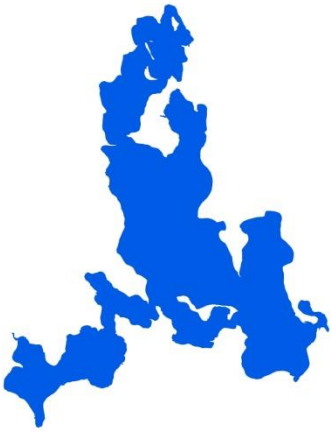
Wabana Lake 31-0392-00 ITASCA COUNTY

Lake Water Quality

Summary



Wabana Lake is located 13.5 miles north of Grand Rapids, MN in Itasca County. It includes many bays covering a total of 2,221 acres (Table 1).

Wabana Lake has three inlets and one outlet, which classify it as a drainage lake. Water enters Wabana Lake from Trout Lake, Wabana Creek, and a ground-fed stream in the north. Wabana Creek exits the lake on the south side of Wabana Lake and carries water south to the Mississippi River.

Water quality data have been collected on Wabana Lake from 1994-2015 (Tables 2 & 3). These data show that the lake is oligotrophic (TSI = 36) with very clear water conditions most of the summer and excellent recreational opportunities.

Wabana Lake is part of the Wabana Chain of Lakes Association (WCOLA). The association is involved in activities such as water quality monitoring and education.

Table 1. Wabana Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	31-0392-00	Surface area (acres):	2,221
County:	Itasca	Littoral area (acres):	1,020
Ecoregion:	Northern Lakes and Forests	% Littoral area:	46
Major Drainage Basin:	Mississippi R. -Grand Rapids	Max depth (ft), (m):	115, 35
Latitude/Longitude:	47.42197/ -93.522702	Inlets:	3
Invasive Species:	None	Outlets:	1
		Public Accesses:	2

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

Data Availability

Transparency data		Good data set from 1992-2015 through the CLMP.
Chemical data		Good data set for evaluation through WCOLA.
Inlet/Outlet data	--	Not necessary

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

Lake Map

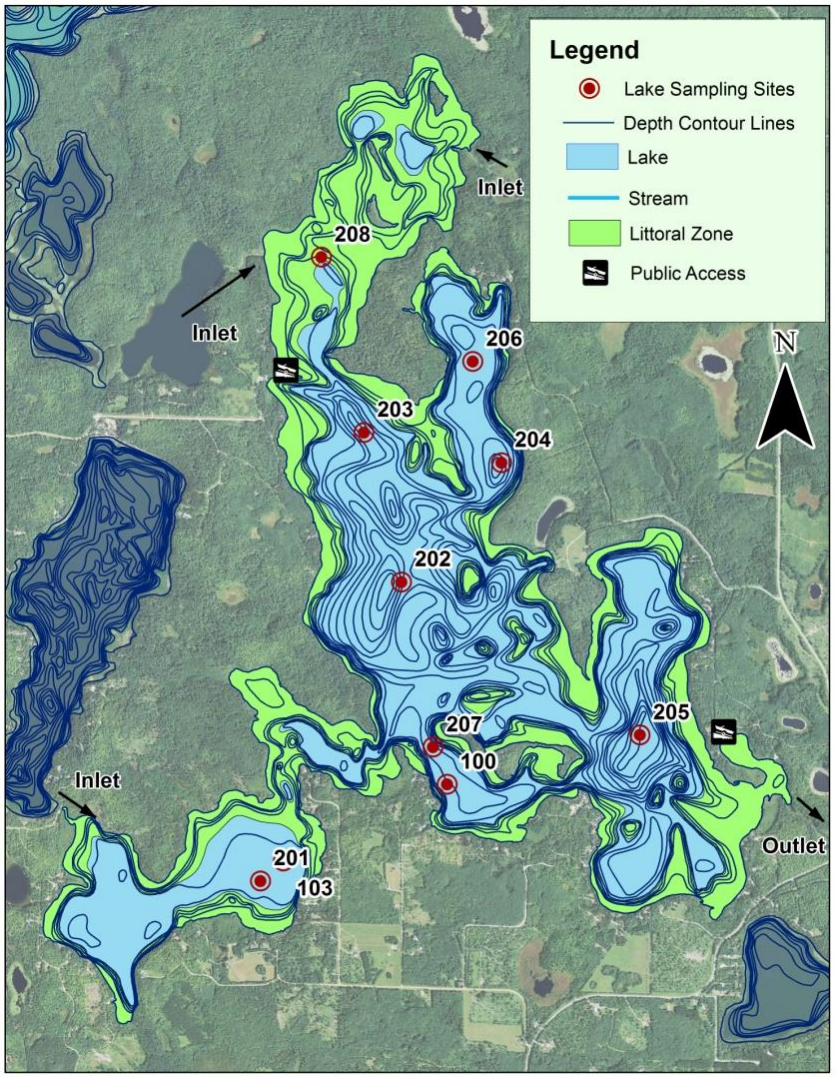


Figure 1. Map of Wabana Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.

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

Lake Site	Depth (ft)	Monitoring Programs
100	30	ICLA: 2001-2002; LMPP: 1991
103	20	LMP: 2000; LMPP: 1988,1991
201	20	CLMP: 1975,1992-2015; CWLSWM: 2015; WCOLA: 1991, 1999-2000, 2003, 2005, 2008, 2010-2011, 2014-2015
202 *Primary	90	CLMP: 1976-1977, 2005-2015; CWLSWM: 2015; WCOLA: 1991, 1999-2000, 2003, 2005, 2008, 2010-2011, 2014-2015
203	70	CLMP: 1988,1990,1992, 2015; LMP: 2000; LMPP: 1985,1988,1991 WCOLA: 1991, 1999, 2003, 2005, 2008, 2010-2011, 2014
204	70	CLMP: 1992
205 *Secondary	110	CLMP: 1999-2015 WCOLA: 1991, 1999-2000, 2003, 2005, 2008, 2010-2011, 2014
206	40	CLMP: 2000-2015
207	40	CLMP: 2002-2015

Average Water Quality Statistics

The information below describes available chemical data for Wabana Lake through 2015 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 202.

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. Wabana 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)	9.2	14 – 27	> 30	Results are better than the expected range for the Northern Lakes and Forests Ecoregion.
[3]Chlorophyll *a* (ug/L)	2.2	4 – 10	> 9	
Chlorophyll *a* max (ug/L)	6.4	< 15		
Secchi depth (ft)	19.0	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)	0.4	<0.4 – 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	115.0	40 – 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	7.3	10 – 35		Indicates clear water with little to no tannins (brown stain).
pH	8.1	7.2 – 8.3		Within the expected range for the ecoregion and indicates a hard water lake. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water.
Chloride (mg/L)	0.9	0.6 – 1.2		Within the expected range for the ecoregion.
Total Suspended Solids (mg/L)	1.7	<1 – 2		Indicates low suspended solids and clear water.
Specific Conductance (umhos/cm)	215.9	50 – 250		Within the expected range for the ecoregion.
TN:TP Ratio	44:1	25:1 - 35:1		Shows the lake is phosphorus limited.

[1]The ecoregion range is the 25th-75th 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. All sites have comparable water quality.

Parameters	Primary Site 202 Central ●	205 South ●	203 North ●	201 Wakeman ●
Total Phosphorus Mean (ug/L):	**9.2**	**11.3**	**12.2**	**13.1**
Total Phosphorus Min:	<5.0	<5.0	<7.0	<5.0
Total Phosphorus Max:	20.0	37.0	48.0	53.0
Number of Observations:	38	12	33	40
Chlorophyll *a* Mean (ug/L):	**2.2**	**2.5**	**2.3**	**3.6**
Chlorophyll-a Min:	<1	<1	<1	<1
Chlorophyll-a Max:	4.0	5.3	5.7	14.4
Number of Observations:	33	13	33	37
Secchi Depth Mean (ft):	**19.0**	**17.6**	**15.9**	**15.5**
Secchi Depth Min:	13.0	8.2	9.1	9.5
Secchi Depth Max:	35.1	27.6	24.9	21.0
Number of Observations:	121	245	24	320

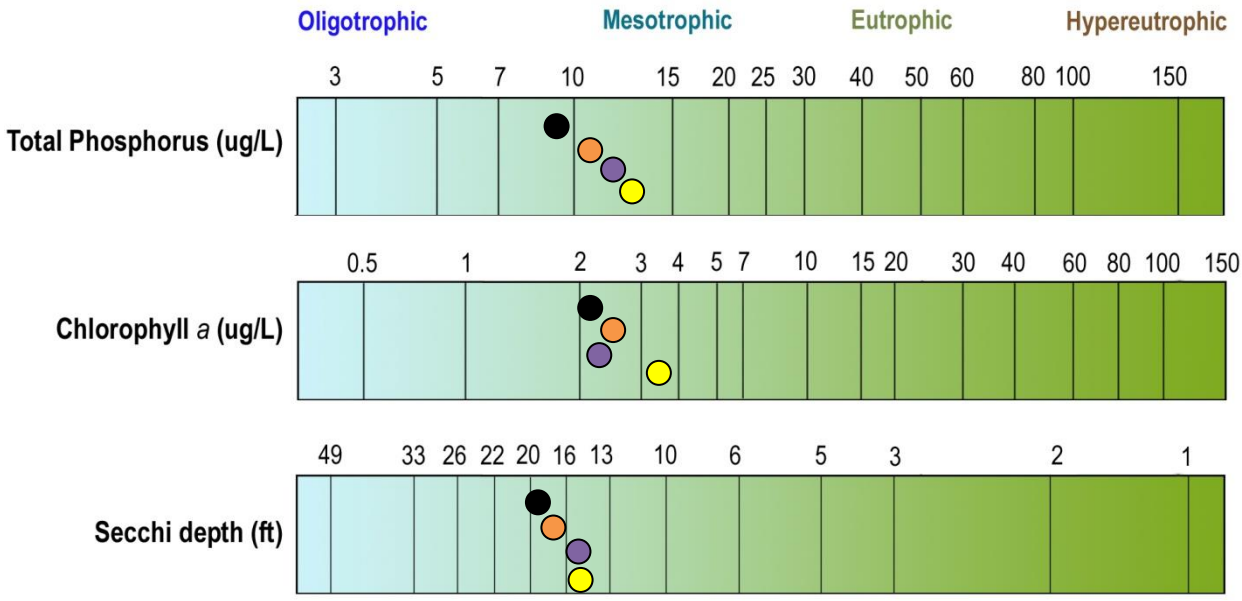


Figure 2. Wabana Lake total phosphorus, chlorophyll a and transparency historical ranges. The dot represents the historical mean for each site. Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

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 Wabana Lake ranges from 12 to 19 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 202 in order to track water quality changes.

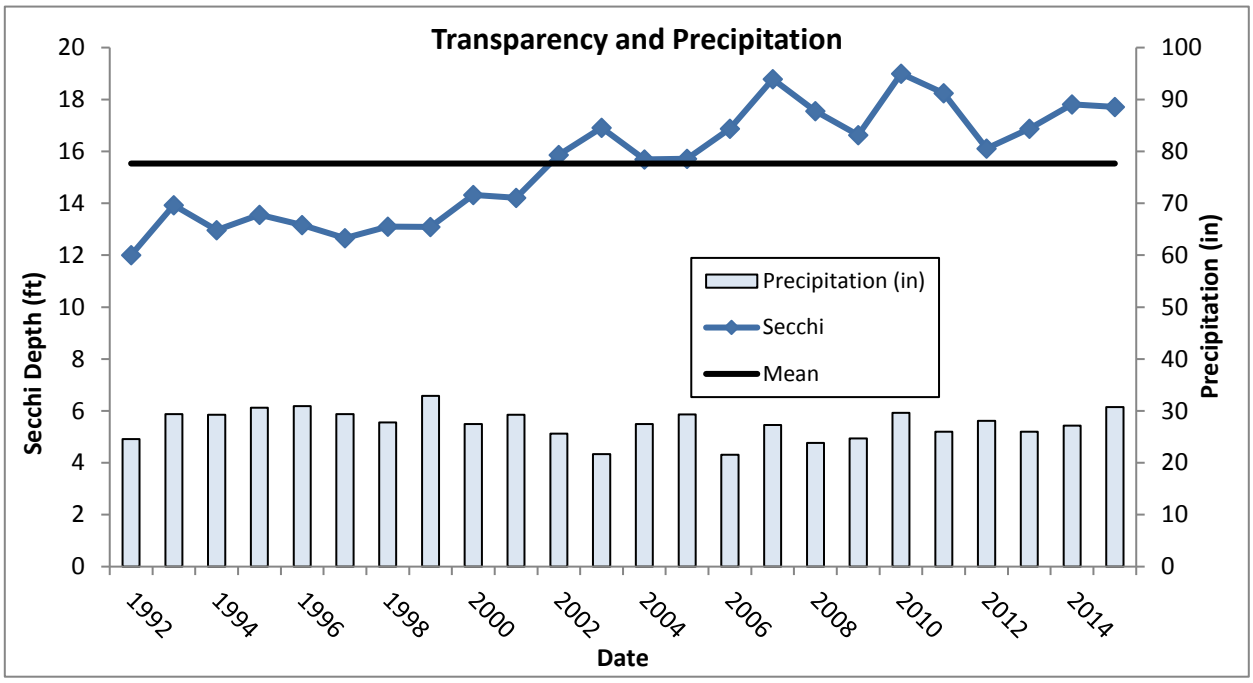


Figure 3. Annual mean transparency compared to long-term mean transparency.

Wabana Lake transparency ranges from 13 to 35 feet at the primary site (202). Figure 4 shows the seasonal transparency dynamics. Wabana Lake transparency is fairly consistent all summer. This transparency dynamic is typical of an oligotrophic Minnesota lake. There is usually not enough algae to cause the transparency to be low in late summer like in mesotrophic lakes. 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.

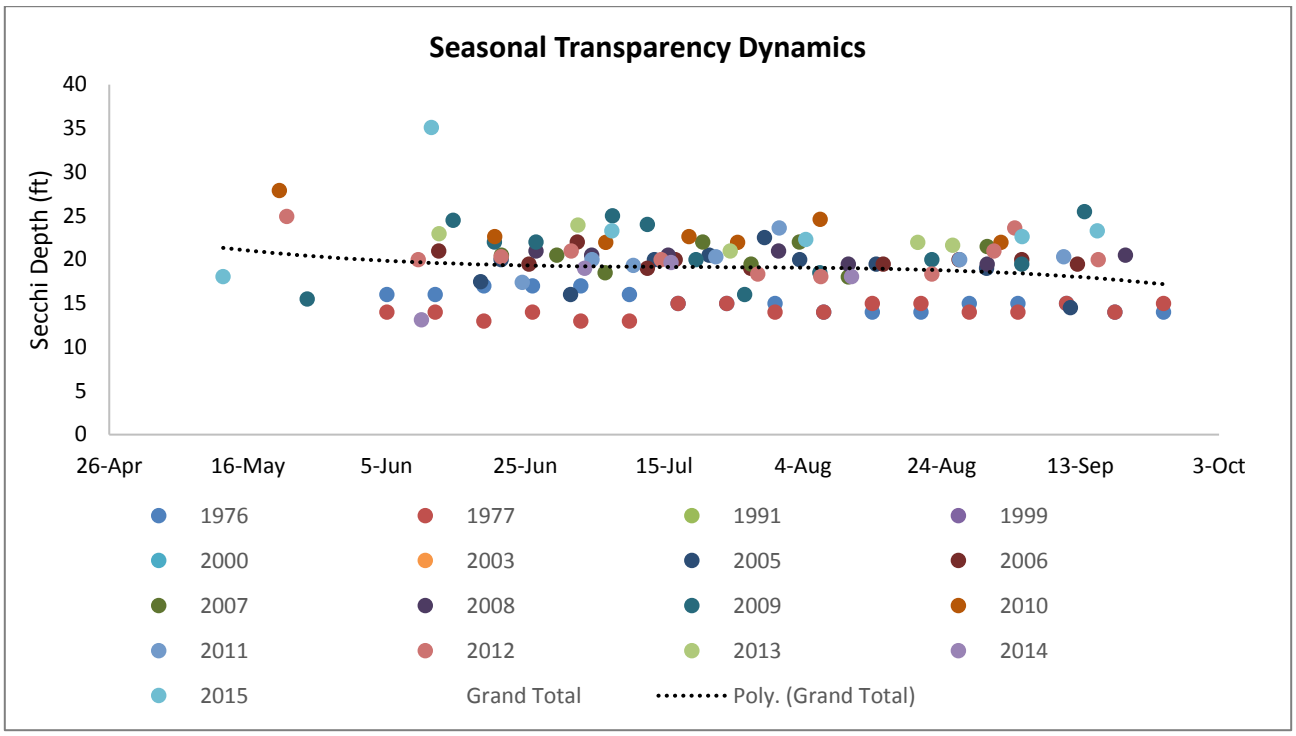


Figure 4. Seasonal transparency dynamics and year to year comparison (Primary Site 201). The black line represents the pattern in the data.

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. Wabana Lake was rated as being "not quite crystal clear" 56% of the time by samplers between 1992 and 2015 (Figure 5).

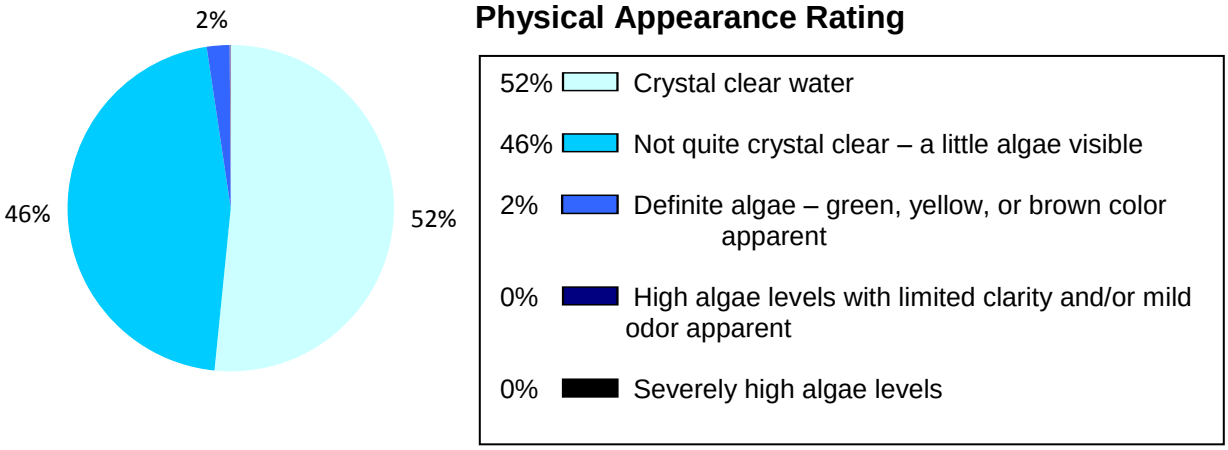


Figure 5. Wabana Lake physical appearance ratings by samplers.

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Wabana Lake was rated as being "beautiful" 58% of the time from 1992 to 2015 (Figure 6).

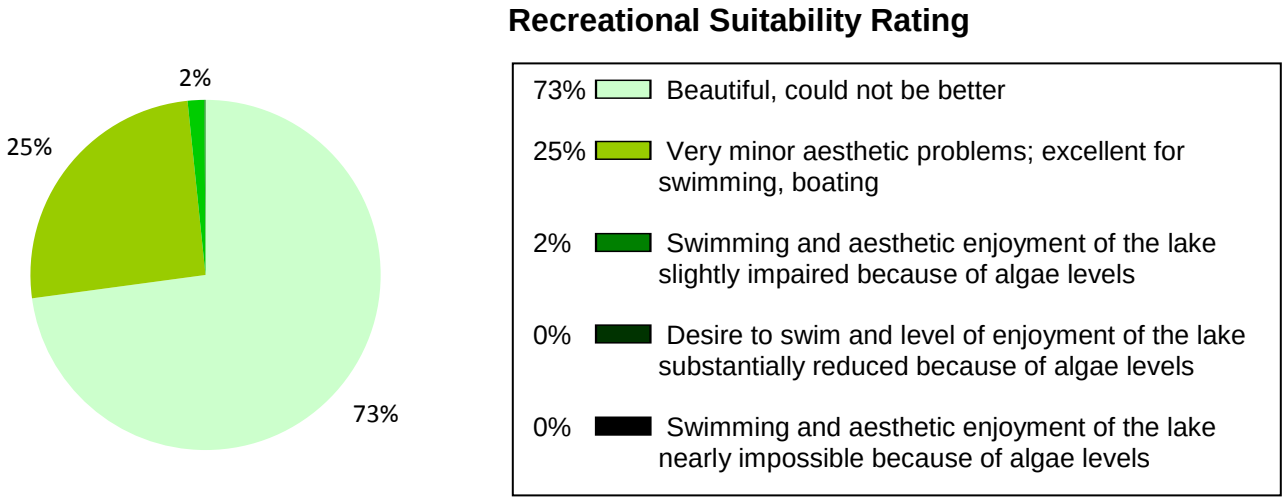


Figure 6. Recreational suitability rating, as rated by the volunteer monitor.

Total Phosphorus

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

Total phosphorus was evaluated in the center of Wabana Lake in 1991, 1999-2000, 2003, 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.

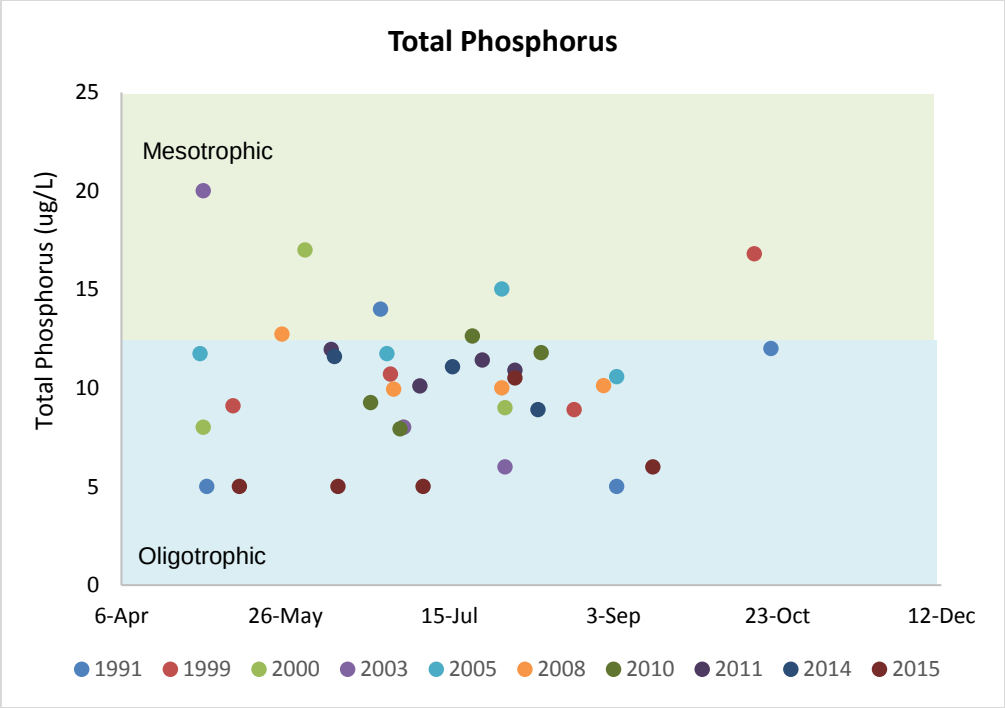


Figure 7. Historical total phosphorus concentrations (ug/L) for Wabana Lake site 202, center.

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.

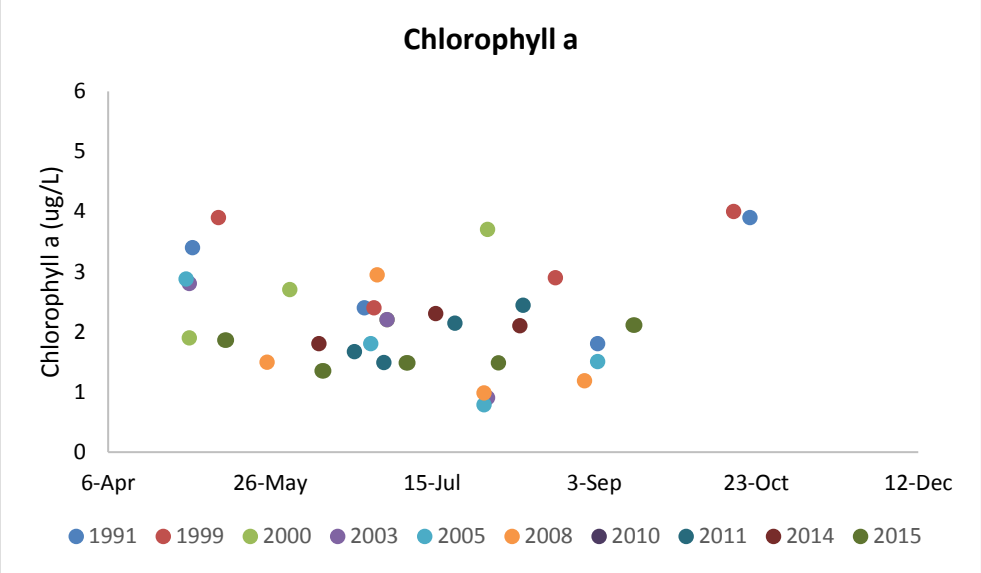
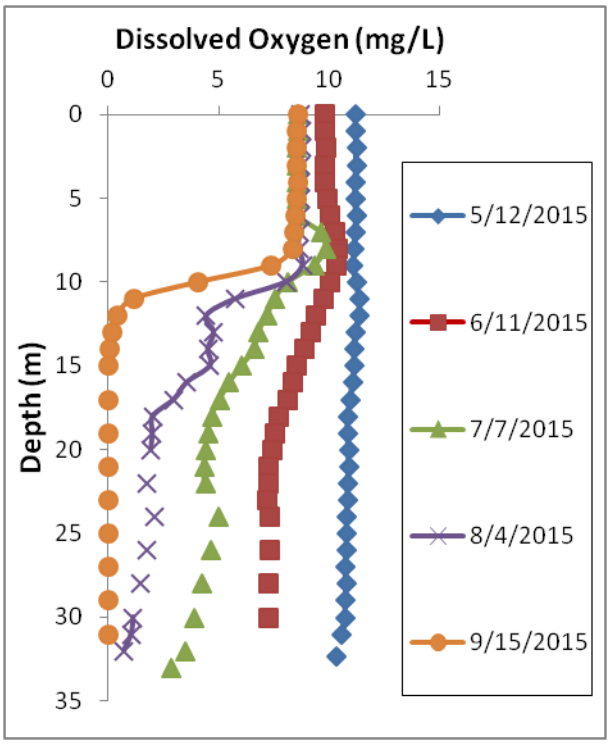


Figure 8. Chlorophyll *a* concentrations (ug/L) for Wabana Lake at site 202.

Chlorophyll *a* was evaluated in Wabana Lake at site 202 in 1991, 1999-2000, 2003, 2008, 2010-2011, 2014-2015 (Figure 8). Chlorophyll *a* concentrations stayed below 10 ug/L in all years, indicating no algae blooms. There was not much variation over the years monitored and chlorophyll *a* concentrations remained relatively steady over the summer.

Dissolved Oxygen



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.

Wabana Lake is a deep lake, with a maximum depth of 115 feet. Dissolved oxygen profiles from data collected in 2015 at site 202 show stratification developing mid-summer (Figure 9). The thermocline occurs at approximately 10 meters (33 feet). Figure 9 is a representative DO profile for Wabana Lake and it illustrates stratification in the summer of 2015 at site 202. The hypolimnion did remain oxygenated until September, showing good cold fish habitat.

Figure 9. Dissolved oxygen profile for Wabana Lake.

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 Wabana 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 Wabana Lake.

Trophic State Index	Site 202
TSI Total Phosphorus	36
TSI Chlorophyll-a	37
TSI Secchi	35
TSI Mean	36
Trophic State:	Oligotrophic

Numbers represent the mean TSI for each parameter.

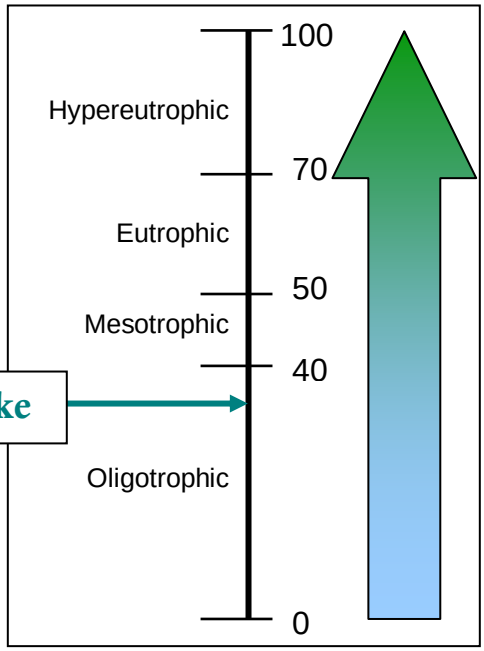


Figure 10. Trophic state index chart with corresponding trophic status.

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.

Wabana Lake had enough data to perform a trend analysis on transparency, phosphorus and chlorophyll (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Wabana Lake.

Lake Site	Parameter	Date Range	Trend	Probability
202	Total Phosphorus	1991, 1999-2000, 2003, 2008, 2010-2011, 2014-2015	No trend	-
202	Chlorophyll *a*	1991, 1999-2000, 2003, 2008, 2010-2011, 2014-2015	Improving	90%
202	Transparency	2005-2015	Improving	90%
201	Transparency	1992-2015	No Trend	-
205	Transparency	1999-2015	Improving	99.9%
206	Transparency	2000-2015	Improving	99.9%
207	Transparency	2002-2015	Improving	98%

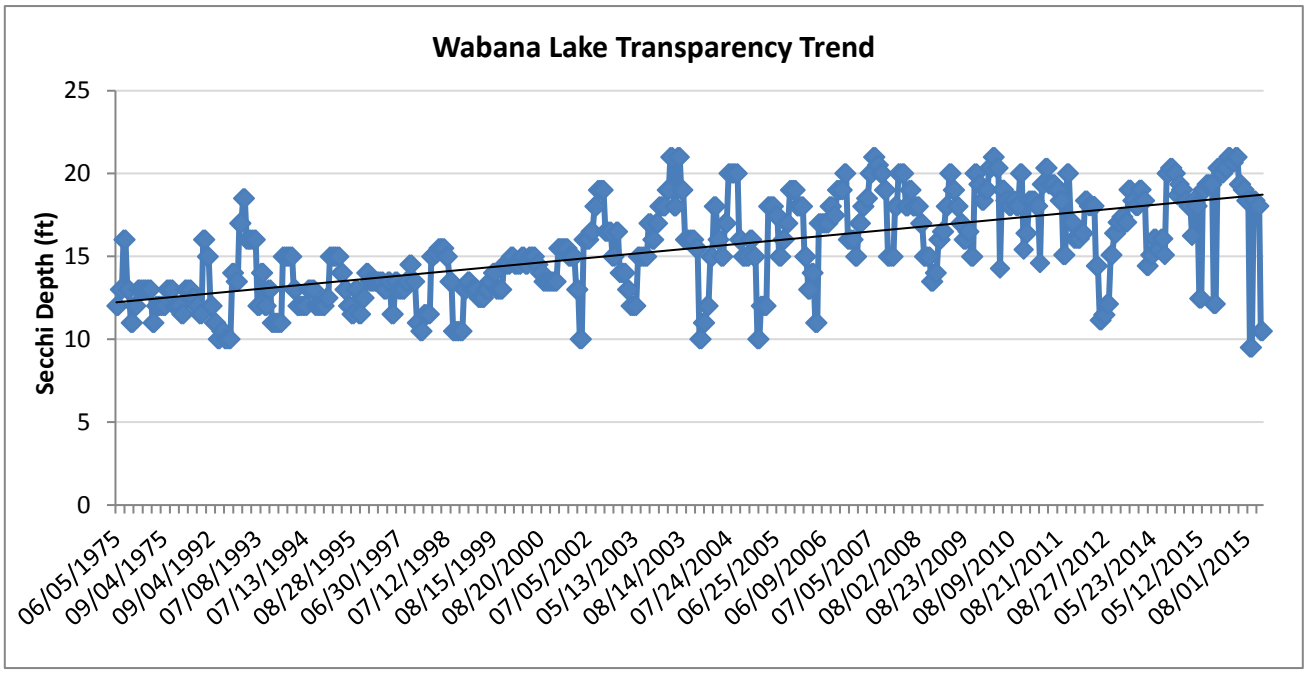


Figure 11. Transparency (feet) trend for site 201 from 1975-2015.

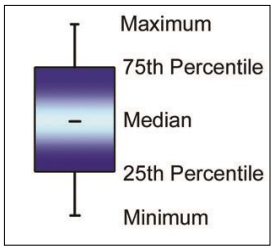
Wabana Lake shows evidence of an increasing transparency trend at numerous lake sites (Figure 11). The chlorophyll a is also improving from the 1990s. From Figure 11, it looks like since around 2002 the transparency has been better than it was in the 1990s. Monitoring should continue so that this trend 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 25th - 75th 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 12. Minnesota Ecoregions.

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



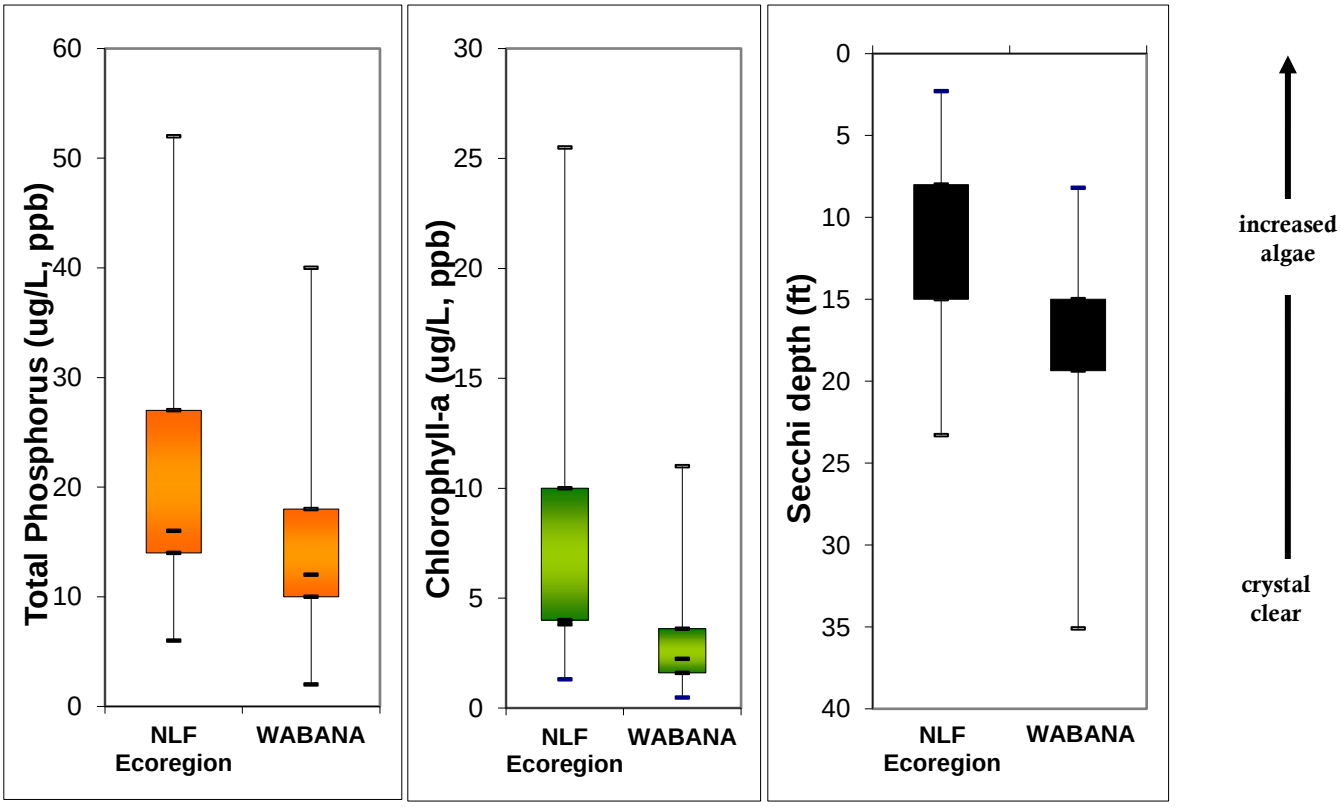


Figure 13. Wabana Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Wabana Lake total phosphorus and chlorophyll *a* ranges are from 132 data points collected in May-September of 1988,1991,2000-2002,2011,2015. The Wabana Lake Secchi depth range is from 2182 data points collected in May-September of 1975-1977,1985,1988,1990-2015.

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. Wabana Lake is located in minor watershed 09047 (Figure 15).

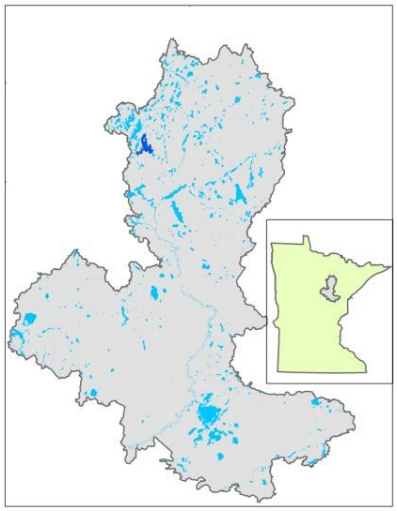


Figure 14. Major Watershed.

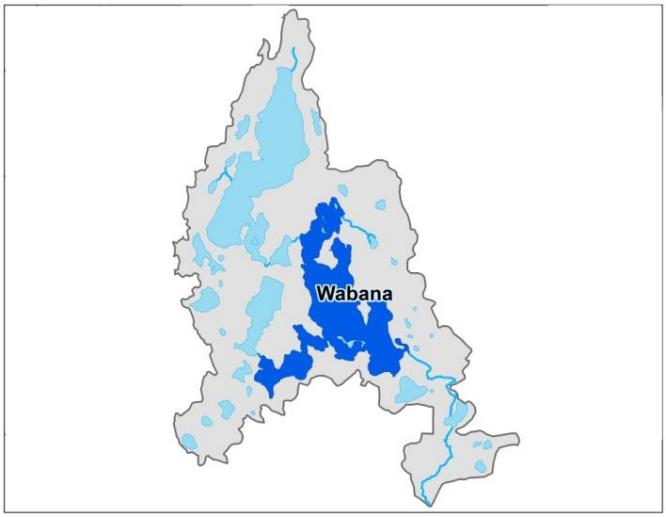


Figure 15. Minor Watershed.

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. Wabana Lake falls within lakeshed 0904703 (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 Wabana Lake 's watershed, containing all the lakesheds upstream of the Wabana Lake lakeshed, see page 17. The data interpretation of the

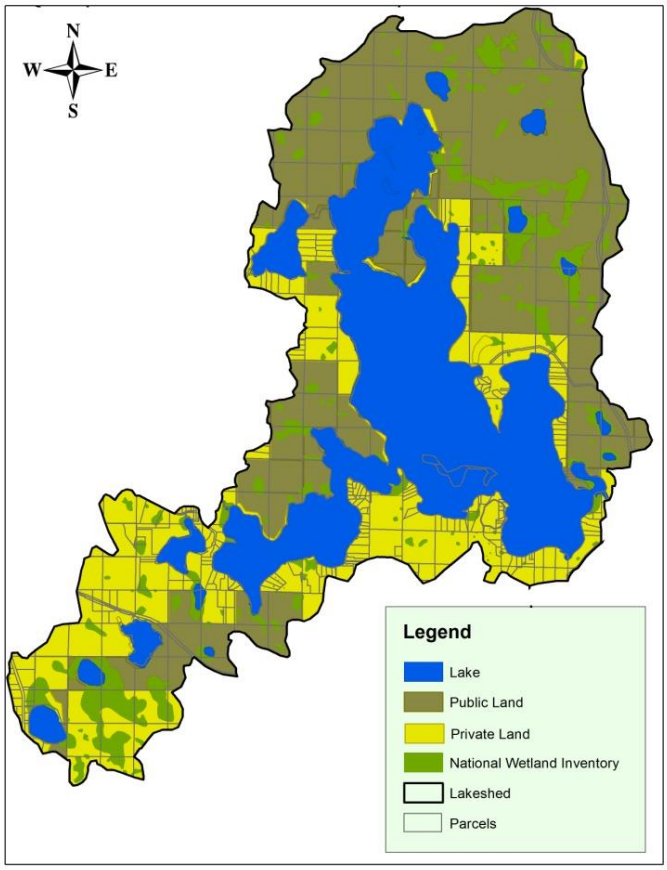


Figure 16. Wabana Lake lakeshed (0904703) with land ownership, lakes, wetlands, and rivers illustrated.

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

Lakeshed Vitals		**Rating**
Lake Area (acres)	2,221	descriptive
Littoral Zone Area (acres)	1,020	descriptive
Lake Max Depth (feet)	115	descriptive
Lake Mean Depth (feet)	25.5	
Water Residence Time	NA	NA
Miles of Stream	1.3	descriptive
Inlets	3	
Outlets	1	
Major Watershed	Mississippi R. -Grand Rapids	descriptive
Minor Watershed	09047	descriptive
Lakeshed	0904703	descriptive
Ecoregion	Northern Lakes and Forests	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	4:1	
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	12:1	
Wetland Coverage (NWI) (acres)	648.2	
Aquatic Invasive Species	None	
Public Drainage Ditches	0	
Public Lake Accesses	2	
Miles of Shoreline	25.3	descriptive
Shoreline Development Index	3.83	
Public Land to Private Land Ratio	1.5:1	
Development Classification	Recreational Development	
Miles of Road	18.6	descriptive
Municipalities in lakeshed	None	
Forestry Practices	None	
Feedlots	None	
Sewage Management	Individual Waste Treatment Systems (septic systems and holding tanks)	
Lake Management Plan	Water Quality Plan, 8/19/2016 http://www.wcola.org/Wabana%20Chain%20of%20Lakes%20water%20mgmt%20plan4.pdf	
Lake Vegetation Survey/Plan	DNR 2000	

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.

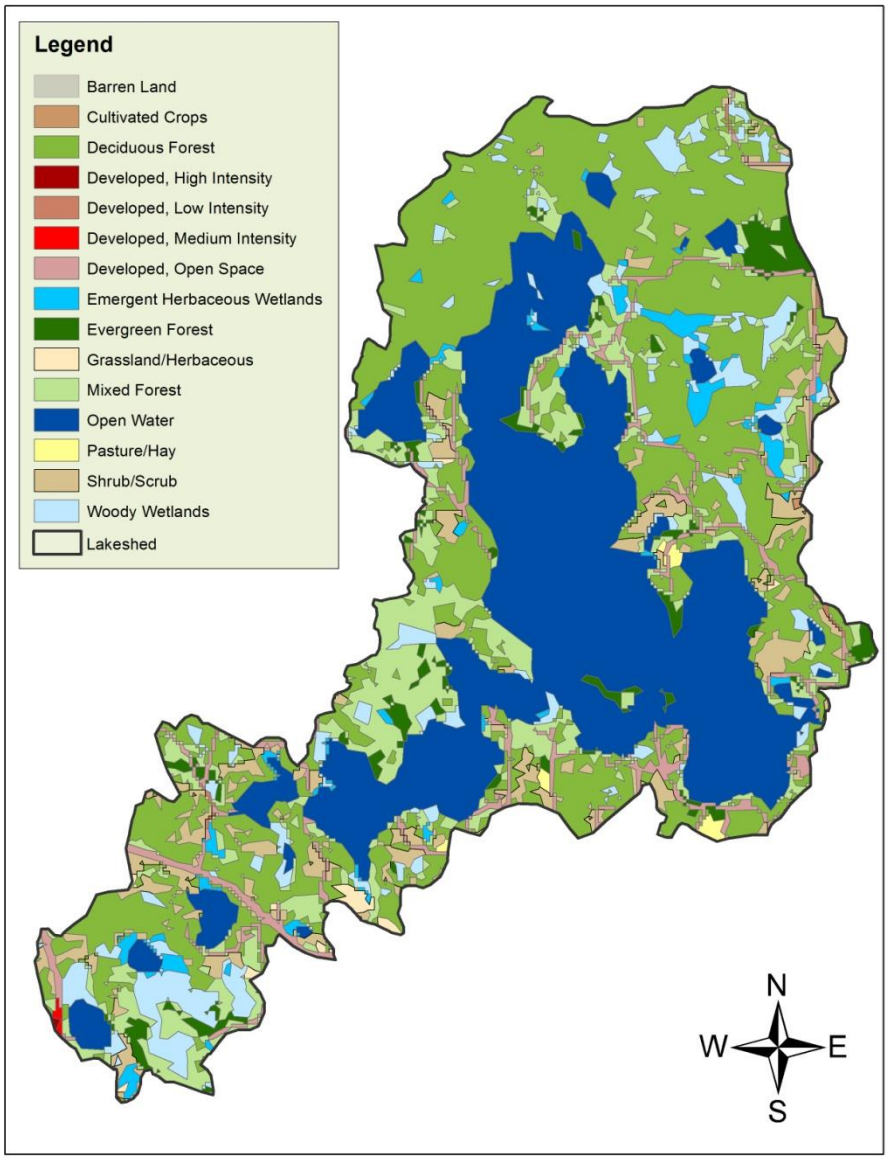


Figure 17. Wabana Lake lakeshed (0904703) land cover (NLCD 2011).

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 Wabana Lake's lakeshed.

The National Land Cover Dataset (NLCD) has records from 2001 and 2011. Table 10 describes Wabana 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. Wabana 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
Cultivated Crops	3.85	0.05	3.41	0.04	-0.01
Deciduous Forest	2905.44	35.78	2892.54	35.62	-0.16
Developed, High Intensity	0	0	1.24	0.02	0.02
Developed, Low Intensity	12.04	0.15	11.41	0.14	-0.01
Developed, Medium Intensity	2.64	0.03	4.33	0.05	0.02
Developed, Open Space	310.83	3.83	309.10	3.81	-0.02
Emergent Herbaceous Wetlands	164.37	2.02	167.50	2.06	0.04
Evergreen Forest	229.97	2.83	227.61	2.80	-0.03
Grassland/Herbaceous	3.94	0.05	30.44	0.37	0.32
Mixed Forest	948.60	11.68	920.87	11.34	-0.34
Pasture/Hay	24.64	0.30	23.55	0.29	-0.01
Shrub/Scrub	486.73	5.99	509.03	6.27	0.28
Woody Wetlands	489.64	6.03	482.01	5.94	-0.09
Open Water	2538.57	31.26	2538.22	31.25	-0.01
Total Area	8121.25		8121.25		

Table 11. Wabana 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	26	0.47	33	0.57	0.1
Urban Acreage	239	2.94	240	2.96	0.02

Demographics

Wabana 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 (Figure 18). (source: http://www.demography.state.mn.us)

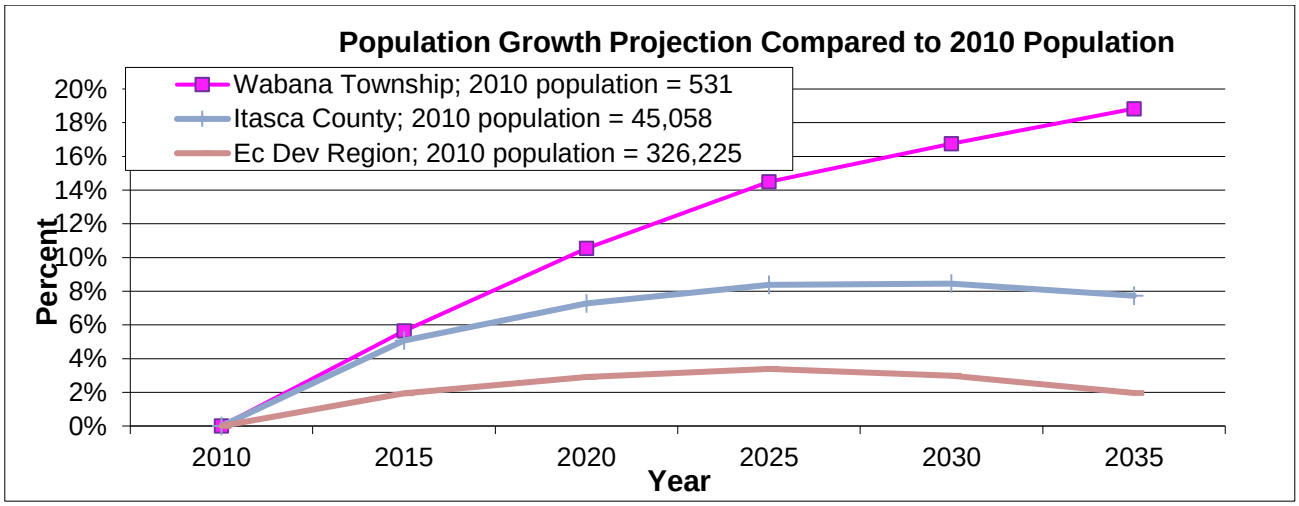


Figure 18. Population growth projection for adjacent townships and Itasca County.

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.

The majority of the privately-owned land within Wabana Lake's lakeshed is forested uplands (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 (26.15)						Public (41.8)		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	2.49	0.29	16.93	3.51	2.94	32.05	0	9.83	31.97
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	89 - 298	6 - 21	121.8		21.11		0	70.68	229.99
Description	Focused on Shoreland	Cropland	Focus of develop-ment 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.

Wabana Lake's lakeshed is classified with having 72% of the watershed protected and 3% of the watershed disturbed (Figure 19). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use. Wabana Lake has 8 lakesheds that flow into it (Figure 20).

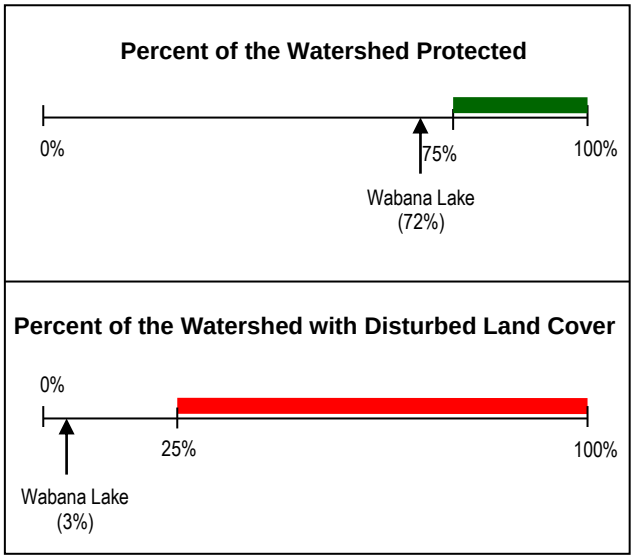


Figure 19. Wabana Lake's lakeshed percentage of watershed protected and disturbed.

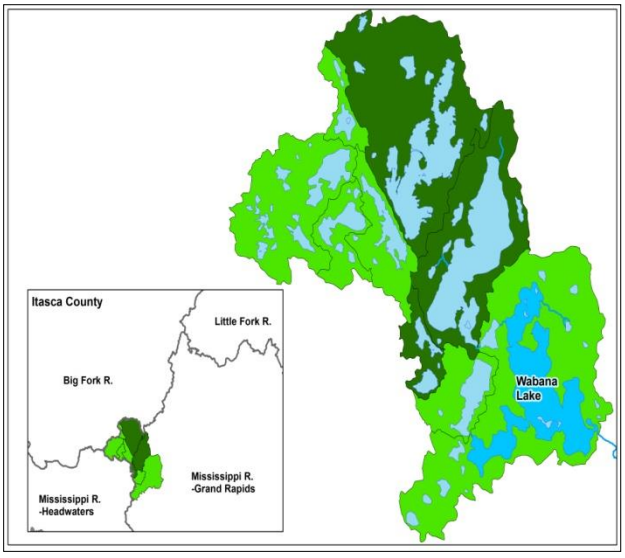


Figure 20. Lakesheds that contribute water to the Wabana Lake lakeshed. Color-coded based on management focus (Table 13).

Status of the Fishery (DNR, as of 07/13/2015)

Wabana is a large lake located about 11 miles north of Grand Rapids, Minnesota. The lake has two public accesses and is moderately developed. The 2010 lake management plan (LMP) indicates Walleye and Northern Pike as the primary species of management with Largemouth Bass and Smallmouth Bass as secondary species. A standard survey was conducted in July of 2015 to assess the status of the fish community. A total of 15 gill nets and 15 trap nets were used in the survey as well as spring night electrofishing for Largemouth and Smallmouth Bass.

The Walleye catch was 4.9 fish/gill net in 2015. The catch approached the management goal of 6.0 fish/net and was within the normal range for similar types of lakes. The sampled fish ranged from 6.6 to 25.5 inches and averaged 15.8 inches. The size distribution goals were nearly attained in 2015.

Past evaluations determined that Walleye natural reproduction was poor in Wabana Lake. It appears that large, deep lakes do not warm fast enough to produce sufficient food for Walleye fry to survive. Walleye fingerlings can often be an effective management tool in these types of lakes where fry and natural reproduction have not been successful. The 2015 survey evaluated a period in which Walleye were stocked annually since 2004. Eleven age-classes from age 1 to 14 were captured with age-2 to age-4 fish representing 60% of the sample. Walleye averaged 15.9 inches after four years of growth. Growth was similar to the statewide averages.

Northern Pike gill-net catch rates have ranged from 1.5 to 5.4 fish/net since 1975. Following the lowest catch on record (1.5 fish/net) in 2009, the catch improved to 4.1 fish/net in 2015. The catch was average when compared to other similar lakes. Northern Pike ranged from 12.6 to 37.0 inches and averaged 23.7 inches. Although size structure was good compared to many Northern Pike populations, the size distribution goals were not attained and will likely not be attained in the absence of length based regulations. Nine age-classes were identified with fish from age 2 to age 11 present. Age-2 fish represented 35% of the sample. Growth was good with Northern Pike averaging 24.3 inches after four years of growth.

Largemouth Bass were sampled with spring night electrofishing. The catch was 31.9fish/hr in 2015. The sampled fish ranged from 6.3 to 15.6 inches and averaged 10.8 inches. Seven year-classes were identified with fish from age 2 to 9 present. The 2011 age class represented 56% of the sample. Growth was slow compared to statewide averages. Our goal to sample more 20 inch and larger fish was not achieved in 2015 and may not be realistic for the lake due to slow growth.

Smallmouth Bass were also sampled with spring night electrofishing in 2015. The catch was 14.7 fish/hr. The sampled fish ranged from 6.0 to 16.8 inches and averaged 10.4 inches. Five year-classes were identified. Fish from age 2 to age 8 were present with age 3 and 4 representing 86% of the sample. Growth was similar to the statewide average through age 4 but slower for older fish.

Tullibees are difficult to sample with our standard summer surveys because they spend most of the time in the open water. Catch rates on Wabana have been relatively stable, with a mean of 3.7/gill net since 1975. The catch of 4.6 in 2015 was near the upper end of the normal range for similar types of lakes. The sampled fish ranged from 7.3 to 20.0 inches and averaged 14.2 inches. The majority of the fish were 17 to 19 inches. No attempt was made to age the fish but the size distribution would suggest at least three age classes were present.

Yellow Perch catches have never exceeded the lake class average. The 2015 catch was 4.7 fish/gill net and catches have ranged from 1.0 to 11.5/net since 1975. The sampled Yellow Perch ranged from 5.5 to 11.0 inches and averaged 7.0 inches. Due to the Yellow Perch size distribution they are probably more important within the fish community as a prey source than as a species desired by anglers.

Other species observed during the survey included Black Crappie, Green Sunfish, Hybrid Sunfish, Pumpkinseed Sunfish, Rock Bass, and White Sucker.

In order to maintain or improve fish and wildlife populations, water quality and habitat must be protected. People often associate water quality problems with large-scale agricultural, forestry, urban development or industrial practices in the watershed. In reality, the impact of land use decisions on one lake lot may be relatively small, yet the cumulative impact of those decisions on many lake lots can result in a significant decline in water quality and habitat. For example, removing shoreline and aquatic vegetation, fertilizing lawns, mowing to the water's edge, installing beach sand blankets, failing septic systems and uncontrolled run-off, all contribute excess nutrients and sediment which degrade water quality and habitat. Understanding these cumulative impacts and taking steps to avoid or minimize them will help to insure our quality fisheries can be enjoyed by future generations.

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=31039200

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring at sites 201, 202, 203 and 205 should be continued annually. All the main sites monitored have shown comparable water quality (Table 5). 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.

The inlets to Wabana Lake appear to be minor, but if they are suspected as phosphorus sources to the lake they could be monitored for phosphorus.

Overall Summary
Wabana Lake is an oligotrophic lake (TSI = 36) with evidence of a long-term improving trend in water clarity. The total phosphorus, chlorophyll *a* and transparency ranges are better than the ecoregion ranges. The transparency and chlorophyll a (algae concentration) appear to have improved greatly in the 2000s from the 1990s. It could be that upgrades in waste treatment in the 1990s contributed to the improvement in water quality.

Wabana Lake has other lakes flowing into it, but the whole watershed is well protected and has good water quality (Figure 20). The evaluation of watershed land use shows that 72% of Wabana's lakeshed is protected (publicly owned, private forests, wetlands, or lakes), and only 3% of the lakeshed is disturbed (developed, agriculture, forestry, mining) (Figure 19).

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. Wabana Lake is classified by the DNR as a Cisco Refuge Lake because it has deep, cold water, and a well-protected lakeshed. Dissolved oxygen profiles from 2015 show good cisco habitat (Figure 9). The 2015 DNR Fisheries survey did show ciscoes are relatively stable in the lake (page 18), which is an indicator that the lake has good water quality.

Priority Impacts to the Lake
Wabana Lake is only moderately developed at this time. In addition, almost half of the lakeshore is publicly owned, which usually protects it from subdivisions (Figure 16). A future potential priority impact to Wabana Lake would be the expansion of residential housing development around the lakeshore on privately-owned lots. In addition, the conversion of small lake cabins to year-round

family homes increases the impervious surface and runoff from the lake lots. The second tier remains in large parcels and has not been subdivided for development (Figure 16). Population projections for the Wabana township show the potential for growth in the area in the next 10 years (Figure 18), and its excellent water quality and proximity to Grand Rapids makes it a desirable place to live.

Best Management Practices Recommendations

The management focus for Wabana Lake should be to protect the current water quality and lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by additional development, and impervious surface area on existing lots (conversion of seasonal cabins to year-round homes).

The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. Forested uplands contribute significantly less phosphorus (lbs/acre/year) than developed land cover (Table 12). Forested uplands can be managed with Forest Stewardship Planning.

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.

The lakeshed still has large undeveloped shoreline parcels, especially on the east and west shores (Figure 16). Because a lot of undeveloped private land still exists, there is a great potential for protecting this land with conservation easements and aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing a whole 100 foot frontage is not necessary and can contribute to additional algae blooms.

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