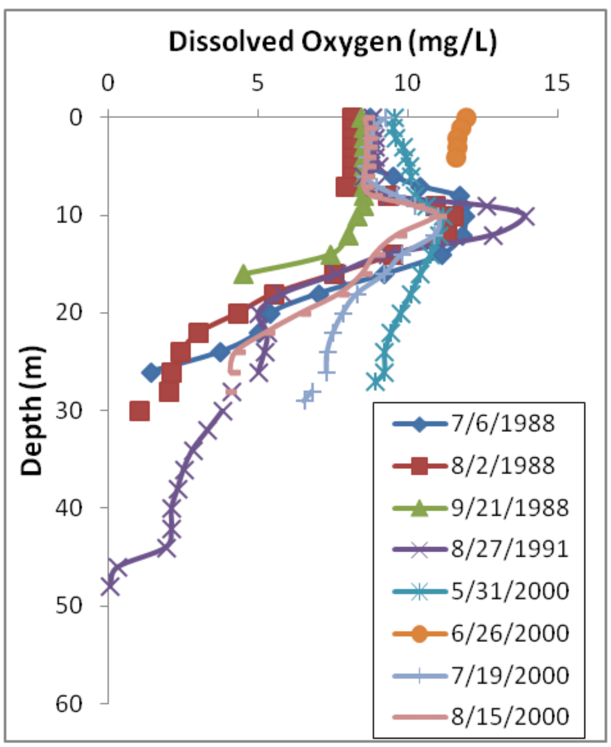



Figure 8. Dissolved oxygen profile for Trout Lake.

Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries.

Trout Lake is a deep lake, with a maximum depth of 157 feet. Dissolved oxygen profiles from data collected in 1988, 1991, and 2000 at site 100 show stratification developing mid-summer (Figure 9). The thermocline occurs at approximately 10 meters (33 feet). The hypolimnion did remain oxygenated until September, showing good cold fish habitat. Trout Lake is designated a cisco refuge lake by the DNR, and also supports lake trout. Ciscos (tullibee) are excellent forage fish for gamefish and need cold water and high oxygen levels to survive. Figure 9 is a representative DO profile for Trout Lake and it illustrates stratification in the summer of 1988, 1991, and 2000 at site 100.

# Trophic State Index (TSI)

TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus, independently estimate algal biomass.

Phosphorus (nutrients), chlorophyll *a* (algae concentration) and Secchi depth (transparency) are related. As phosphorus increases, there is more food available for algae, resulting in increased algal concentrations. When algal concentrations increase, the water becomes less transparent and the Secchi depth decreases. If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake.

The mean TSI for Trout Lake falls into the oligotrophic range (Figure 10). There is good agreement between the TSI for phosphorus, chlorophyll *a* and transparency, indicating that these variables are strongly related (Table 6).

Oligotrophic lakes (TSI 0-39) are characteristic of extremely clear water throughout the summer and sandy or rocky shores. They are excellent for recreation. Some very deep oligotrophic lakes are able to support a trout fishery.

Table 6. Trophic State Index for Trout Lake.

| Trophic State Index | Site 204 |
|---|---|
| TSI Total Phosphorus | 37 |
| TSI Chlorophyll-a | 36 |
| TSI Secchi | 37 |
| TSI Mean | 36 |
| Trophic State: | Oligotrophic |

*Numbers represent the mean TSI for each parameter.*

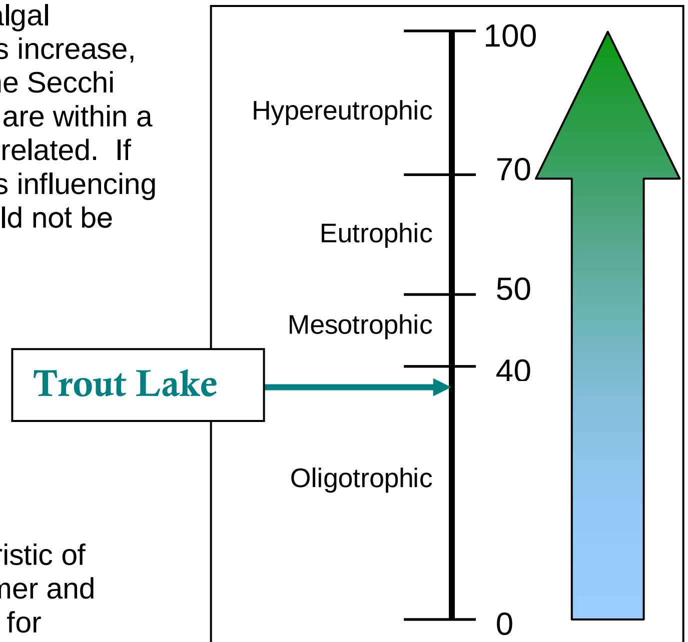



Figure 9. Trophic state index chart with corresponding trophic status.

Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics.

| TSI | Attributes | Fisheries & Recreation |
|---|---|---|
| <30 | Oligotrophy: Clear water, oxygen throughout the year at the bottom of the lake, very deep cold water. | Trout fisheries dominate |
| 30-40 | Bottom of shallower lakes may become anoxic (no oxygen). | Trout fisheries in deep lakes only. Walleye, Cisco present. |
| 40-50 | Mesotrophy: Water moderately clear most of the summer. May be "greener" in late summer. | No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate. |
| 50-60 | Eutrophy: Algae and aquatic plant problems possible. "Green" water most of the year. | Warm-water fisheries only. Bass may dominate. |
| 60-70 | Blue-green algae dominate, algal scums and aquatic plant problems. | Dense algae and aquatic plants. Low water clarity may discourage swimming and boating. |
| 70-80 | Hypereutrophy: Dense algae and aquatic plants. | Water is not suitable for recreation. |
| >80 | Algal scums, few aquatic plants | Rough fish (carp) dominate; summer fish kills possible |

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

# Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Trout Lake had enough data to perform a trend analysis on all three parameters (Table 8). The data were analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Trout Lake.

| Lake Site | Parameter | Date Range | Trend |
|---|---|---|---|
| 204 | Total Phosphorus | 1999-2000, 2003, 2005, 2008, 2010-2011, 2014-2015 | No Trend |
| 204 | Chlorophyll *a* | 1999-2000, 2003, 2005, 2008, 2010-2011, 2014-2015 | No Trend |
| 202 | Transparency | 1988,1990,1993-2001, 2003-2011 | No Trend |
| 203 | Transparency | 1988, 1990-2001, 2003-2011, 2014 | No Trend |
| 204 | Transparency | 1992-2014 | No Trend |

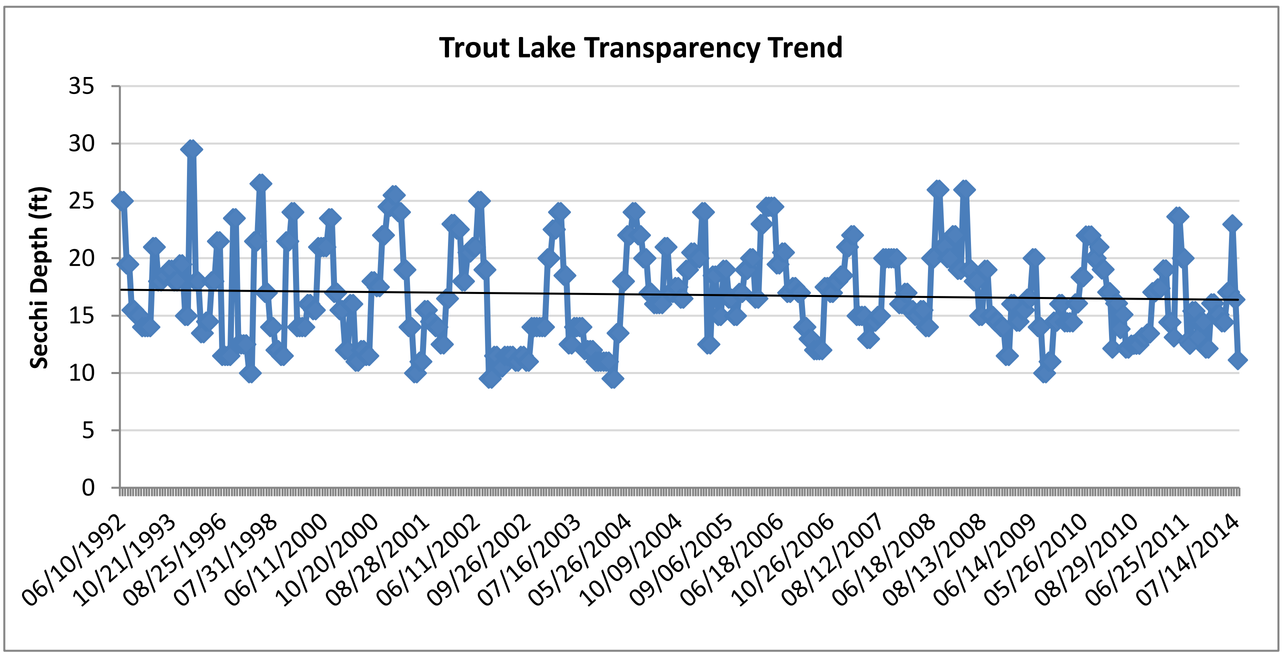



Figure 10. Transparency (feet) trend for site 204 from 1992-2014.

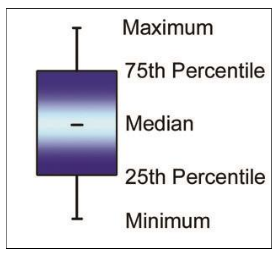
Trout Lake shows no evidence of a trends in transparency, phosphorus or chlorophyll a (Figure 11). Monitoring should continue so that trends can be tracked in future years.

## Ecoregion Comparisons

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology (Figure 12). The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. From 1985-1988, the MPCA evaluated the lake water quality for reference lakes. These reference lakes are not considered pristine, but are considered to have little human impact and therefore are representative of the typical lakes within the ecoregion. The "average range" refers to the 25$^{th}$ - 75$^{th}$ percentile range for data within each ecoregion. For the purpose of this graphical representation, the means of the reference lake data sets were used.

Figure 11. Minnesota Ecoregions.

Trout Lake is in the Northern Lakes and Forest Ecoregion. The mean total phosphorus, chlorophyll *a* and transparency (Secchi depth) for Trout Lake are better than the ecoregion ranges (Figure 13).



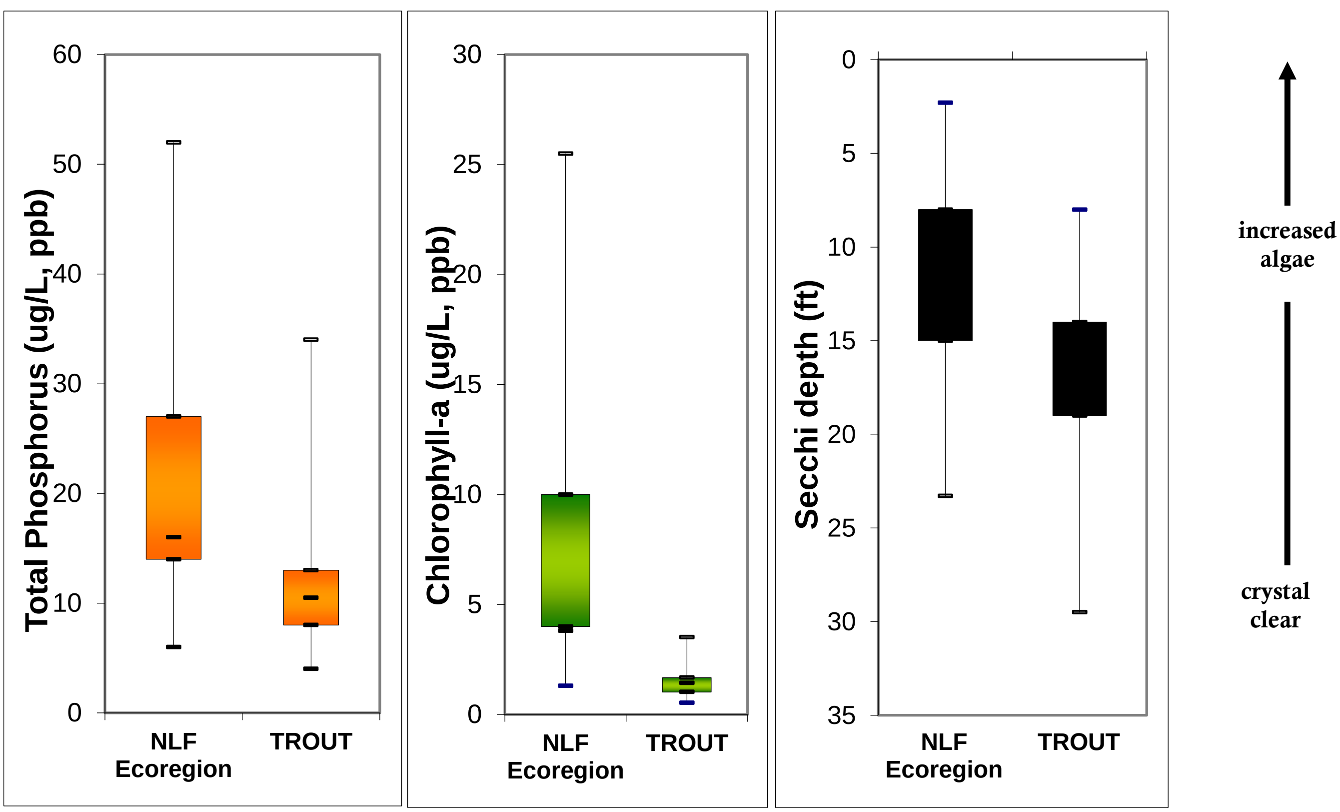



Figure 12. Trout Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Trout Lake total phosphorus and chlorophyll *a* ranges are from 50 data points collected in May-September of 1988,1991,2000-2002,2011,2015. The Trout Lake Secchi depth range is from 1448 data points collected in May-September of 1988,1990-2011,2014-2015.

## Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The Mississippi River Grand Rapids Major Watershed is one of the watersheds that make up the Mississippi River Basin, which drains south to the Gulf of Mexico (Figure 14). This major watershed is made up of 133 minor watersheds. Trout Lake is located in minor watershed 09047 (Figure 15).

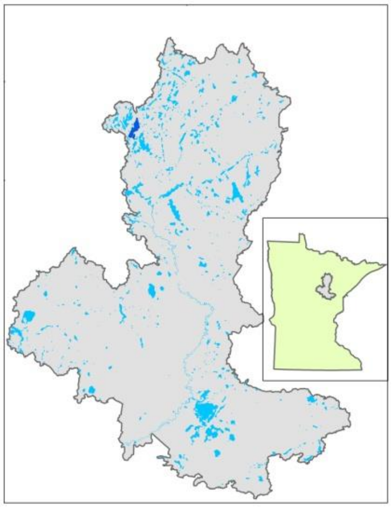


Figure 13. Major Watershed.

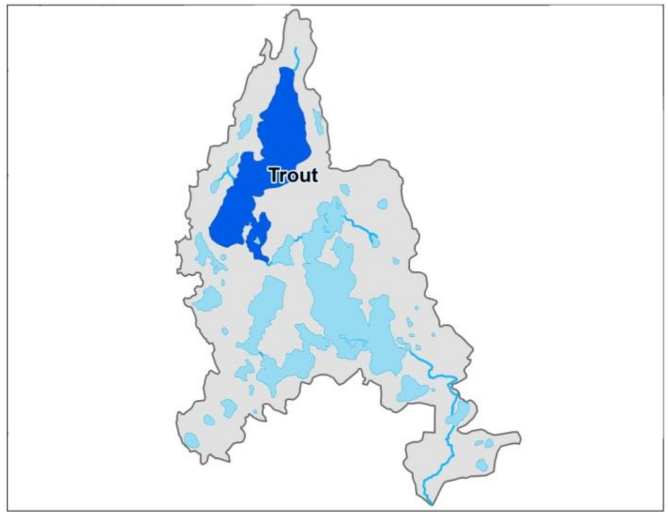



Figure 14. Minor Watershed.

The MN DNR also has evaluated catchments for each individual lake with greater than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Trout Lake falls within lakeshed 0904701 (Figure 16). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks. For further discussion of Trout Lake 's watershed, containing all the lakesheds upstream of the Trout Lake lakeshed, see page 17. The data interpretation of the

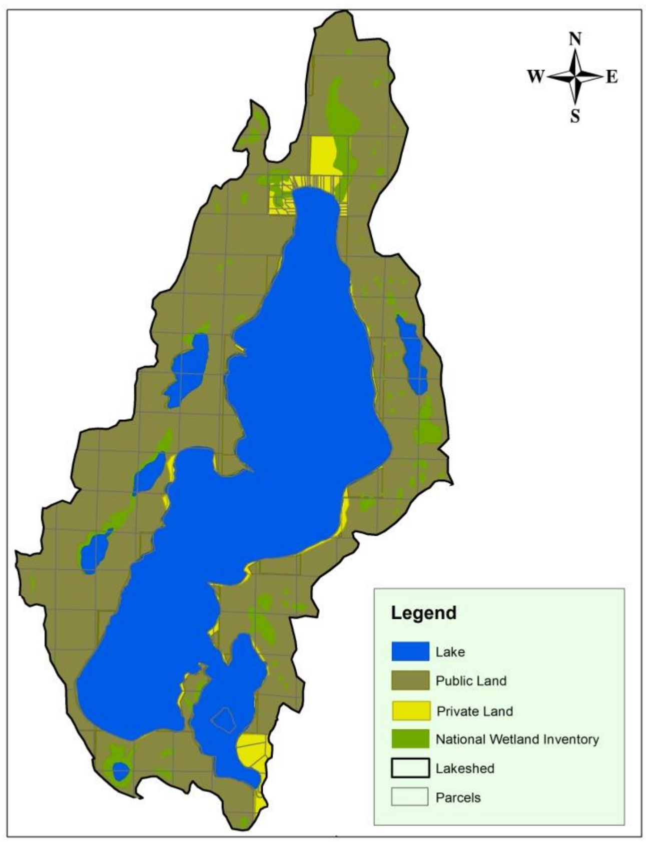



Figure 15. Trout Lake lakeshed (0904701) with land ownership, lakes, wetlands, and rivers illustrated.

Trout Lake lakeshed includes only the immediate lakeshed as this area is the land surface that flows directly into Trout Lake.

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 9). Criteria were developed using limnological concepts to determine the effect to lake water quality.

**KEY**

Possibly detrimental to the lake
Warrants attention
Beneficial to the lake

Table 9. Trout Lake lakeshed vitals table.

| **Lakeshed Vitals** | | **Rating** |
|---|---|---|
| Lake Area (acres) | 1736 | descriptive |
| Littoral Zone Area (acres) | 741 | descriptive |
| Lake Max Depth (feet) | 156.8 | descriptive |
| Lake Mean Depth (feet) | 43.8 | Beneficial to the lake |
| Water Residence Time | NA | NA |
| Miles of Stream | 1.2 | descriptive |
| Inlets | 4 minor | Warrants attention |
| Outlets | 1 | Warrants attention |
| Major Watershed | Mississippi R. -Grand Rapids | descriptive |
| Minor Watershed | 09047 | descriptive |
| Lakeshed | 0904701 | descriptive |
| Ecoregion | Northern Lakes and Forests | descriptive |
| Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area) | 3:1 | Warrants attention |
| Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas) | 10:1 | Beneficial to the lake |
| Wetland Coverage (NWI) (acres) | 195.6 | Beneficial to the lake |
| Aquatic Invasive Species | None | Beneficial to the lake |
| Public Drainage Ditches | 0 | Beneficial to the lake |
| Public Lake Accesses | 0 | Beneficial to the lake |
| Miles of Shoreline | 13.5 | descriptive |
| Shoreline Development Index | 2.31 | Warrants attention |
| Public Land to Private Land Ratio | 13.2:1 | Beneficial to the lake |
| Development Classification | Recreational Development | Warrants attention |
| Miles of Road | 4.9 | descriptive |
| Municipalities in lakeshed | None | Beneficial to the lake |
| Forestry Practices | None | Beneficial to the lake |
| Feedlots | 0 | Beneficial to the lake |
| Sewage Management | Individual Waste Treatment Systems (septic systems and holding tanks) | Warrants attention |
| Lake Management Plan | NA | Warrants attention |
| Lake Vegetation Survey/Plan | DNR 2000 | Beneficial to the lake |

## Land Cover / Land Use

The activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed. The basic purpose of land use planning is to ensure that each area of land will be used in a manner that provides maximum social benefits without degradation of the land resource.

Changes in land use, and ultimately land cover, impact the hydrology of a lakeshed. Land cover is also directly related to the land's ability to absorb and store water rather than cause it to flow overland (gathering nutrients and sediment as it moves) towards the lowest point, typically the lake. Impervious intensity describes the land's inability to absorb water, the higher the % impervious intensity the more area that water cannot penetrate in to the soils. Monitoring the changes in land use can assist in future planning procedures to address the needs of future generations.

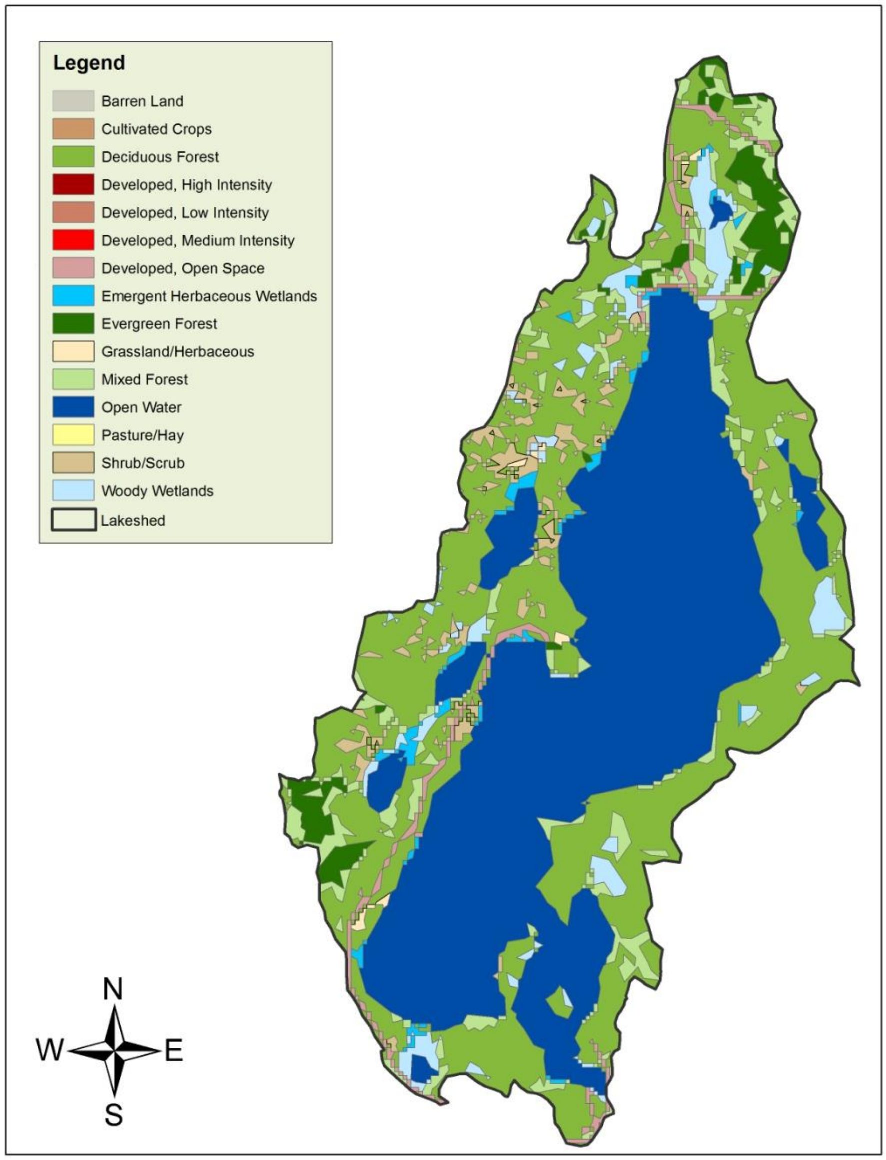



Figure 16. Trout Lake lakeshed (0904701) land cover (NLCD 2011).

Phosphorus export, which is the main cause of lake eutrophication, depends on the type of land cover occurring in the lakeshed. Figure 17 depicts the land cover in Trout Lake's lakeshed.

The National Land Cover Dataset (NLCD) has records from 2001 and 2011. Table 10 describes Trout Lake's lakeshed land cover statistics and percent change from 2001 to 2011. Overall, there was not much change over this decade or from 1990-2000 (Table 11)

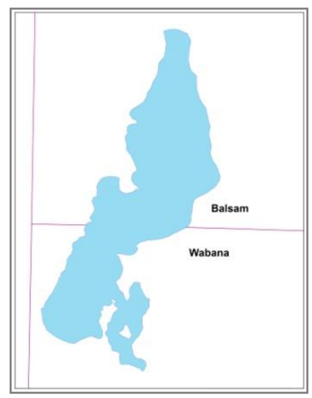
Table 10. Trout Lake's lakeshed land cover statistics and % change from 2001 to 2011 (Data Source: NLCD).

| Land Cover | 2001 Acres | Percent | 2011 Acres | Percent | % Change 2001 to 2011 |
|---|---|---|---|---|---|
| **Deciduous Forest** | 1622.39 | 36.63 | 1623.43 | 36.65 | 0.02 |
| **Developed, Low Intensity** | 0.25 | 0.01 | 1.48 | 0.03 | 0.02 |
| **Developed, Open Space** | 74.03 | 1.67 | 71.50 | 1.61 | -0.06 |
| **Emergent Herbaceous Wetlands** | 50.20 | 1.13 | 50.07 | 1.13 | 0 |
| **Evergreen Forest** | 140.80 | 3.18 | 139.81 | 3.16 | -0.02 |
| **Grassland/Herbaceous** | 10.47 | 0.24 | 10.77 | 0.24 | 0 |
| **Mixed Forest** | 302.14 | 6.82 | 304.48 | 6.87 | 0.05 |
| **Shrub/Scrub** | 129.13 | 2.92 | 128.92 | 2.91 | -0.01 |
| **Woody Wetlands** | 165.04 | 3.73 | 164.39 | 3.71 | -0.02 |
| **Open Water** | 1934.61 | 43.68 | 1934.20 | 43.67 | -0.01 |
| **Total Area** | 4429.05 | | 4429.05 | | |

Table 11. Trout Lake development area and % change from 1990-2000 (Data Source: UMN Landsat).

| Category | 1990 Acres | Percent | 2000 Acres | Percent | % Change 1990 to 2000 |
|---|---|---|---|---|---|
| **Total Impervious Area** | 4 | 0.16 | 7 | 0.26 | 0.1 |
| **Urban Acreage** | 64 | 1.45 | 64 | 1.45 | 0 |

# Demographics




Trout Lake is classified as a Recreational Development lake. Recreational Development lakes usually have between 60 and 225 acres of water per mile of shoreline, between 3 and 25 dwellings per mile of shoreline, and are more than 15 feet deep.

The Minnesota Department of Administration Geographic and Demographic Analysis Division extrapolated future population in 5-year increments out to 2035. Compared to Itasca County as a whole, Wabana Township has a higher growth projection while Balsam Township has a lower growth projection (Figure 18). (source: http://www.demography.state.mn.us)

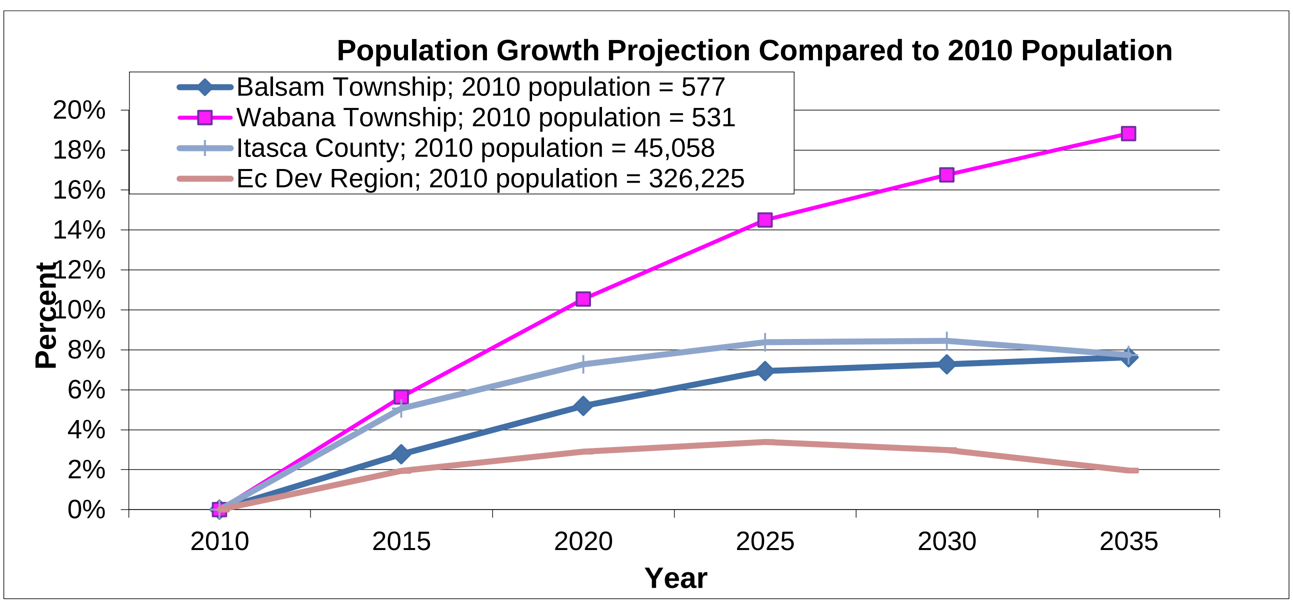



Figure 17. Population growth projection for adjacent townships and Itasca County.

## Lakeshed Water Quality Protection Strategy

Each lakeshed has a different makeup of public and private lands. Looking in more detail at the makeup of these lands can give insight on where to focus protection efforts. The protected lands (easements, wetlands, public land) are the future water quality infrastructure for the lake. Developed land and agriculture have the highest phosphorus runoff coefficients, so this land should be minimized for water quality protection.

Trout Lake's lakeshed is 97% open water and public land. The majority of the private land within Trout Lake's lakeshed is forested upland (Table 12). This land can be the focus of development and protection efforts in the lakeshed.

Table 12. Land ownership, land use/land cover, estimated phosphorus loading, and ideas for protection and restoration in the lakeshed (Sources: County parcel data and the 2011 National Land Cover Dataset).

| | **Private (3.0)** | | | | | | **Public (54.08)** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Developed** | **Agriculture** | **Forested Uplands** | **Other** | **Wetlands** | **Open Water** | **County** | **State** | **Federal** |
| **Land Use (%)** | 0.39 | 0 | 1.89 | 0.07 | 0.65 | 42.92 | 0 | 0.14 | 53.94 |
| **Runoff Coefficient** Lbs of phosphorus/acre/year | 0.45 – 1.5 | 0.26 – 0.9 | 0.09 | | 0.09 | | 0.09 | 0.09 | 0.09 |
| **Estimated Phosphorus Loading** Acreage x runoff coefficient | 8 - 26 | 0 | 7.5 | | 2.56 | | 0 | 0.55 | 212.68 |
| **Description** | Focused on Shoreland | Cropland | Focus of development and protection efforts | Open, pasture, grass-land, shrub-land | Protected | | | | |
| **Protection and Restoration Ideas** | Shoreline restoration | Restore wetlands; CRP | Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives | | Protected by Wetland Conservation Act | | County Tax Forfeit Lands | State Forest | National Forest |

## DNR Fisheries approach for lake protection and restoration

*Credit: Peter Jacobson and Michael Duval, Minnesota DNR Fisheries*

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 13). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 13. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.

| Watershed Disturbance (%) | Watershed Protected (%) | Management Type | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25-60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Trout Lake's lakeshed is classified with having 93% of the watershed protected and 1% of the watershed disturbed (Figure 19). Therefore, this lakeshed should have a vigilance focus. Goals for the lake should be to keep public lands protected. Trout Lake has six upstream lakesheds.

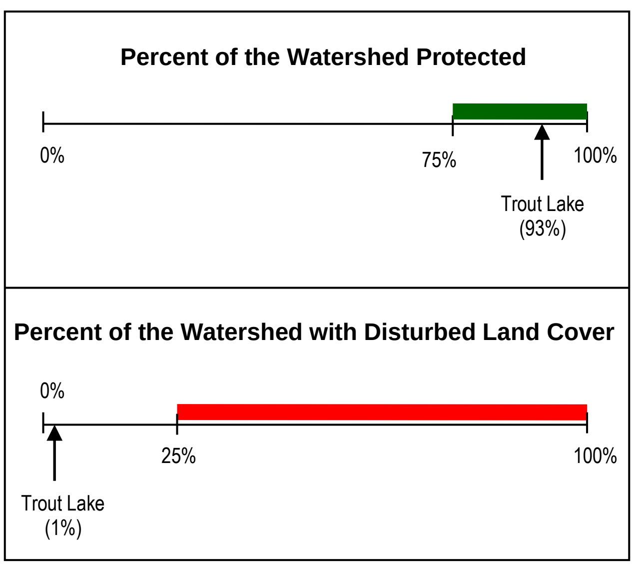



Figure 19. Trout Lake's lakeshed percentage of watershed protected and disturbed.

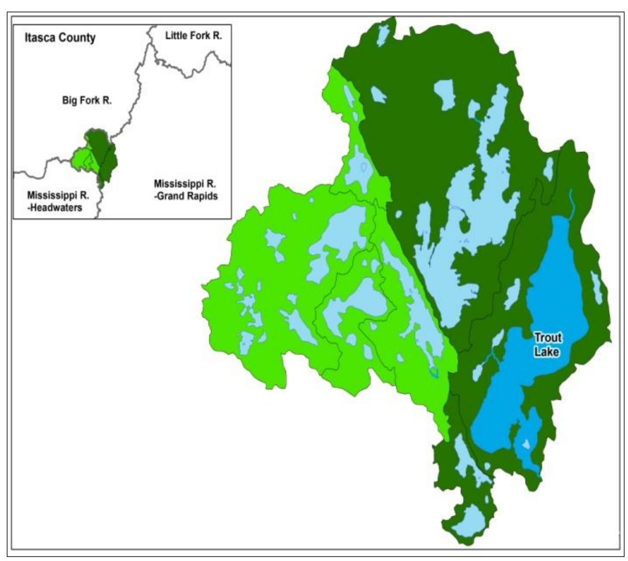



Figure 20. Lakesheds that contribute water to the Trout Lake lakeshed. Color-coded based on management focus (Table 13).

## Status of the Fishery (DNR, as of 08/13/2007)

Trout Lake has been primarily managed for lake trout since 1975. Although periodic stockings were done in previous years, recently yearlings have been stocked on an every-other-year schedule. Because of the difficulty of ageing lake trout, all stocked yearlings, since 1993, were given a specific fin clip to differentiate between stocked age classes and natural reproduction. Beginning in 2005, as part of a strain evaluation project, both Gillis Lake and Mountain Lake strain lake trout were stocked at 2.5 fish/acre (4,383). Each strain was assigned a fin clip to distinguish between the strains and assign ages to individual fish. The goal of the project was to evaluate growth and survival of the paired stockings at age-4 across the state.

Deepwater gill nets sampled 14 lake trout at a rate lower than the previous assessment, yet similar to the historic low since deepwater gill net sets were used. Captured lake trout ranged in length from 7.5-31.1 inches. Nearly 80% of the sampled fish were less than 10 inches and identified as age-1 through fin clips. One yearling was identified as Mountain strain and ten were Gillis strain. All age-1 fish were from the 2007 spring stocking. Fin clip markings also identified one age-5 Gillis strain fish from the 2003 stocking. Two large fish lacking a fin clip were also sampled, signifying some recruitment through natural reproduction. Scale analysis suggests that both of these individuals were age-9. Caution should be exercised when reviewing back-calculated length-at-age data due to the difficulty of accurately reading lake trout scales. A small sample size may be inadequate to accurately determine growth. However, growth appears to be similar to a little faster then Bluewater Lake, which is attached to Trout Lake through a chain of lakes. Growth may also be biased because of the high number of yearling, hatchery reared fish in the sample.

Evaluating between the lake trout strains in Trout Lake is difficult due to no fish being sampled from the 2005 stocking (age-3). However, 91% of the stocked (2007) yearlings sampled were Gillis strain. Other lakes in the Grand Rapids area included in the project were Bluewater Lake and Caribou Lake. One age-3 fish was sampled in Bluewater, a 414mm Gillis strain lake trout. Five marked yearlings were also sampled in Bluewater, three Gillis strain and two Mountain strain. There was five age-3 fish sampled in Caribou, of which four were identified as Gillis strain and one Mountain strain. There was no yearling stocked lake trout sampled in Caribou. At this time, more Gillis strain lake trout have been sampled in the Grand Rapids area, but more time and a larger sample size is needed to draw any conclusions.

Tullibee were sampled at a rate of 15.9 fish/gill net. The 2007 catch rate was similar to the lake mean of 19.5 TLC/net since deepwater gill nets have been used. Tullibee catch rates tend to be variable due to their schooling, open water nature. Lengths ranged from 6.5-9.2 inches with a mean length of 7.5 inches. Larger size tullibee are not typically sampled in Trout Lake.

Catch rates for other species sampled in gill nets set deep, targeting lake trout, are not very useful as an indicator of species abundance. However, length and growth information provides some information on the status of the fishery. Black crappie, smallmouth and largemouth bass, northern pike, walleye, white sucker and yellow perch were all sampled in the deepwater gill net sets in relatively low abundance. Despite the low sample size, northern pike and walleye were of a relatively larger size with an average length of 27.4 and 24.1 inches, respectively.

Trap nets sampled black crappie within the expected range with an average length of 6.3 inches. Bluegill and largemouth bass catch rates exceeded the expected range with average lengths of 5.4 and 8.0 inches, respectively. All three species were sampled at a rate above the previous assessment. Other species sampled in trap nets include green sunfish, hybrid sunfish, northern pike, pumpkinseed, rock bass, smallmouth bass, walleye, and yellow perch.

See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=31041000

# Key Findings / Recommendations

**Monitoring Recommendations**

Transparency monitoring at site 204 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Total Phosphorus and chlorophyll *a* monitoring should continue, as the budget allows, to track trends in water quality.

**Overall Summary**

Trout Lake is an oligotrophic lake (TSI = 36) with no evidence of a long-term trend in transparency, phosphorus or algae concentration (chlorophyll a). The total phosphorus, chlorophyll *a* and transparency ranges are better than the ecoregion ranges.

Only 1% of the Trout Lake lakeshed is disturbed by development and agriculture (Figure 19), and 97% is federally owned or open water (Table 12).

The dissolved oxygen profile in Trout Lake shows an interesting pattern in that it is highest from 7-10 meters (23 - 32 feet) (Figure 9). This pattern is called a Metalimnetic Oxygen Maxima. It is caused by algae producing oxygen in that area of 7-10 meters deep. This pattern is usually only observed in lakes with good transparency and a very small closed deep basin, which applies Bluewater Lake (Figure 1). This small deep hole stratifies very strongly as there is not much surface area for wind mixing.

Ciscos (*Coregonus artedi),* also called Tullibee, can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. Trout Lake is classified by the DNR as a Cisco Refuge Lake because it has deep, cold water, and a well-protected lakeshed. The 2007 DNR Fisheries survey did show Ciscoes present in the lake, which is an indicator that the lake has good water quality. Trout Lake is also stocked with Lake Trout, which only the coldest, cleanest and deepest lakes in Minnesota can support.

**Priority Impacts to the Lake**

Trout Lake's lakeshore is almost entirely federally owned. Just a small portion on the north end is developed (Figure 16), and the second tier above that development is public land as well. Therefore, it appears that there is essentially no more developable land remaining around Trout Lake, which is good protection for water quality.

**Best Management Practices Recommendations**

The management focus for Trout Lake should be to protect the current water quality and lakeshed and keep the public land protected. The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. In addition, filter strips or native vegetative buffers could be installed to decrease or slow the runoff reaching the water's edge. Septic systems should be pumped and inspected regularly.

There is a private boat access on the north end of the lake that should be involved in aquatic invasive species prevention efforts.

**Project Implementation**
The best management practices above can be implemented by a variety of entities. Some possibilities are listed below.

Individual property owners

- Shoreline restoration
- Rain gardens
- Aquatic plant bed protection (only remove a small area for swimming)
- Conservation easements

Lake Associations

- Lake condition monitoring
- Ground truthing – visual inspection upstream on stream inlets
- Watershed runoff mapping by a consultant
- Shoreline inventory study by a consultant
- Conservation easements

Soil and Water Conservation District (SWCD) and Natural Resources Conservation Service (NRCS)

- Shoreline restoration
- Stream buffers
- Wetland restoration
- Forest stewardship planning

# Organizational contacts and reference sites

| | |
|---|---|
| Lake Association | Wabana Chain of Lakes<br>http://www.wcola.org/ |
| Itasca County Environmental Services Department | 124 NE 4th St., Grand Rapids, MN 55744<br>(218) 327-2857<br>https://www.co.itasca.mn.us |
| Itasca Soil and Water Conservation District | 1889 East Highway 2, Grand Rapids, MN 55744<br>(218) 326-0017<br>http://www.itascaswcd.org |
| DNR Fisheries Office | 1201 East Highway 2, Grand Rapids, MN 55744<br>(218) 327-4430<br>http://www.dnr.state.mn.us/areas/fisheries/grandrapids/index.html |
| Regional Minnesota Pollution Control Agency Office | 525 Lake Avenue South, Duluth, MN 55802<br>(218) 723-4660<br>http://www.pca.state.mn.us |
| Regional Board of Soil and Water Resources Office | 1601 Minnesota Drive, Brainerd, MN 56401<br>(218) 828-2383<br>http://www.bwsr.state.mn.us |