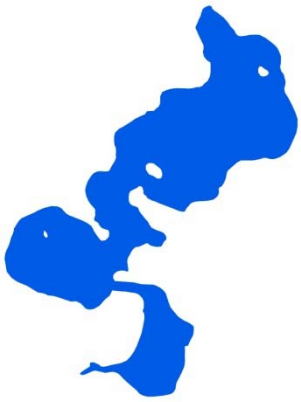
Island Lake 18-0183-00 CROW WING COUNTY

Lake Water Quality

Summary



Island Lake is located 4 miles southeast of Emily, MN in Crow Wing County. It is a round lake covering 237.5 acres (Table 1).

Island Lake has one inlet and one outlet, which classify it as a drainage lake. Water enters Island Lake from Mud Brook to the north. Mud Brook then exits the lake to the south, and eventually joins with the Pine River.

Water quality data have been collected on Island Lake from 1984-2014 (Tables 2 & 3). These data show that the lake is mesotrophic (TSI = 42) with clear water conditions most of the summer and excellent recreational opportunities.

Island Lake has an organized association that is involved in activities such as water quality monitoring and education.

Table 1. Island Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	18-0183-00	Surface area (acres):	239.5
County:	Crow Wing	Littoral area (acres):	150.0
Ecoregion:	Northern Lakes and Forests	% Littoral area:	62.6
Major Drainage Basin:	Pine R.	Max depth (ft), (m):	35.0, 10.7
Latitude/Longitude:	46.689292/-93.895476	Inlets:	1
Invasive Species:	None (as of 2014)	Outlets:	1
		Public Accesses:	1

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

Data Availability

Transparency data		Good data set from 1984-2014.
Chemical data		Fair data set from 2004-2005 and 2012-2013.
Inlet/Outlet data		No data exist.

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

Lake Map

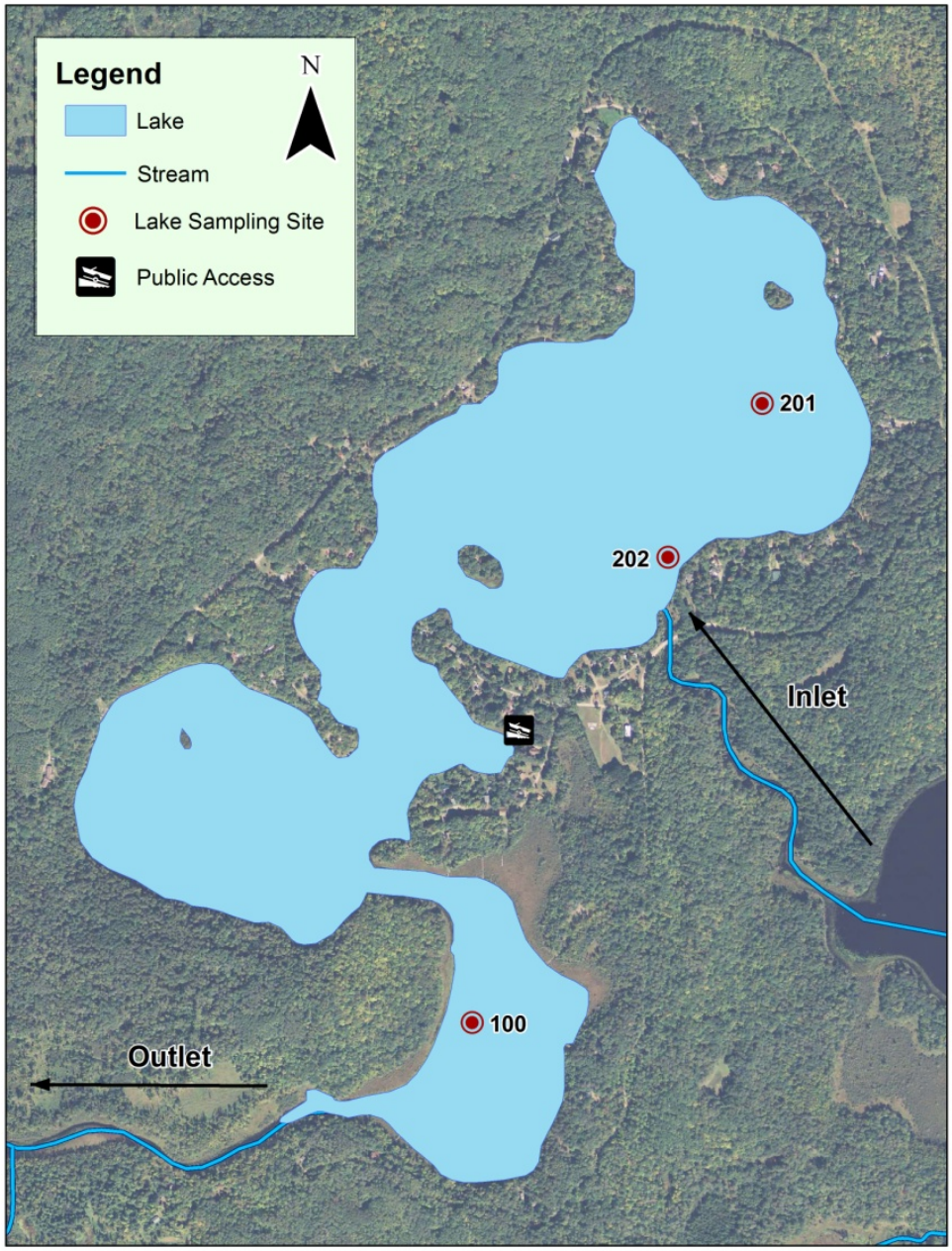


Figure 1. Map of Island Lake with 2010 aerial imagery, sample site locations, inlets and outlets, and public access points.

Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), Clean Water Legacy Surface Water Monitoring (CWL), Whitefish Area Property Owners Association (WAPOA).

Lake Site	Depth (ft)	Monitoring Programs
201*primary site	37	CLMP: 1984-2014; CWL: 2012-2013
202	10	CLMP: 2007-2014
100	20	WAPOA: 2004-2005

Average Water Quality Statistics

The information below describes available chemical data for Island Lake through 2014 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth 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. Island 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)	13.2	14 – 27	> 30	Results are within the expected range for the Northern Lakes and Forests Ecoregion.
[3]Chlorophyll *a* (ug/L)	4.6	4 – 10	> 9	
Chlorophyll *a* max (ug/L)	6.4	< 15		
Secchi depth (ft)	15.0	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)	1.0	<0.4 – 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	38.2	40 – 140		Indicates a soft water lake with a sensitivity to acid rain.
Color (Pt-Co Units)	NA	10 – 35		No data available.
pH	7.5	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)	1.0	0.6 – 1.2		Within the expected range for the ecoregion.
Total Suspended Solids (mg/L)	3.8	<1 – 2		Indicates low suspended solids and clear water.
Conductivity (umhos/cm)	83.9	50 – 250		Indicates a soft water lake. Within the expected range for the ecoregion.
TN:TP Ratio	75:1	25:1 - 35:1		Within the expected range for the ecoregion, and shows the lake is phosphorus limited.

[1]The ecoregion range is the 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.

Parameters	Site 100	Site 201
Total Phosphorus Mean (ug/L):	**13.2**	**NA**
Total Phosphorus Min:	12	
Total Phosphorus Max:	16	
Number of Observations:	10	
Chlorophyll *a* Mean (ug/L):	**4.6**	**16.8**
Chlorophyll-a Min:	<1	6.8
Chlorophyll-a Max:	6.4	42.3
Number of Observations:	10	12
Secchi Depth Mean (ft):	**15.0**	**6.1**
Secchi Depth Min:	10.5	2.0
Secchi Depth Max:	19.0	13.5
Number of Observations:	10	398

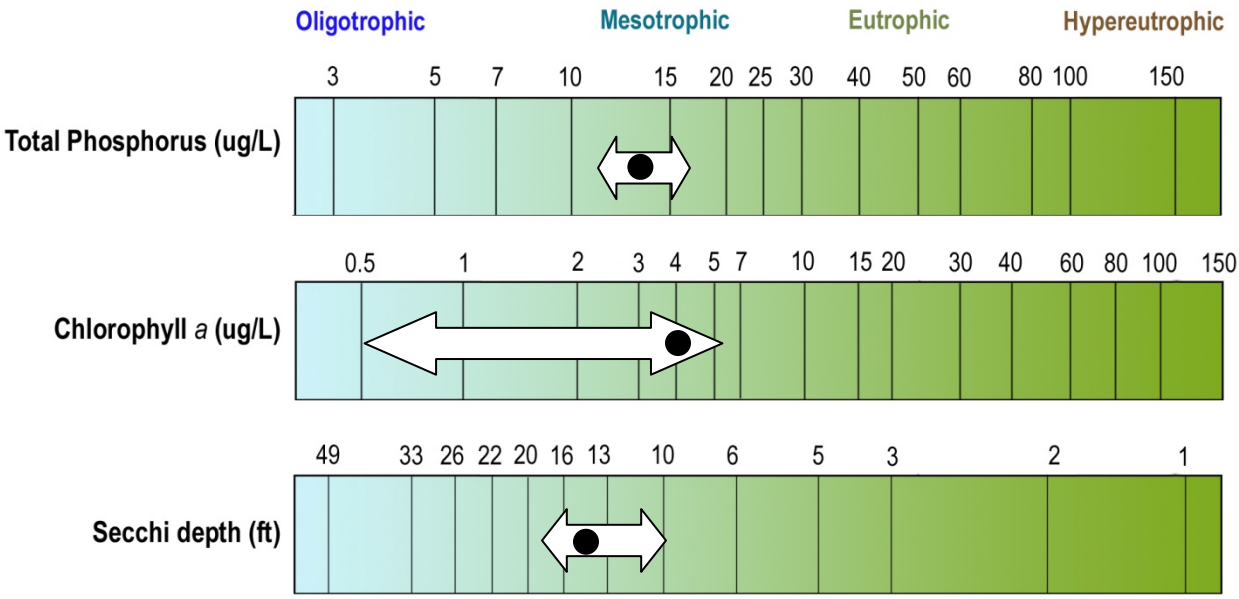


Figure 2. Island Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Site 100). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

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 Island Lake ranges from 3.1 to 9.9 feet (Figure 3). The annual means have been lower since 2011. This likely due to a flood in 2012 that caused lake levels to rise 3-4 feet in the lake. For trend analysis, see page 10. Transparency monitoring should be continued annually at site 201 in order to track water quality changes.

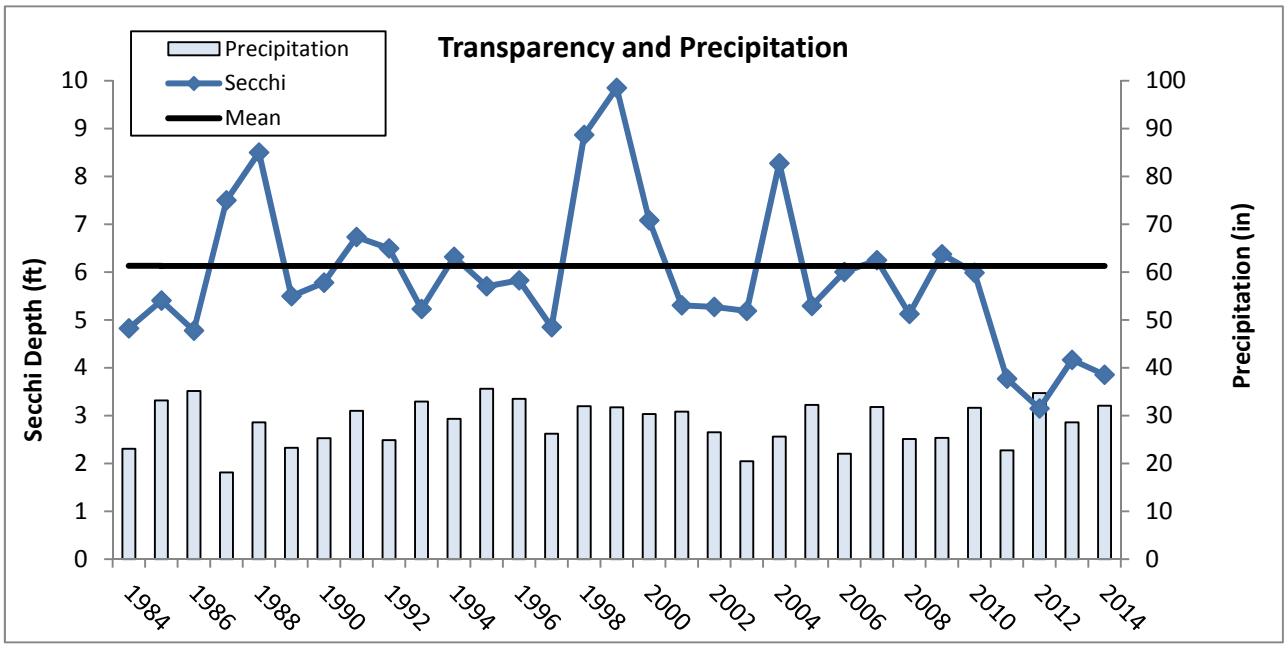


Figure 3. Annual mean transparency compared to long-term mean transparency.

Island Lake transparency ranges from 10.5 to 19.0 ft at the primary site (201). Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Island 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.

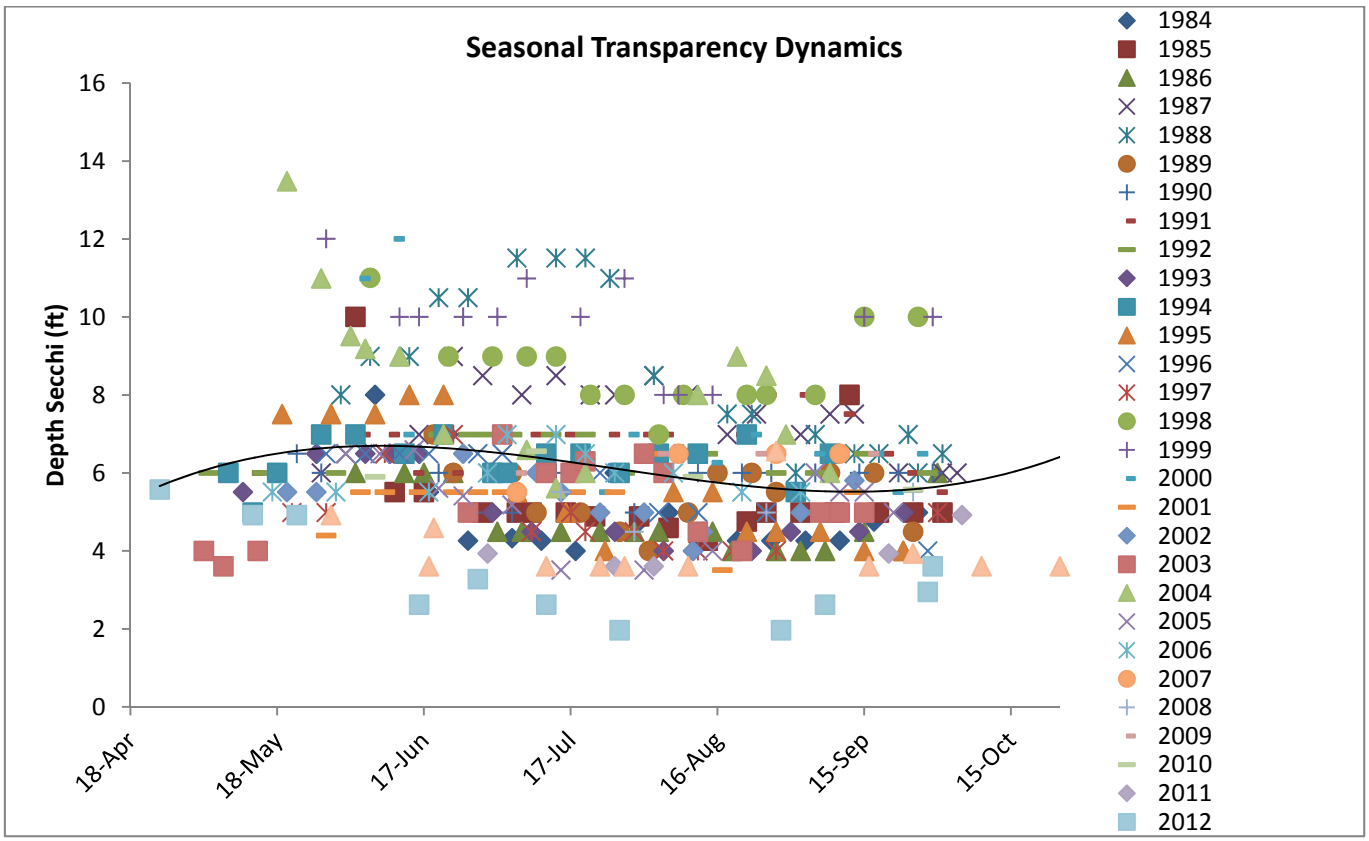


Figure 4. Seasonal transparency dynamics and year to year comparison (Primary Site 201). The black line represents the pattern in the data.

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. Island Lake was rated as having "definite algae" 41% of the time by samplers at site 201 between 1987 and 2014 (Figure 5).

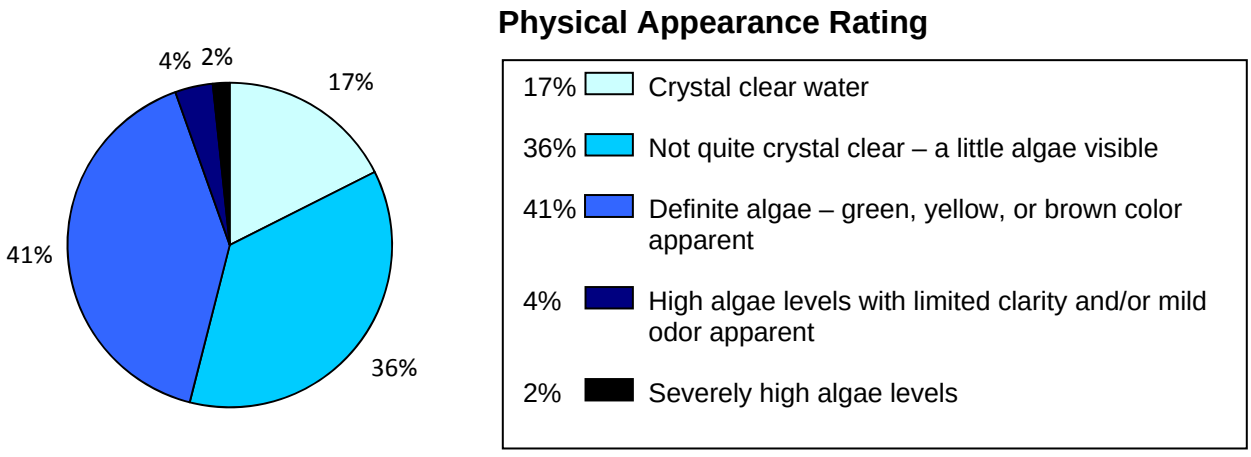


Figure 5. Island Lake physical appearance ratings by samplers.

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Island Lake was rated as being "beautiful" 45% of the time from 1987 to 2014 (Figure 6).

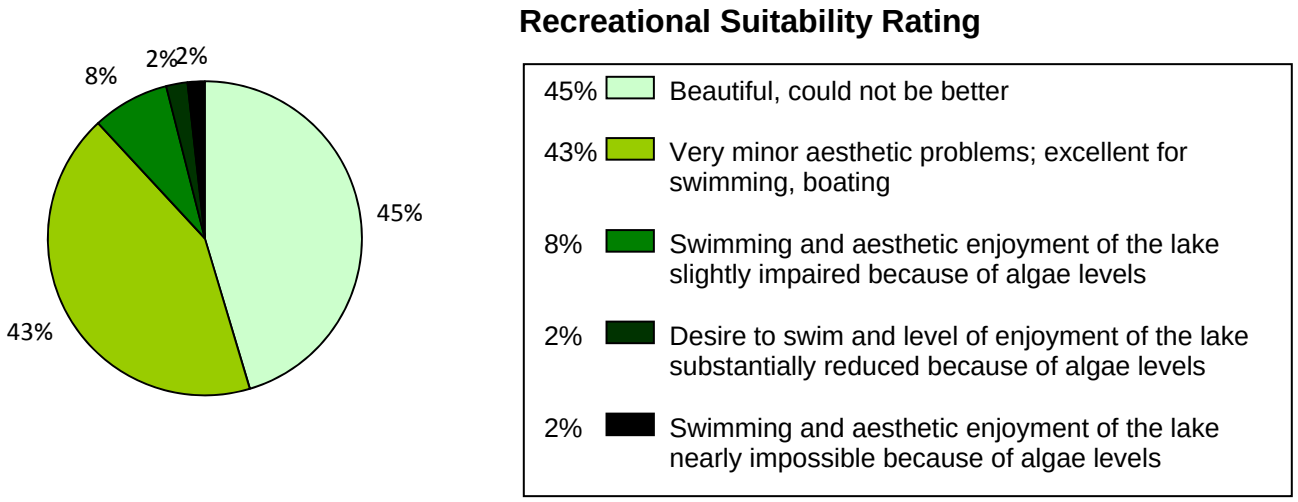


Figure 6. Recreational suitability rating, as rated by the volunteer monitor.

Total Phosphorus

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

Total phosphorus was evaluated in Island Lake in 2004-2005. The data do not indicate much seasonal variability. The majority of the data points fall into the mesotrophic/oligotrophic border (Figure 7).

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

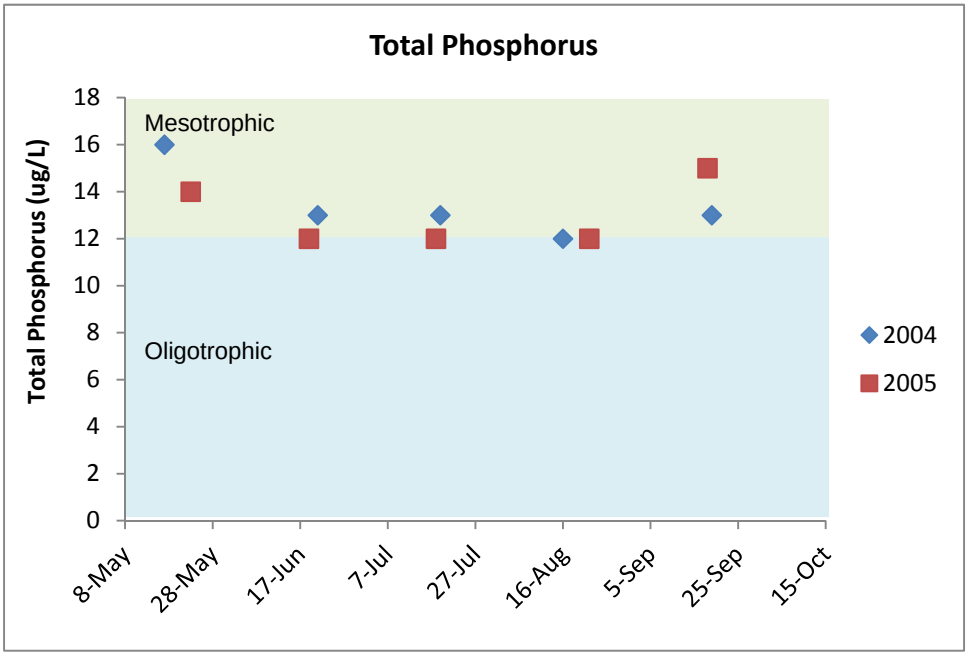


Figure 7. Historical total phosphorus concentrations (ug/L) for Island Lake site 202.

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.

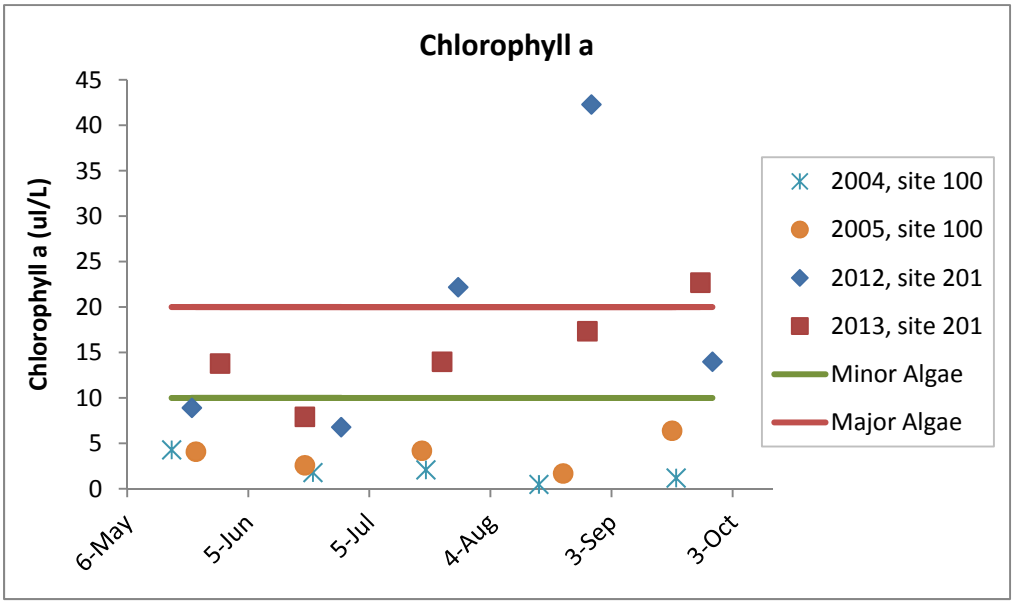
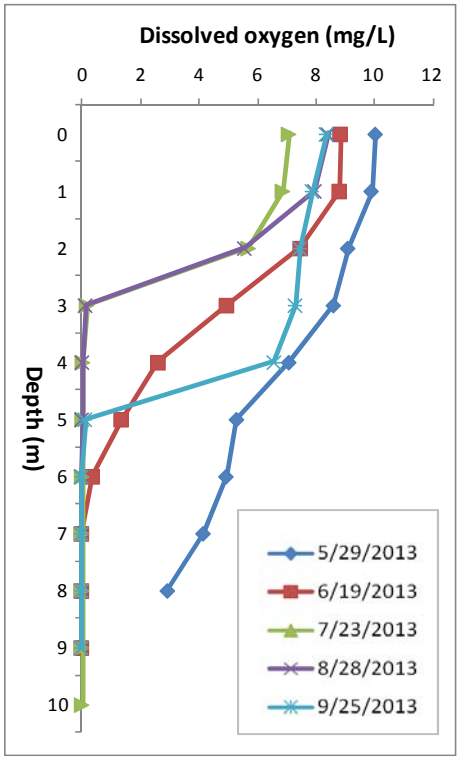


Figure 8. Chlorophyll *a* concentrations (ug/L) for Island Lake.

Chlorophyll *a* was evaluated in Island Lake at site 100 in 2004-2005 and site 201 in 2012-2013 (Figure 8). Chlorophyll *a* concentrations went above 20 ug/L in 2004-2005, indicating algae blooms. In 2004-2005 the chlorophyll remained below 10 ug/L indicating clear water.

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.

Island Lake is a moderately deep lake, with a maximum depth of 35 feet. Dissolved oxygen profiles from data collected in 2013 shows stratification developing mid-summer (Figure 9). The thermocline occurs at 3 meters (10 feet) and the dissolved oxygen is depleted below this depth. This means that gamefish will be scarce below 10 feet depth in mid-summer.

Figure 9. Dissolved oxygen profile for Island 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 Island Lake falls into the mesotrophic 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).

Mesotrophic lakes (TSI 40-50) are characterized by moderately clear water most of the summer. "Meso" means middle or mid; therefore, mesotrophic means a medium amount of productivity. Mesotrophic lakes are commonly found in central Minnesota and have clear water with algal blooms in late summer (Table 7). They are also good for walleye fishing.

Table 6. Trophic State Index for Island.

Trophic State Index	Site 100
TSI Total Phosphorus	41
TSI Chlorophyll-a	46
TSI Secchi	38
TSI Mean	42
Trophic State:	Mesotrophic

Numbers represent the mean TSI for each parameter.

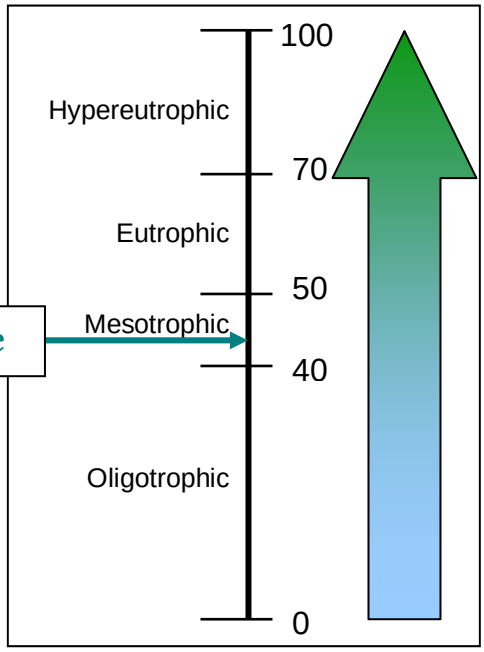


Figure 10. Trophic state index chart with corresponding trophic status.

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.

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

Table 8. Trend analysis for Island Lake.

Lake Site	Parameter	Date Range	Trend	Probability
100	Total Phosphorus	2004-2005	Insufficient data	--
201	Chlorophyll *a*	2012-2013	Insufficient data	--
201	Transparency	1984-2014	No trend	--
201	Transparency	2004-2014	Declining	95%

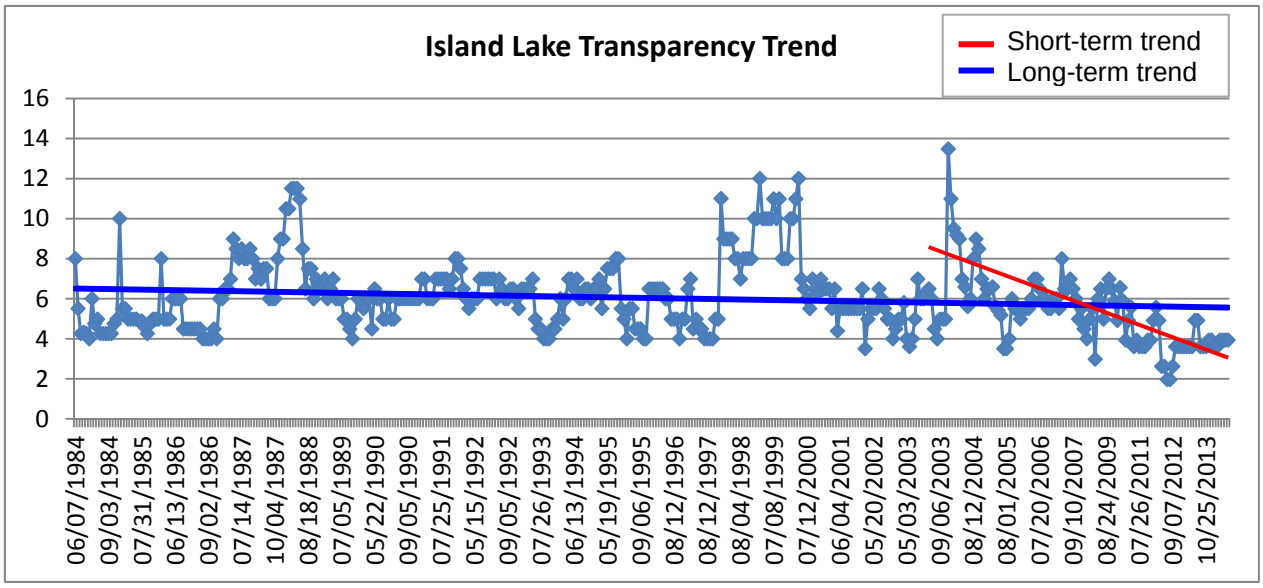


Figure 11. Transparency (feet) trend for site 201 from 1984-2014.

Island Lake shows evidence of a declining transparency trend in the short-term (Table 8). Transparency is especially lower in 2013-2014 due to high water levels. Transparency 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.

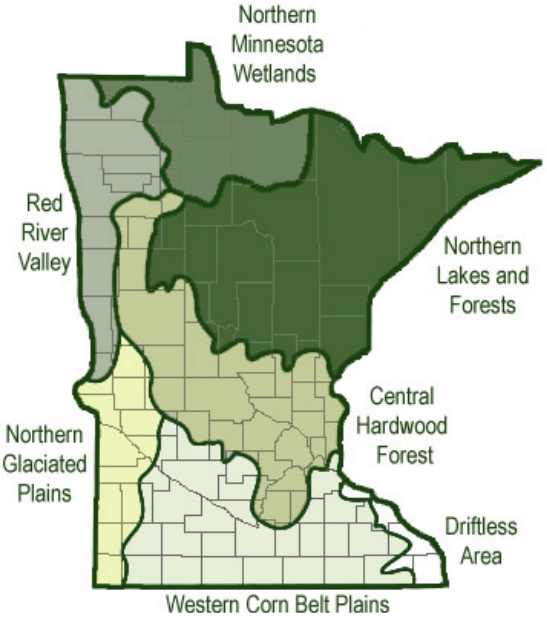
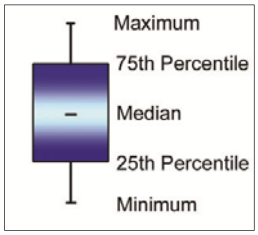


Figure 12. Minnesota Ecoregions.

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



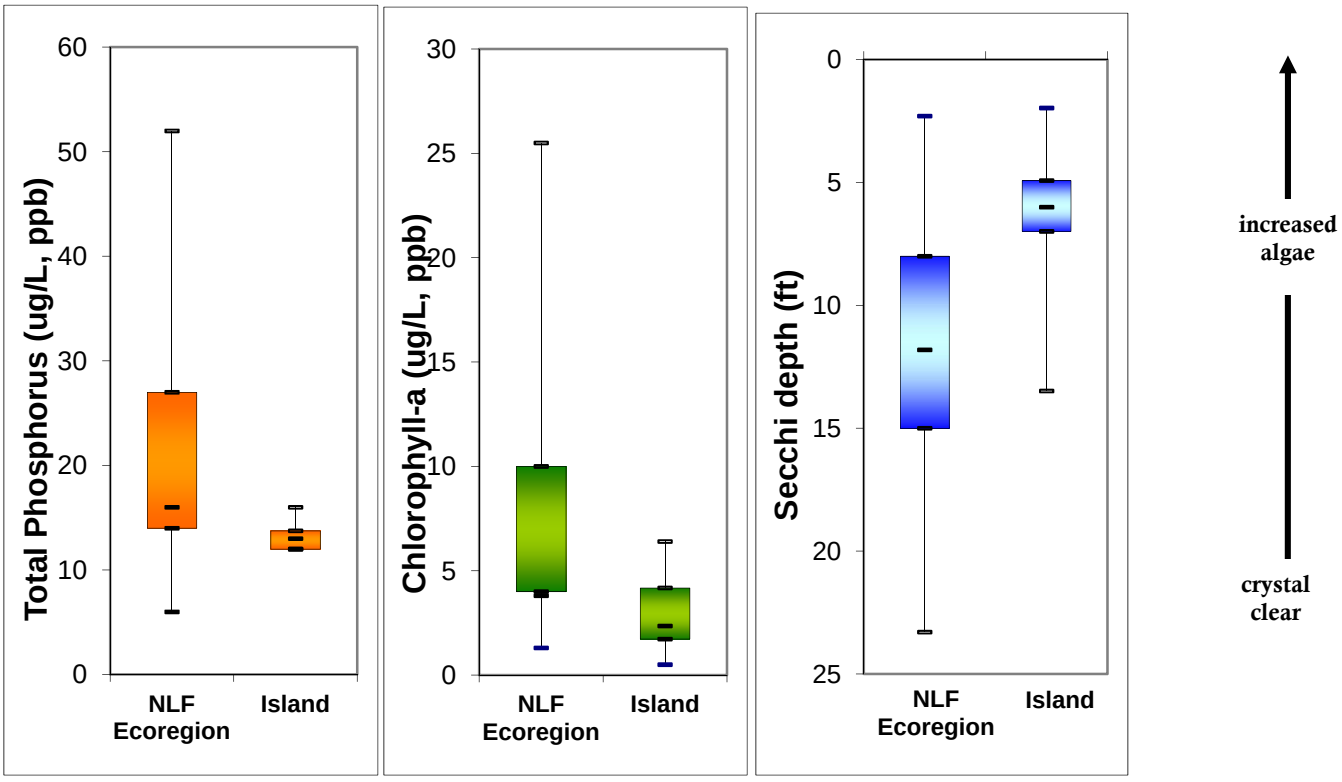


Figure 13. Island Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Island Lake total phosphorus and chlorophyll *a* ranges are from 10 data points collected in May-September of 2004-2005. The Island Lake Secchi depth range is from 398 data points collected in May-September of 1994-2014.

Lakeshed Data and Interpretations

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 Pine River Major Watershed is one of the watersheds that make up the Upper Mississippi Basin, which drains south to the Gulf of Mexico (Figure 14). This major watershed is made up of 132 minor watersheds. Island Lake is located in minor watershed 11050 (Figure 15).

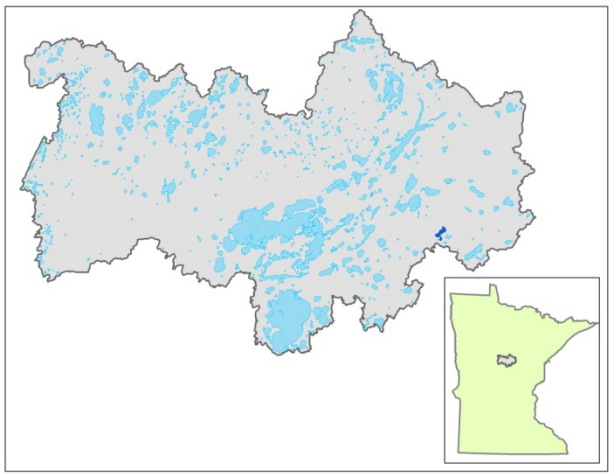


Figure 14. Major Watershed.

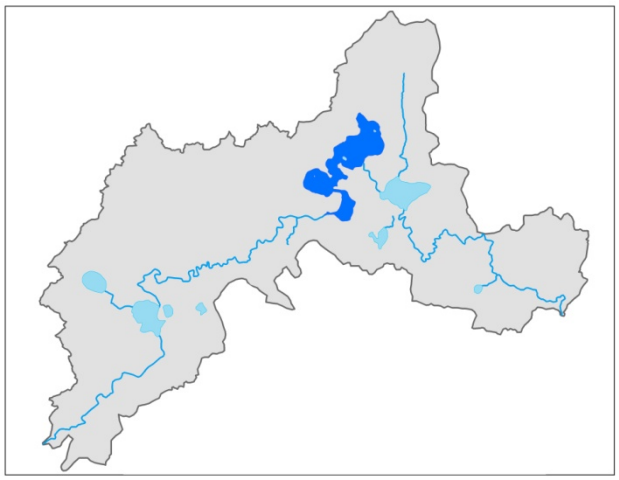


Figure 15. Minor Watershed.

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. Island Lake falls within lakeshed 1105001 (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 Island Lake 's watershed, containing all the lakesheds upstream of the Island Lake lakeshed, see page 17. The data interpretation of the Island Lake lakeshed

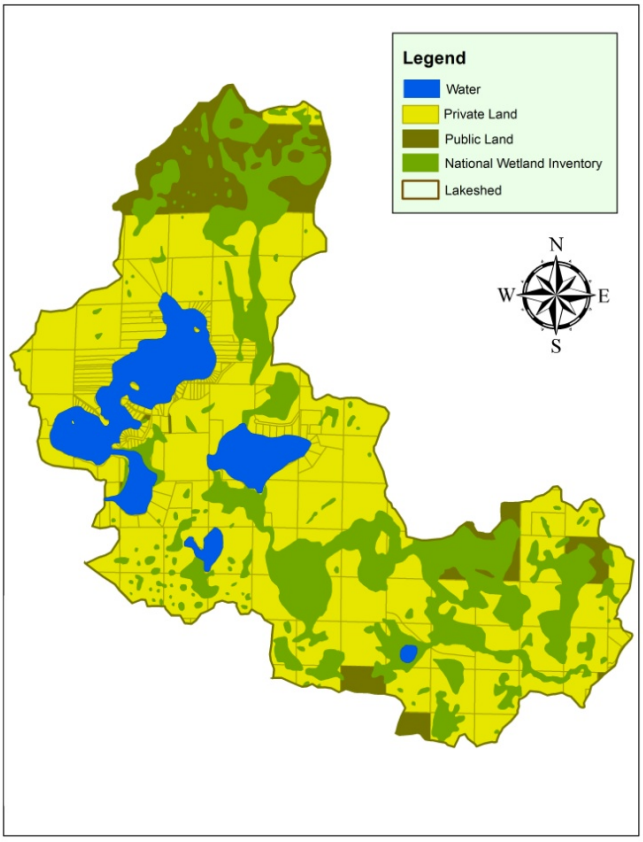


Figure 16. Island Lake lakeshed (1105001) with land ownership, lakes, wetlands, and rivers illustrated.

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

Lakeshed Vitals		**Rating**
Lake Area	239.53 acres	descriptive
Littoral Zone Area	90.16 acres	descriptive
Lake Max Depth	37 miles	descriptive
Lake Mean Depth	12.4 miles	descriptive
Water Residence Time	NA	NA
Miles of Stream	6.97 miles	descriptive
Inlets	1	
Outlets	1	
Major Watershed	11 - Pine River	descriptive
Minor Watershed	11050	descriptive
Lakeshed	1105001	descriptive
Ecoregion	Northern Lakes and Forests	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	15:1	
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	109:1	
Wetland Coverage (NWI)	24.9%	
Aquatic Invasive Species	None	
Public Drainage Ditches	0	
Public Lake Accesses	1	
Miles of Shoreline	5.12 miles	descriptive
Shoreline Development Index	2.35	
Public Land to Private Land Ratio	1:5.09	
Development Classification	General Development	
Miles of Road	7.44 miles	descriptive
Municipalities in lakeshed	None	
Forestry Practices	None	
Feedlots	0	
Sewage Management	Individual Subsurface Sewage Treatment Systems (Inspection and assessment required for all permits and property transfers within the Shoreland Protection Zone)	
Lake Management Plan	None	
Lake Vegetation Survey/Plan	DNR, 1996	

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.

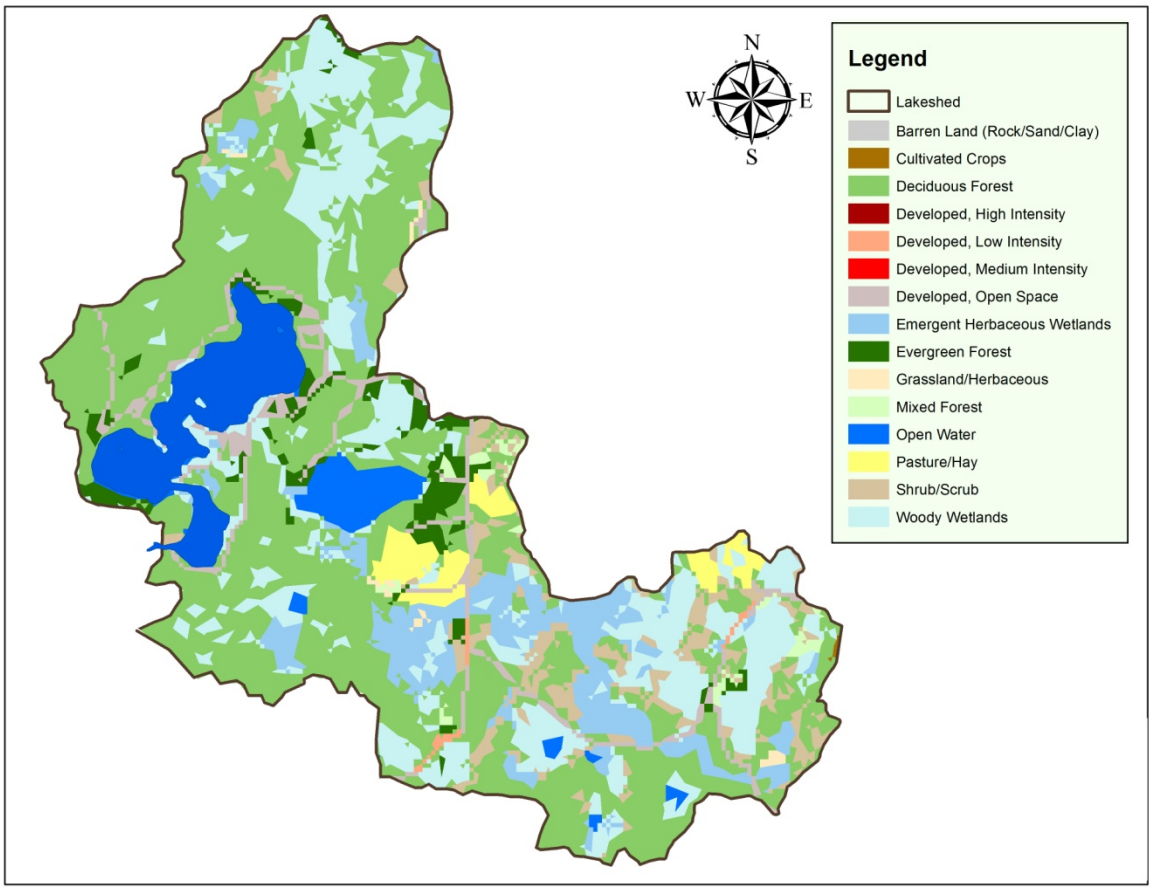


Figure 17. Island Lake lakeshed (1105001) land cover (NLCD 2011).

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.

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 Island Lake's lakeshed.

The National Land Cover Dataset (NLCD) has records from 2001 and 2011. Table 10 describes Island 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. Island Lake's lakeshed land cover statistics and % change from 2001 to 2011 (Data Source: NLCD).

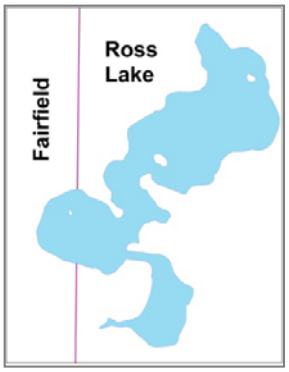
Land Cover	2001 Acres	Percent	2011 Acres	Percent	% Change 2001 to 2011
Cultivated Crops	0.00	0.00	1.34	0.04	0.0372
Deciduous Forest	3149.33	29.88	1675.45	46.43	16.5540
Developed, Low Intensity	1.92	0.02	9.60	0.27	0.2477
Developed, Open Space	303.10	2.88	141.14	3.91	1.0360
Emergent Herbaceous Wetlands	235.11	2.23	318.35	8.82	6.5917
Evergreen Forest	140.13	1.33	122.06	3.38	2.0533
Grassland/Herbaceous	9.78	0.09	11.60	0.32	0.2286
Mixed Forest	536.05	5.09	29.11	0.81	-4.2783
Open Water	3432.00	32.56	313.06	8.68	-23.8815
Pasture/Hay	239.76	2.27	88.53	2.45	0.1788
Shrub/Scrub	294.58	2.79	194.47	5.39	2.5948
Woody Wetlands	2199.75	20.87	703.86	19.51	-1.3623
Total Area	3608.58				

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

Category	1990 Acres	Percent	2000 Acres	Percent	Change (acres) 1990 to 2000
Total Impervious Area	12	0.37	19	0.57	7 acres
Urban Acreage	117	3.24	118	3.27	1 acre

Demographics

Island Lake is classified as a General Development lake. General Development lakes usually have more than 225 acres of water per mile of shoreline, 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 Crow Wing County as a whole, Fairfield Township has a slightly higher growth projection (Figure 18). (source: http://www.demography.state.mn.us)

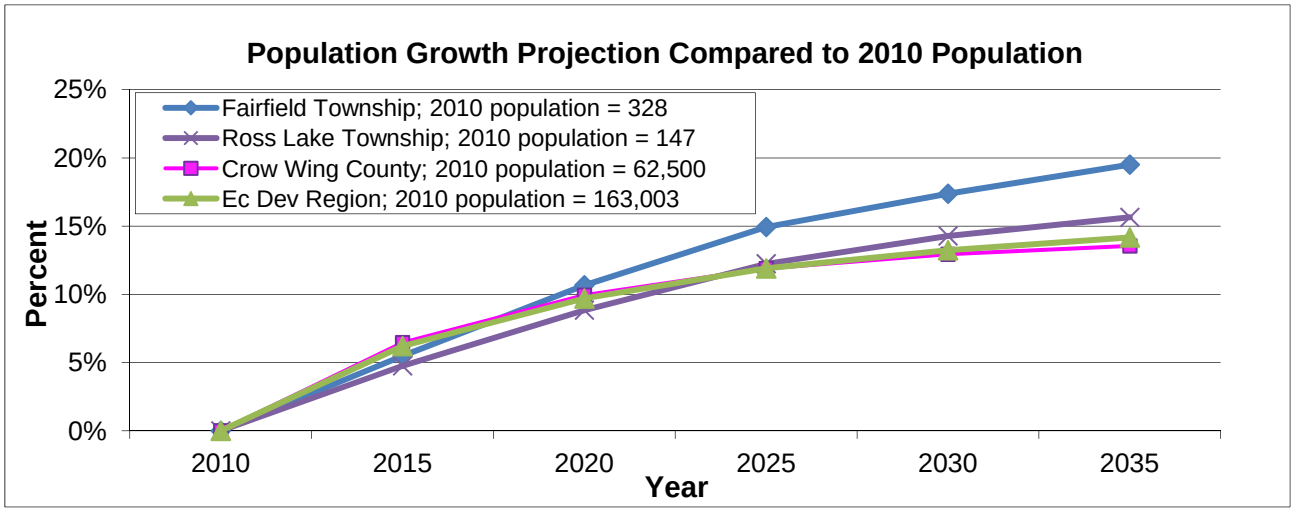


Figure 18. Population growth projection for adjacent townships and Crow Wing County.

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 land within Island 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 (75.8)					9.3	Public (14.9)		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	3.97	2.44	48.20	0.28	21.02	9.3	11.02	3.87	0
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	64 –215	23 –79	157		1.9		35.76	12.561	0
Description	Focused on Shoreland	Cropland	Focus of develop-ment and protection efforts	Open, pasture, grass-land, shrub-land	Protected				
Potential Phase 3 Discussion Items	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.

Island Lake's lakeshed is classified with having 25% of the watershed protected and 5% 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. There are many other lakesheds that flow into Island Lake, but they are well protected (Figure 20).

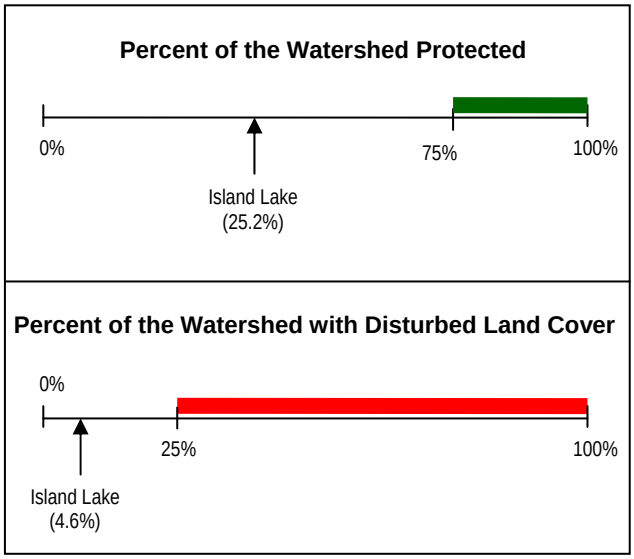


Figure 19. Island Lake's lakeshed percentage of watershed protected and disturbed.

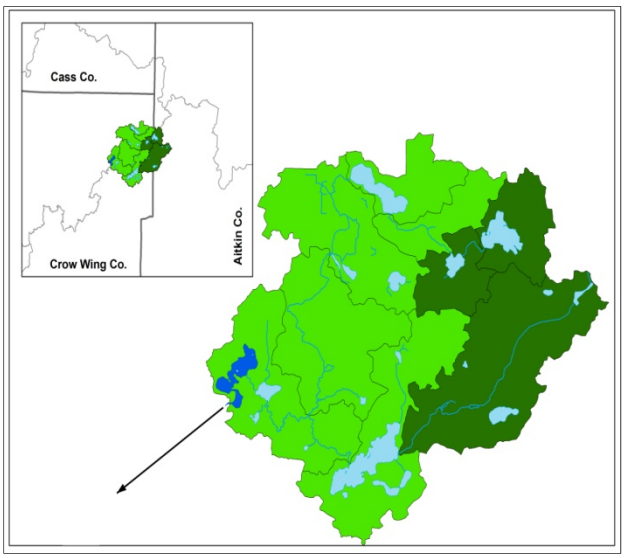


Figure 20. Lakesheds that contribute water to the Island Lake lakeshed. Color-coded based on management focus (Table 13).

Status of the Fishery (DNR, as of 08/02/2010)

Island Lake is a 240 acre, moderately fertile, soft water lake located 3 miles southeast of Emily, in Crow Wing County. A public access is located on the east side of the lake. The maximum depth is 37 feet and 63% of the lake is less than 15 feet deep. The number of cabins/homes around the lake remained relatively unchanged from the previous count in 1999 with 19 cabins/homes per shoreline mile. Shallow water substrates are primarily sand, with gravel and muck also common. The lake supports a very diverse aquatic plant community consisting of 38 species. Aquatic plants help prevent erosion, stabilize bottom sediments, provide spawning habitat, and provide food and shelter for a variety of aquatic organisms.

An assessment of the fish population was completed in 2010 and compared to the seven previous surveys dating back to 1966. Northern pike were captured at a rate of 2.0 per gill net. This catch, while low compared to similar lakes throughout the state, was typical of past netting results. Growth was average, and 33% of pike sampled were at least 24".

Despite a long history of stocking, the catch rate for walleye (0.7 per gill net) was again below average for this type of lake, which is consistent with previous survey results. Walleye growth was slow, with age two fish averaging just 7.8".

Spring electrofishing was used to sample largemouth bass in Island Lake for the first time in 2010. The catch of 35 fish per hour was low for the area, but several year classes were identified. Growth was average, with fish averaging 11.2".

The catch of black crappie remained similar to the last survey. Fish between 4.8 to 11.2 inches were sampled. Growth was slow and only 19% were greater than 8". The bluegill catch of 7.9 per trap net was similar to previous catches. Several year classes were observed, but growth was slow and only 14% were greater than 7".

Additional sampling for nearshore fish was also conducted using shoreline seining and backpack electrofishing. A total of 16 species of fish were collected in all sampling methods combined during the 2010 survey.

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=18018300

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring at site 201 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.

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

Overall Summary
Island Lake is a eutrophic lake (TSI = 42) with evidence of a declining trend in water clarity since 2004. The total phosphorus, chlorophyll *a* and transparency ranges are within the ecoregion ranges.

Only four percent (4.6%) of the Island Lake lakeshed is disturbed by development and agriculture (Figure 19). The threshold of disturbance where water quality tends to decline is 25%. Island Lake is well under this threshold. Almost half (48%) of the lakeshed is forested, which is generally good for water quality. Twenty percent (20%) of the lakeshed is wetlands which protects that land from development (Table 12).

Island Lake's water quality was very good until a flood in 2012 that caused the lake levels to rise 3-4 feet. This lake level rise and flushing of wetlands in the area greatly affected water quality. Algae blooms occurred in 2012 and 2013, but not in 2004-2005 (Figure 8). The declining trend in water clarity is also likely due to the water level rise. Continued monitoring will be important to see if the lake's water quality recovers.

Priority Impacts to the Lake
The priority impacts to Island Lake are the high water levels and the expansion of residential housing development in the lakeshed. The conversion of small lake cabins to year-round family homes increases the impervious surface and runoff from the lake lots. Some of the private land around the lake has been developed in the first tier. The parcels on the west and south shores of the lake appear large (Figure 16) and have not been divided into two tiers or concentrated developments.

Overall, the development pressure for Island Lake appears low. Data from 1990-2000 and 2001-2011 show there wasn't much increase in development during that period of time (Tables 10-11).

Best Management Practices Recommendations
The management focus for Island Lake should be to protect the current water quality and lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by high water, 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). In addition, filter strips or native vegetative buffers could be installed to decrease or slow the runoff reaching the water's edge. This is especially important during times of high water to prevent shoreline erosion. Septic systems should be pumped and inspected regularly.

There are still some large undeveloped shoreline parcels on the south end of the lake (Figure 16). 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.

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
- Work with farmers to
    - Restore wetlands
    - Implement conservation farming practices
    - Land retirement programs such as Conservation Reserve Program

County-wide Recommendation
In order to better manage the impact of septic systems on lake water quality, it is recommended that the county implement a lake-wide septic inspection program. In a program such as this, the county would focus on one to three lakes a year, pull septic system records on those lakes, and require old systems to be inspected. This program can rotate through the county doing a few lakes each year.

Since conversion of small cabins to large lake homes could be a future issue, strengthening county shoreline ordinances such as set-backs, impervious surface limits and shoreline alteration (installation of retaining walls and removing trees) will help to protect water quality.

Organizational contacts and reference sites

Island Lake Property Owners Association	
Crow Wing County Land Services Department	322 Laurel Street, Suite 14, Brainerd, MN 56401 218-824-1128 http://crowwing.us/index.aspx?nid=211
Crow Wing Soil and Water Conservation District	322 Laurel Street, Suite 13, Brainerd, MN 56401 (218) 828-6197 http://www2.co.crow-wing.mn.us/swcd/
DNR Fisheries Office	1601 Minnesota Drive, Brainerd, MN 56401 (218) 828-2550 http://www.dnr.state.mn.us/lakefind/index.html
Regional Minnesota Pollution Control Agency Office	7678 College Road, Suite 105, Baxter, MN 56425 (218) 828-2492 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