Roosevelt Lake 11-0043-00 CASS AND CROW WING COUNTIES

Lake Water Quality

Summary

Roosevelt Lake is located at Outing, MN, and extends across both Cass and Crow Wing Counties. Roosevelt Lake is very long, narrow and deep, covering 1,510 acres. Lake trout have been stocked in Roosevelt Lake since 1982.

Roosevelt Lake has two inlets and one outlet, which classifies it as a drainage lake. It is the third lake in a chain connected by Crooked Creek, with Leavitt and Lawrence Lakes flowing into it on the east side. Crooked Creek drains out of the south end of Roosevelt Lake and eventually joins the Pine River.

Water quality data have been collected on Roosevelt Lake from 1994-2011 (Tables 2-3). These data show that the lake is mesotrophic. Mesotrophic lakes are commonly found in north-central Minnesota and have clear water with occasional algal blooms in late summer.

The Roosevelt & Lawrence Area Lakes Association (RALALA) includes Roosevelt, Lawrence, Leavitt and Smokey Hollow Lakes**.** Their mission is to work together to maintain water quality in their lakes and the surrounding environment for themselves and future generations. They have been active in many projects, including water quality monitoring, lake protection, aquatic vegetation, exotic species, land use and zoning issues, and the Healthy Lakes Program.

Table 1. Roosevelt Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	11-0043-00	Surface area (acres):	1,510
County:	Cass and Crow Wing	Littoral area (acres):	390
Ecoregion:	Northern Lakes & Forests	% Littoral area:	26%
Major Drainage Basin:	Upper Mississippi	Max depth (ft), (m):	130, 39.6
Latitude/Longitude:	46.79166667 / -93.95861111	Inlets:	2
Invasive Species:	None as of 2011	Outlets:	1
		Public Accesses:	1

Table 2: Availability of data and an observation of the quantity of sample points.

Data Availability

Transparency data		Numerous yearly Secchi readings from 1994-2011 through the MPCA CLMP program.
Chemical data		Good amount of data, but not enough for a trend analysis.
Inlet/Outlet data		No inlet or outlet data exist for Roosevelt Lake.

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

Lake Map

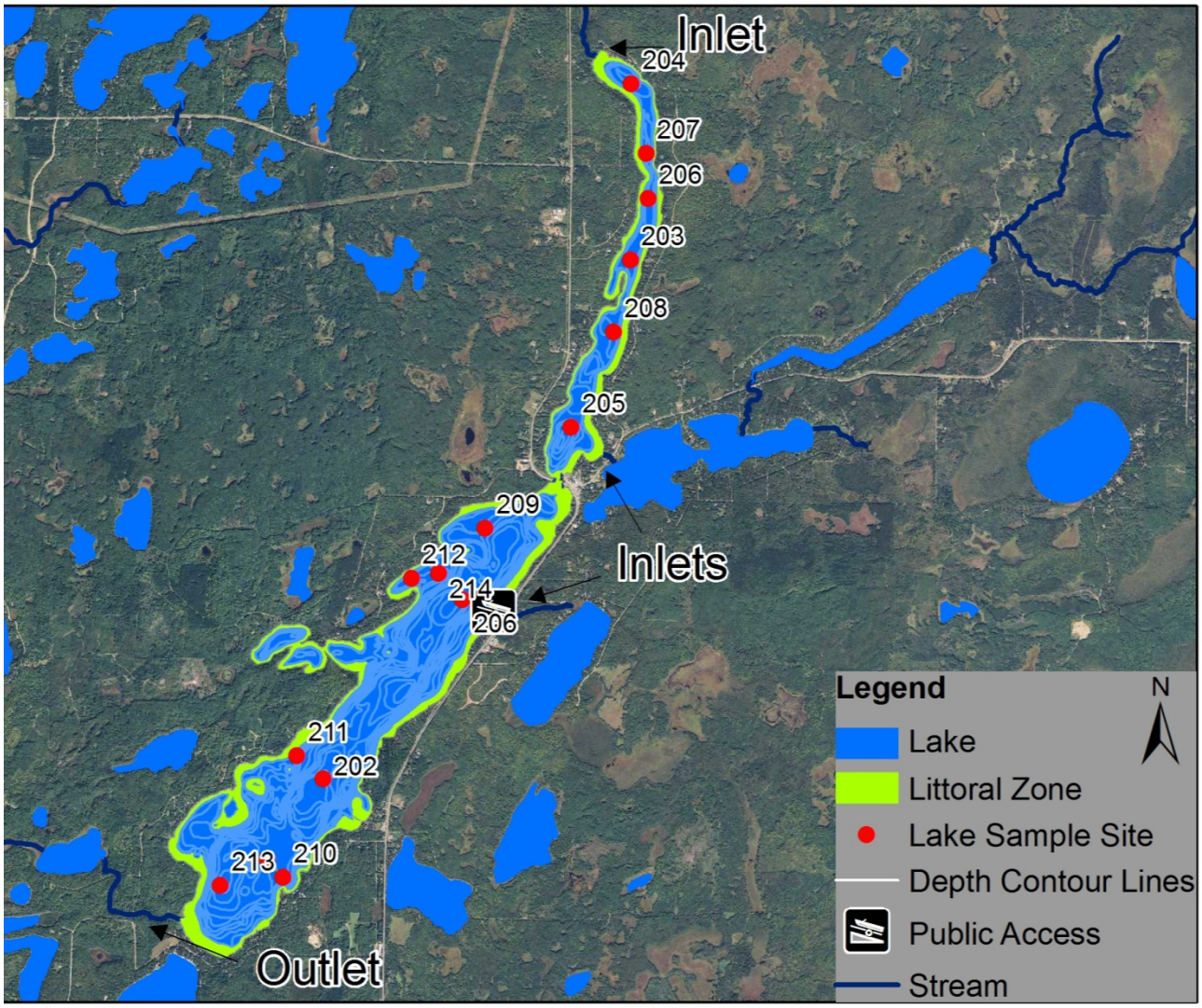


Figure 1. Map of Roosevelt Lake illustrating bathymetry, lake sample site locations, stream inlets and outlets and aerial land use. The green shaded areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic plants to grow.

Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), Minnesota Pollution Control Agency (MPCA), Whitefish Area Property Owners Association (WAPOA).

Bay	Lake Site	Depth (ft)	Monitoring Programs
North	203	45	CLMP: 1995-2005, 2007; CLMP+: 2002;
North	204	50	CLMP: 1996-2011
North	205	50	CLMP: 1996-2005, 2007
North	206	50	WAPOA: 1991, 2001, 2009-2010
South	201	60	CLMP: 1994-1005, 2004, 2006-2009, 2011; WAPOA: 2008
South	202	120	CLMP: 1995, 2004, 2006-2009, 2011
South	206* Primary site	110	CLMP: 1999-2011; CLMP+:2002; WAPOA: 2007
South	210	70	CLMP: 2004, 2006, 2008-2011
South	212	40	CLMP: 2005-2006, 2008-2011
South	213	100	CLMP: 2006-2011; WAPOA: 2009-2010

Average Water Quality Statistics

The information below describes available chemical data for Roosevelt Lake through 2011. The data set is limited, and all parameters, with the exception of total phosphorus, chlorophyll *a* and Secchi depth, are means for just 2002 data.

Minnesota is divided into seven 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.

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)	15	14 - 27	> 30	Results are within the expected range for the ecoregion.
[3]Chlorophyll *a* (ug/L)	5	4 - 10	> 9	
Chlorophyll *a* max (ug/L)	7	<15		
Secchi depth (ft)	11.0	7.5 - 15	< 6.5	
Dissolved oxygen	DImictic *see page 8*			Dissolved oxygen depth profiles show that the deep areas of the lake are anoxic in late summer.
Total Kjeldahl Nitrogen (mg/L)	0.40	0.40 - 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	138	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	15	10 - 35		Indicates clear water with little to no tannins (brown stain).
pH	8.4	7.2 - 8.3		A pH of 8 is common in a hardwater lake. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water.
Chloride (mg/L)	2.0	0.6 - 1.2		Chloride levels are slightly higher than the ecoregion range, but still considered low level.
Total Suspended Solids (mg/L)	2.0	<1 - 2		Indicates low suspended solids and clear water.
Specific Conductance (umhos/cm)	267	50 - 250		Slightly above the ecoregion average.
Total Nitrogen :Total Phosphorus	26:1	25:1 – 35:1		Within the expected range for the ecoregion.

[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	South Bay Primary Site 206	South Bay Site 213	North Bay Site 206	North Bay Site 204
Total Phosphorus Mean (ug/L):	**15**	**16**	**18**	
Total Phosphorus Min:	10	11	11	
Total Phosphorus Max:	24	24	28	
Number of Observations:	16	10	10	
Chlorophyll *a* Mean (ug/L):	**5**	**4**	**4**	
Chlorophyll-a Min:	1	1	2	
Chlorophyll-a Max:	7	8	13	
Number of Observations:	15	10	10	
Secchi Depth Mean (ft):	**11.0**	**12.4**	**11.2**	**11.2**
Secchi Depth Min:	5.5	6.5	7.2	5.0
Secchi Depth Max:	17.5	19.0	20.1	17.0
Number of Observations:	165	37	15	145

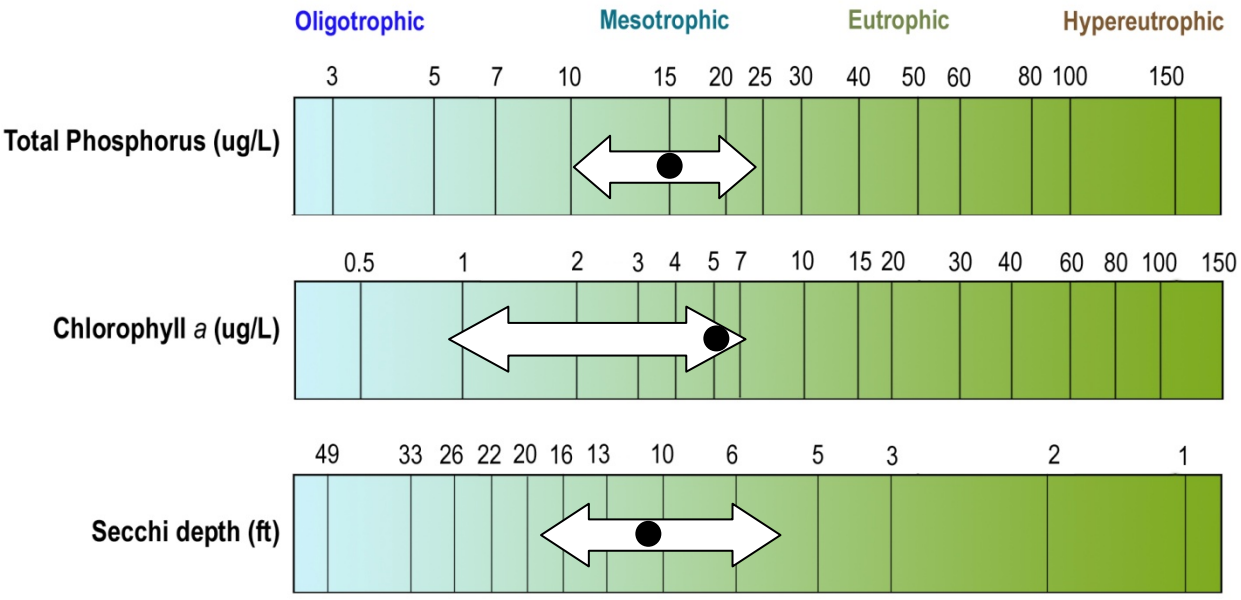


Figure 2. Roosevelt Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 206). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. 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.

For all the sites that had more than 20 transparency data points, the mean transparency ranges from 7.4 to 15.0 feet. The transparency throughout the lake appears to be relatively uniform, with different sites having the best transparency in different years.

In most years, the mean transparencies follow the same pattern (Figure 3). The transparency in 2008-2010 appears to be better than the long-term average, but in 2011 the transparency decreased at all sites. Transparency monitoring should be continued on all sites, especially sites 204 in the north bay and 206 in the south bay, yearly in order to track water quality changes.

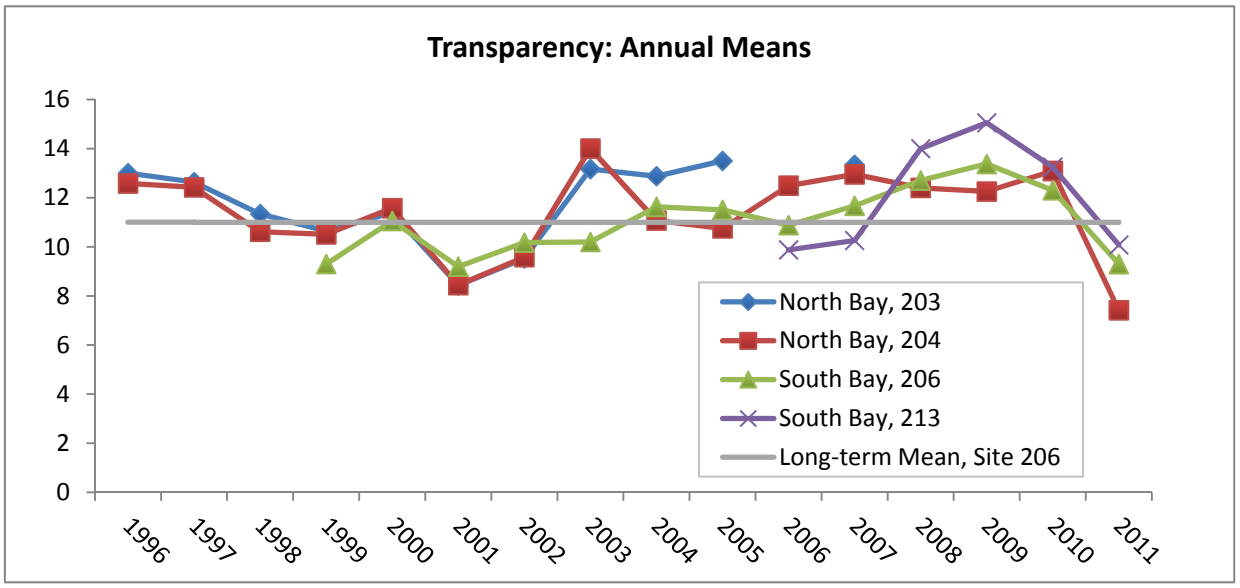


Figure 3. Annual mean transparency (ft) compared to long-term mean transparency.

Roosevelt Lake transparency ranges from 5.5 to 17.5 ft at the primary site (206). Figure 4 shows the seasonal transparency dynamics. Generally, Roosevelt Lake transparency is highest in May - June and then declines through July - August and recovers in September - October. This pattern is typical for a deep lake in northern Minnesota. 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 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.

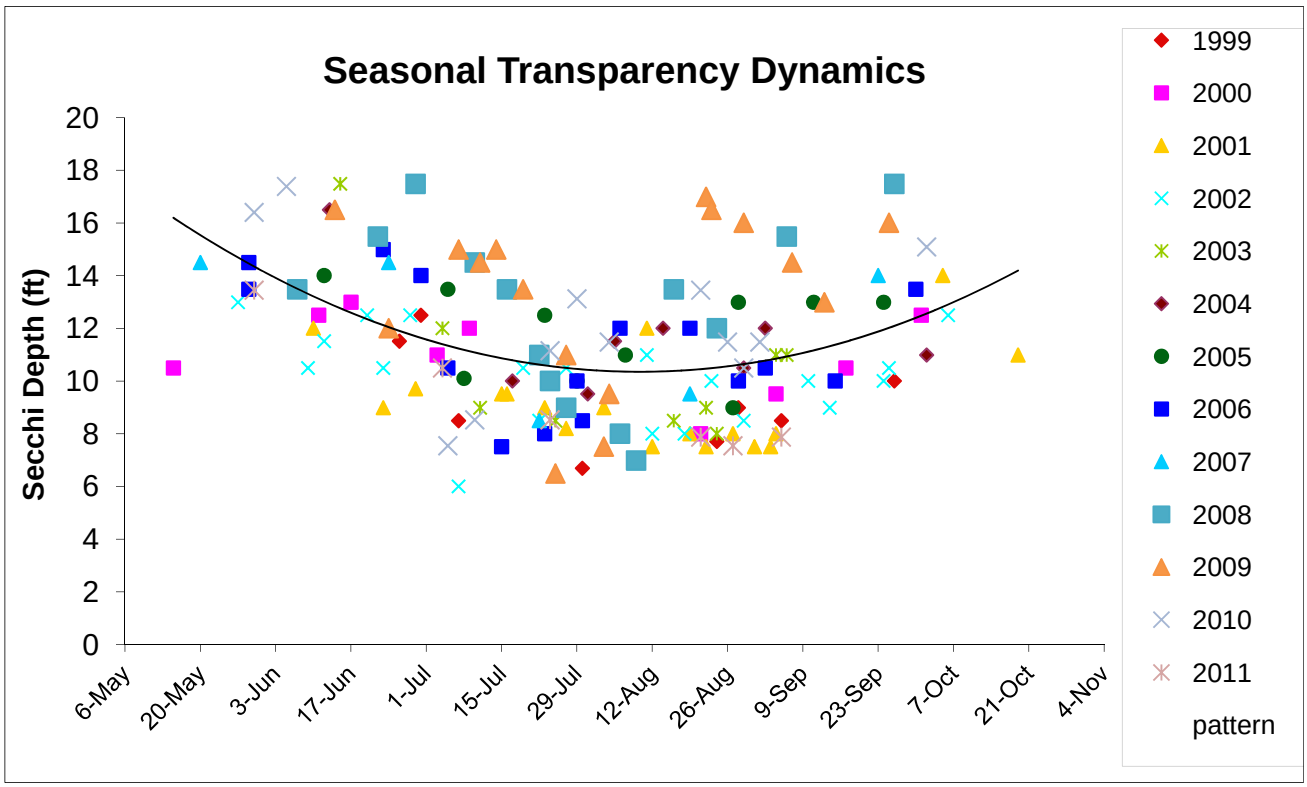
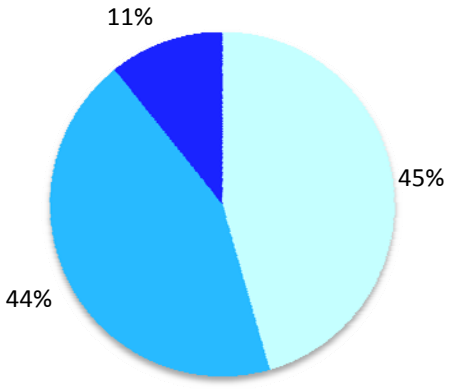


Figure 4. Seasonal transparency dynamics and year-to-year comparison (site 206). The black line represents the pattern in the data.

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. Roosevelt Lake was rated as being "crystal clear" 45% of the time between 1999-2011 (Figure 5).

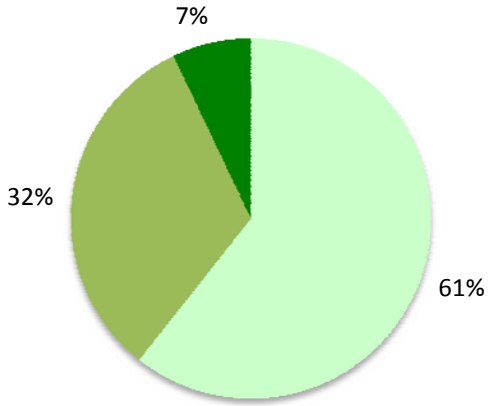


Physical Appearance Rating

45%	Crystal clear water
44%	Not quite crystal clear – a little algae visible
11%	Definite algae – green, yellow, or brown color apparent
0%	High algae levels with limited clarity and/or mild odor apparent
0%	Severely high algae levels

Figure 5. Physical appearance rating, as rated by the volunteer monitor).

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Roosevelt Lake was rated as being "beautiful" 61% of the time from 1999-2011 (Figure 6).



Recreational Suitability Rating

61%	Beautiful, could not be better
32%	Very minor aesthetic problems; excellent for swimming, boating
7 %	Swimming and aesthetic enjoyment of the lake slightly impaired because of algae levels
0%	Desire to swim and level of enjoyment of the lake substantially reduced because of algae levels
0%	Swimming and aesthetic enjoyment of the lake nearly impossible because of algae levels

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

Total Phosphorus

Roosevelt Lake is phosphorus limited. This means that algae and aquatic plant growth is dependent upon available phosphorus.

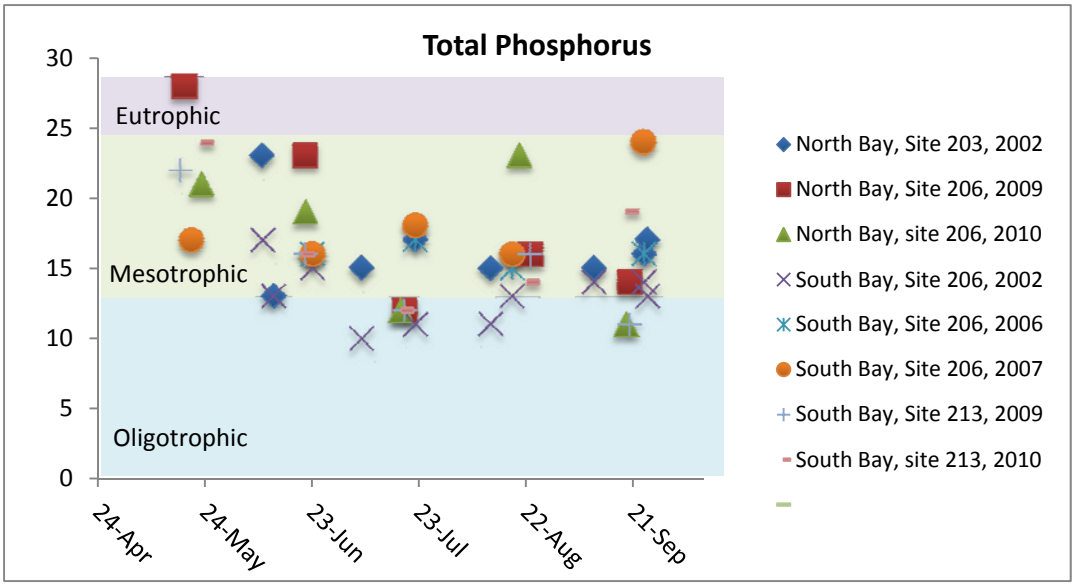


Figure 7. Historical total phosphorus concentrations (ug/L) for Roosevelt Lake.

Total phosphorus was evaluated in Roosevelt Lake in 2002, 2006-2010 (Figure 7). The data do not indicate much seasonal variability. Phosphorus concentrations were similar for both bays across all years. The majority of the data points fall into the mesotrophic range.

Phosphorus should be focused on only one site in each bay to get a better understanding of Roosevelt Lake and any future changes that occur in water quality. Recommended sites can be found in the recommendations on page 18.

Chlorophyll *a*

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.

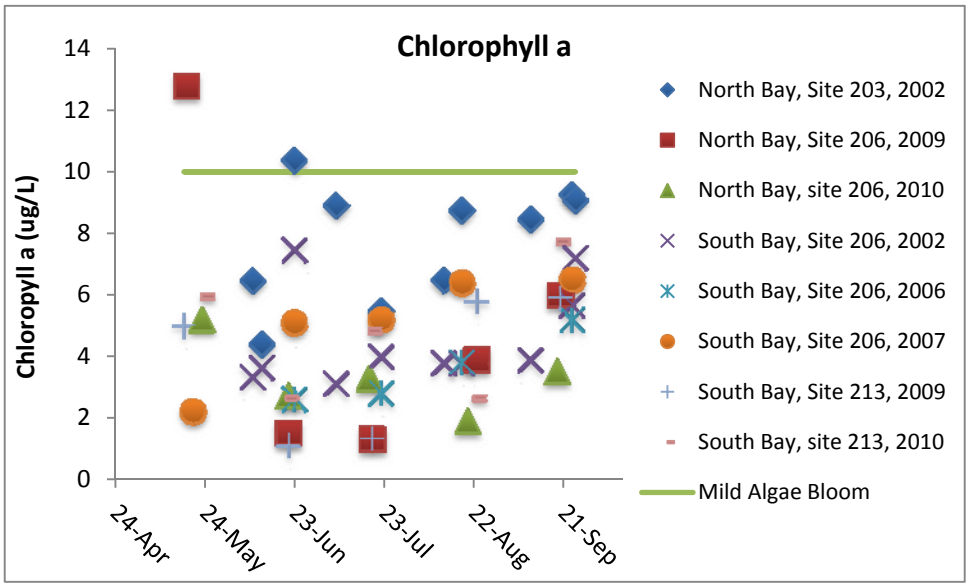


Figure 8. Chlorophyll *a* concentrations (ug/L) for Roosevelt Lake.

Chlorophyll *a* was evaluated in Roosevelt Lake in 2002, 2006- 2010 (Figure 8). Site 203 in the northern bay of the lake had higher chlorophyll *a* concentrations than site 206, and experienced mild algae blooms in late June and late August (>10 ug/L). At site 206 in the southern bay, chlorophyll *a* concentrations remained below 10 ug/L, indicating clear water most of the summer.

Dissolved Oxygen

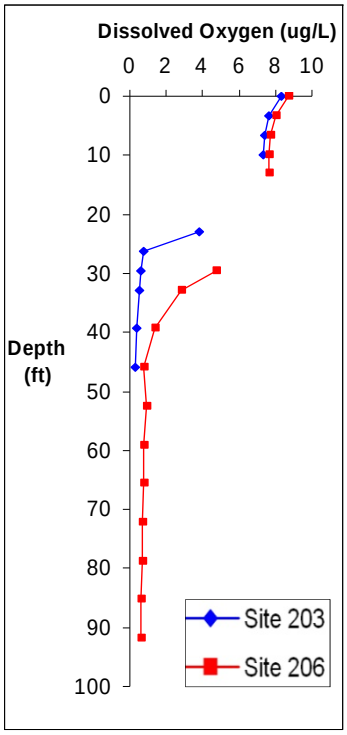


Figure 9. Dissolved oxygen profile for Roosevelt Lake on September 25, 2002.

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.

Roosevelt Lake is a relatively deep lake, with a mean depth of 35 feet and a maximum depth of 130 ft. Dissolved oxygen profiles from 2002 indicate that both sites 203 in the north bay and 206 in the south bay stratify in the summer. Benthic phosphorus samples indicate minor internal loading when this site is stratified. Figure 9 illustrates stratification on September 25, 2002. The benthic phosphorus concentration on that same day at that same site was 30 ug/L. For comparison, the average surface phosphorus concentration for Roosevelt Lake is 15 ug/L.

Lake trout have been stocked in Roosevelt Lake since 1982, and they need oxygen concentrations at approximately 7 mg/L to survive long-term. Figure 9 shows that dissolved oxygen falls below 7 mg/L at 20 ft for site 203 and 30 ft for site 206 in the summer. This lack of oxygen below 30 ft is problematic for Lake trout populations.

Dissolved oxygen and temperature profile data should be collected in future years to track anoxic conditions.

Trophic State Index

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.

Table 6. Trophic State Index.

Trophic State Index	North Bay	South Bay
TSI Total Phosphorus	44	42
TSI Chlorophyll-a	50	45
TSI Secchi	43	44
TSI Mean	46	43
Trophic State:	Mesotrophic	Mesotrophic

Numbers represent the mean TSI for each parameter.

The results from these three measurements cover different units and ranges and thus cannot be directly compared to each other or averaged. In order to standardize these three measurements to make them directly comparable, we convert them to a trophic state index (TSI).

The mean TSI for the two main sites of Roosevelt Lake fall in the mesotrophic range (Figure 10). The TSI is slightly higher at site 203 in the north bay of the lake than site 206 in the south bay (Table 6). The south bay is larger and deeper than the north bay, which could be why the TSI is lower.

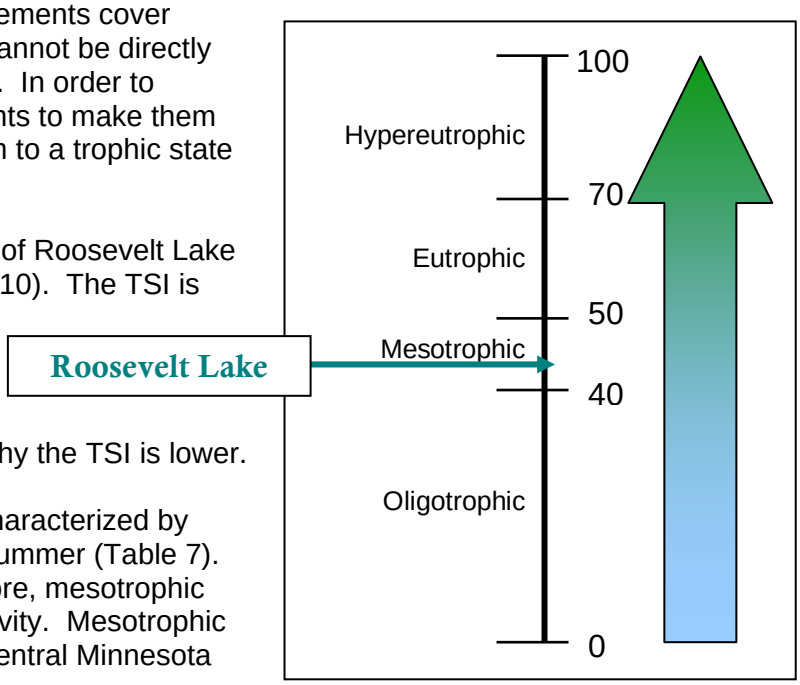


Figure 10. Trophic state index chart with corresponding trophic status.

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

Table 7. Trophic states and corresponding lake and fishery conditions.

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.

There is not enough historical data to perform trend analysis for total phosphorus or chlorophyll *a* on Roosevelt Lake. Sites 204 and 206 had at least 8 years of transparency data, which was enough data to perform a long-term trend analysis (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analyses for Roosevelt Lake.

Lake Site	Parameter	Date Range	Trend	Probability
204, North Bay	Transparency	1996-2011	No Trend	--
204, North Bay	Transparency	2001-2011	No Trend	--
206, South Bay	Transparency	1999-2011	Improving	95%

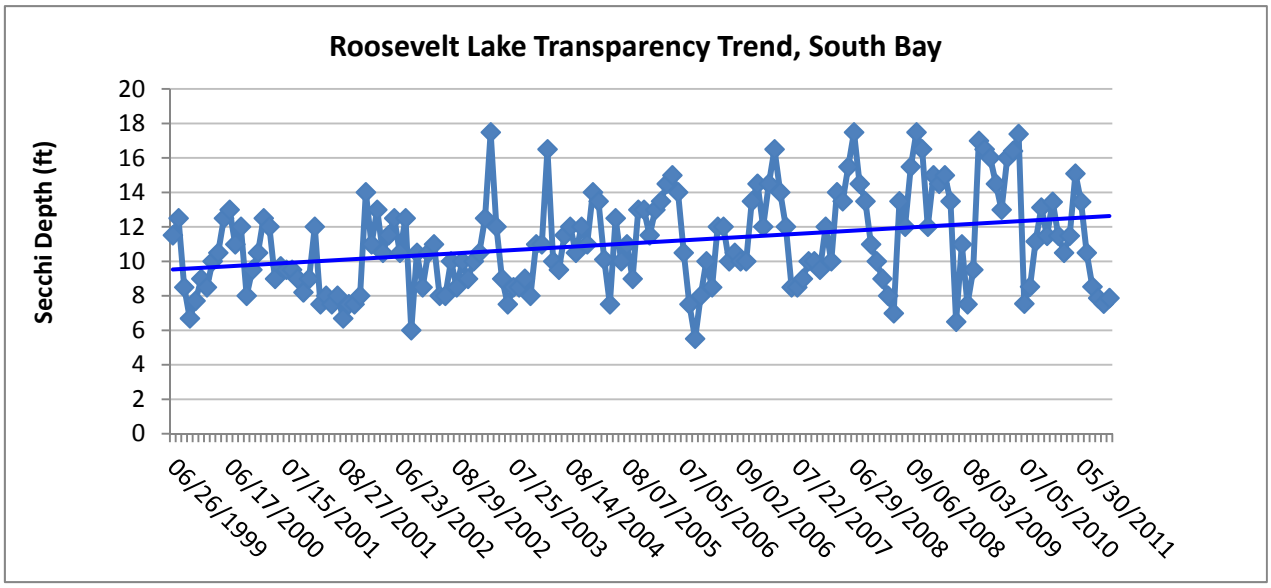


Figure 11. Transparency trend for site 206 from 1999-2011.

The North Bay of Roosevelt Lake shows no significant trend in transparency from 1995-2011 or 2001-2011. That means the transparency is not getting significantly better or worse, it is maintaining at the same level. The South Bay shows an improving trend in transparency from 1999-2011. The transparency has improved an average of 2 feet in the South Bay (Figure 11). Transparency monitoring should continue so that these 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 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.

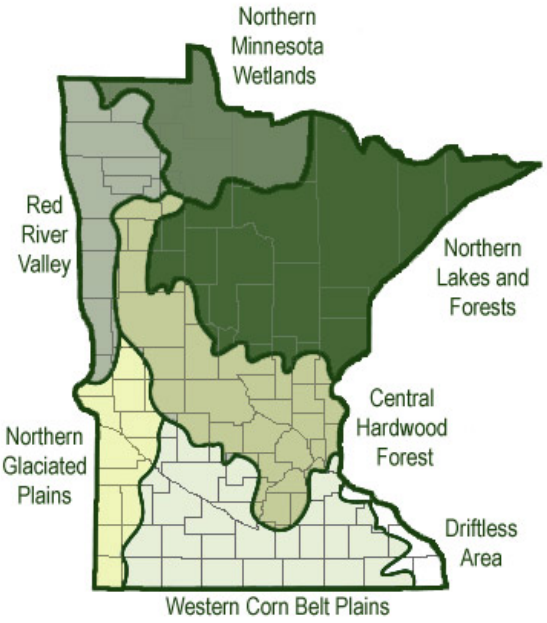
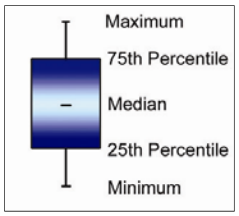
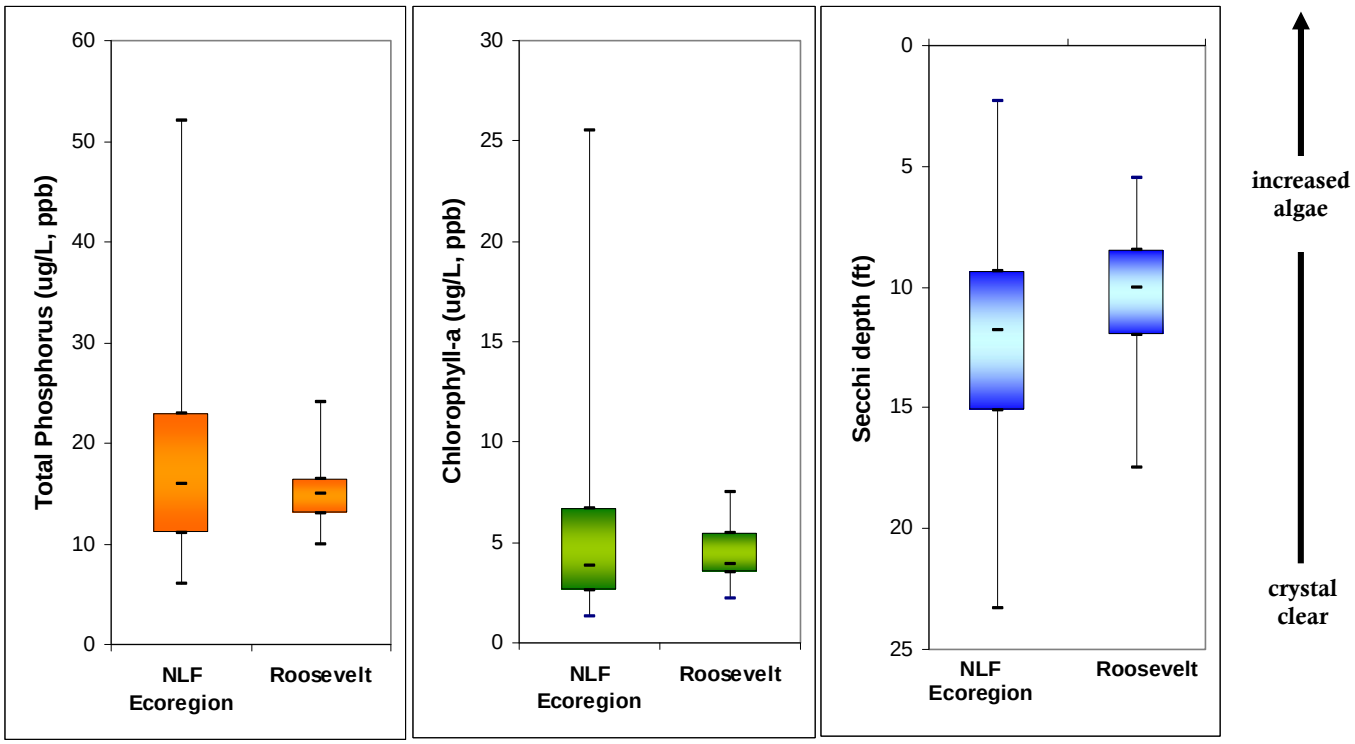


Figure 12. Map of Minnesota with the seven ecoregions.

Roosevelt Lake is in the Northern Lakes and Forests Ecoregion. The mean total phosphorus, chlorophyll a and transparency (Secchi depth) for Roosevelt Lake are all within the expected ecoregion ranges (Figure 13).





Figures 13a-c. Roosevelt Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Roosevelt Lake total phosphorus and chlorophyll *a* ranges are from 19 data points collected in May-September of 2002, and 2006-2007. The Roosevelt Lake Secchi depth range is from 114 data points collected in May-September from 1999-2007.

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 River Basin, which eventually drains south to the Gulf of Mexico (Figure 14). This major watershed is made up of 69 minor watersheds. Roosevelt Lake is located in **minor watershed 11041** (Figure 15).

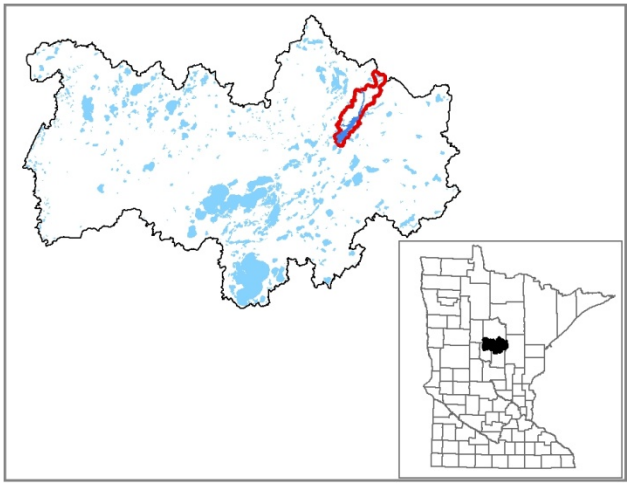


Figure 14. Pine River Watershed.

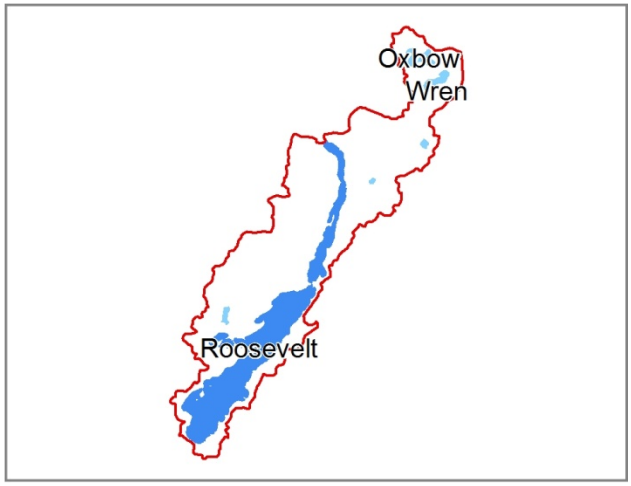


Figure 15. Minor Watershed 11041.

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. Roosevelt Lake falls within the **Roosevelt (1104105) lakeshed** (Figure 16). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not true watersheds because they do 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 Roosevelt Lake's full watershed, containing all the upstream lakesheds, see page 17. The data interpretation of the Roosevelt Lake lakeshed is only the immediate lakeshed, not including the upstream lakesheds, as this area is the land surface that flows directly into Roosevelt Lake.

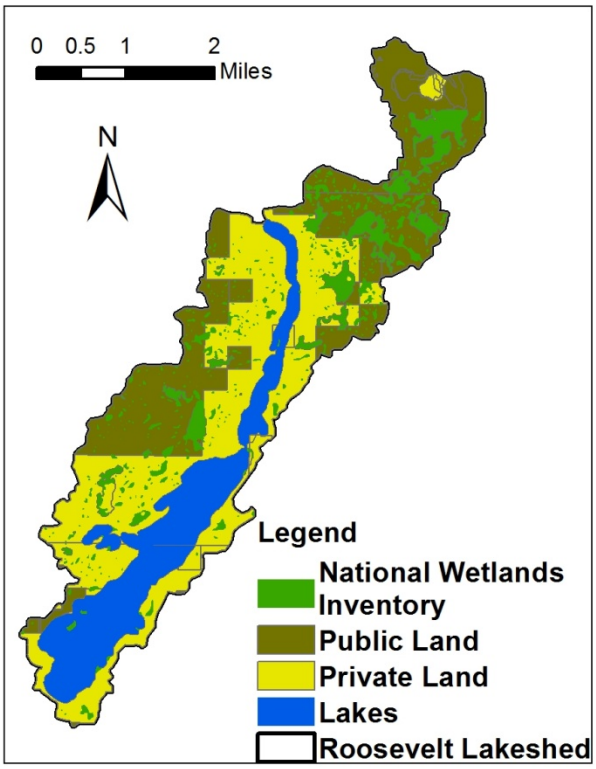


Figure 16. The Roosevelt (1104105) Lakeshed. This area is the land and water surface that flow directly into Roosevelt Lake.

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. Roosevelt Lake lakeshed vitals table.

Lakeshed Vitals		Rating
Lake Area	1,510 acres	descriptive
Littoral Zone Area	390 acres	descriptive
Lake Max Depth	130 ft.	descriptive
Lake Mean Depth	35 ft	
Water Residence Time	NA	NA
Miles of Stream	0.66	descriptive
Inlets	2 – Spring Brook, Crooked Creek	
Outlets	1 – Crooked Creek	
Major Watershed	11 - Pine River	descriptive
Minor Watershed	11041	descriptive
Lakeshed	1104105	descriptive
Ecoregion	Northern Lakes and Forest	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	5:1	
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	17:1	
Wetland Coverage	14%	
Aquatic Invasive Species	None	
Public Drainage Ditches	None	
Public Lake Accesses	1	
Miles of Shoreline	18.64	descriptive
Shoreline Development Index	3.4	
Public Land to Private Land Ratio	0.9:1	
Development Classification	General Development	
Miles of Road	17.5	descriptive
Municipalities in lakeshed	Outing (unincorporated)	
Forestry Practices	County Forest Management: http://www.co.crow-wing.mn.us/index.aspx?NID=261	
Feedlots	None	
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	Healthy Lakes & Rivers Partnership program, 2008	
Lake Vegetation Survey/Plan	Survey Completed 2008	

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 lands 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 lands 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.

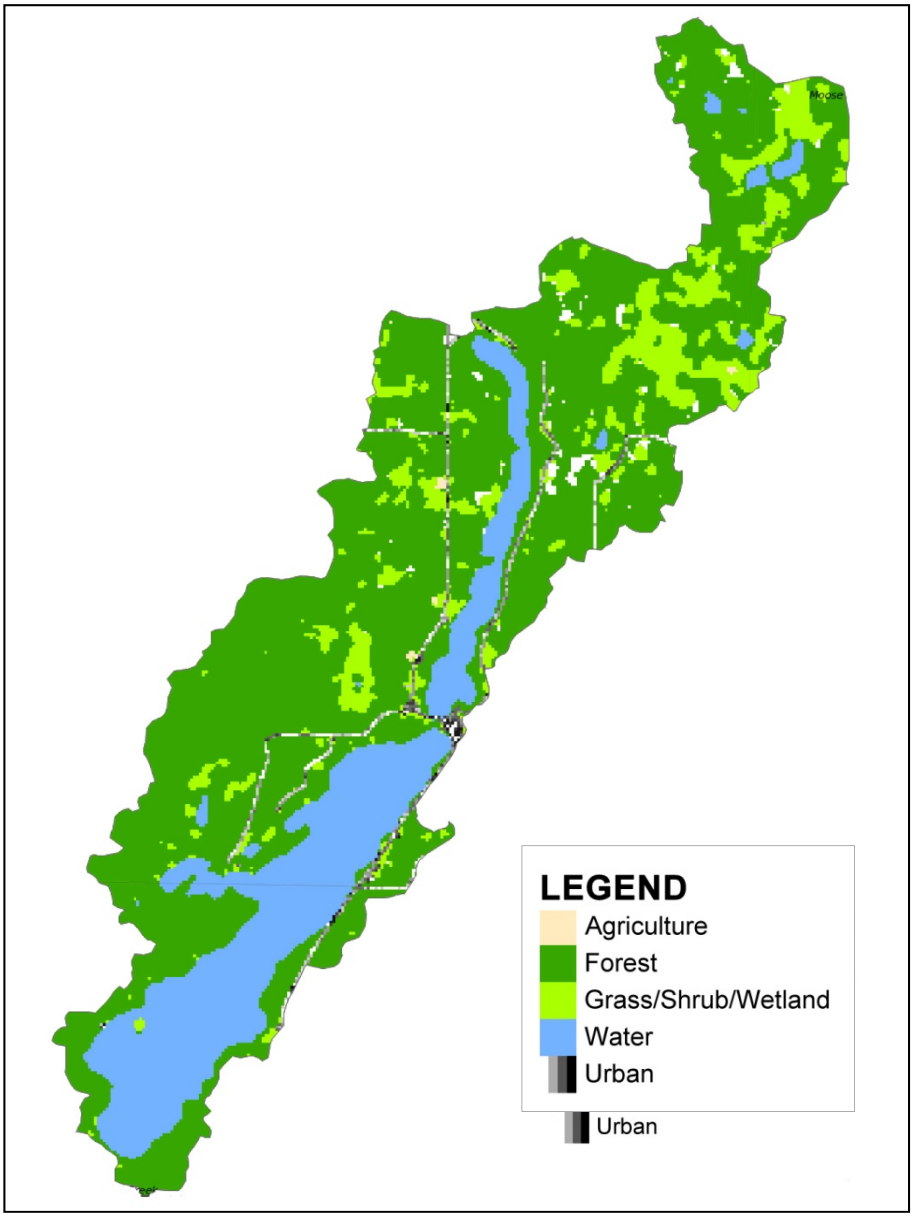


Figure 17. The Roosevelt Lake (1104105) lakeshed land cover (http://land.umn.edu).

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

The University of Minnesota has online records of land cover statistics from years 1990 and 2000 (http://land.umn.edu). Table 10 describes Roosevelt Lake's lakeshed land cover statistics and percent change from 1990 to 2000. Due to the many factors that influence demographics, one cannot determine with certainty the projected statistics over the next 10, 20, 30+ years, but one can see the transition within the lakeshed from agricultural, grass/shrub/wetland, and water acreages to forest and urban acreages. The largest change in percentage is the decrease in agriculture cover (86%); however, in acreage, forest cover has increased the most (293 acres). In addition, the impervious intensity has increased, which has implications for storm water runoff into the lake. The increase in impervious intensity is consistent with the increase in urban acreage.

Table 10. Roosevelt Lake lakeshed land cover statistics and % change from 1990 to 2000 (http://land.umn.edu).

	1990		2000		% Change
Land Cover	**Acres**	**Percent**	**Acres**	**Percent**	**1990 to 2000**
Agriculture	57	0.75	8	0.1	86% Decrease
Forest	4,754	62.18	5,047	66.01	6.2% Increase
Grass/Shrub/Wetland	877	11.47	856	11.2	2.4% Decrease
Water	1,755	22.95	1,525	19.95	13.1% Decrease
Urban	206	2.69	213	2.79	3.4% Increase
Impervious Intensity %					
0	7,500	98.05	7,468	97.63	0.4% Decrease
1-10	48	0.63	50	0.65	4.2% Increase
11-25	49	0.64	62	0.81	26.5% Increase
26-40	24	0.31	37	0.48	54.2% Increase
41-60	19	0.25	13	0.17	31.6% Decrease
61-80	6	0.08	11	0.14	83.3% Increase
81-100	4	0.05	8	0.1	100% Increase
Total Area	7,646		7,646		
Total Impervious Area (Percent Impervious Area Excludes Water Area)	35	0.59	46	0.75	31.4% Increase

Demographics

Roosevelt Lake is classified as a general development lake. General development lakes usually have more than 225 acres of water per mile of shoreline 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 Crow Wing County as a whole, the city of Emily has a slightly higher extrapolated growth projection (Figure 18)

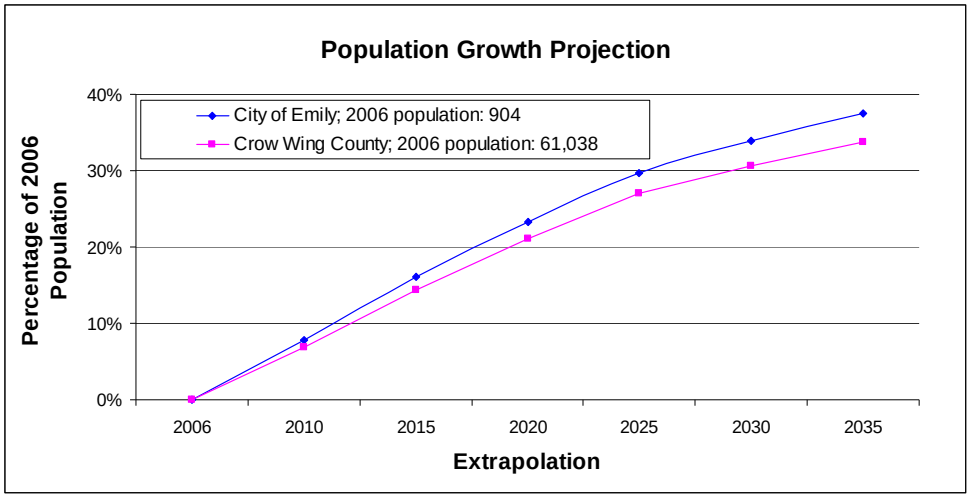


Figure 18. Population growth projection for the city of Emily and Crow Wing County. Figure excludes one Cass County township (source: http://www.demography.state.mn.us/resource.html?Id=19332).

Roosevelt Lake 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 private ownership land within Roosevelt Lake's lakeshed is made up of private forested uplands (Table 11). This land can be the focus of development and protection efforts in the lakeshed. In addition, Land Cover Dataset may not account for all of the forested developed areas, so some of the forested uplands could already be developed.

Table 11. Land ownership, land use/land cover, estimated phosphorus loading, and ideas for protection and restoration in the lakeshed (Sources: Crow Wing County parcel data, National Wetlands Inventory, and the 2006 National Land Cover Dataset).

	Private (41%)					**22%**	**Public (37%)**		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	3%	0.1%	30%	3.9%	4%	22%	0%	36%	1%
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
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 12). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 12. 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.

Roosevelt Lake is classified with having 59.9% of the watershed protected and 3.8% of the watershed disturbed (Figure 19). Therefore, Roosevelt Lake should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use. In addition, Roosevelt Lake was designated by DNR Fisheries as a high valued fishery lake because of its cisco population.

Figure 20 displays the upstream lakesheds that contribute water to the lakeshed of interest. All of the land and water area in this figure has the potential to contribute water to Roosevelt Lake, whether through direct overland flow or through a creek or river. Five of the 9 upstream lakesheds have the same management focus (protection).

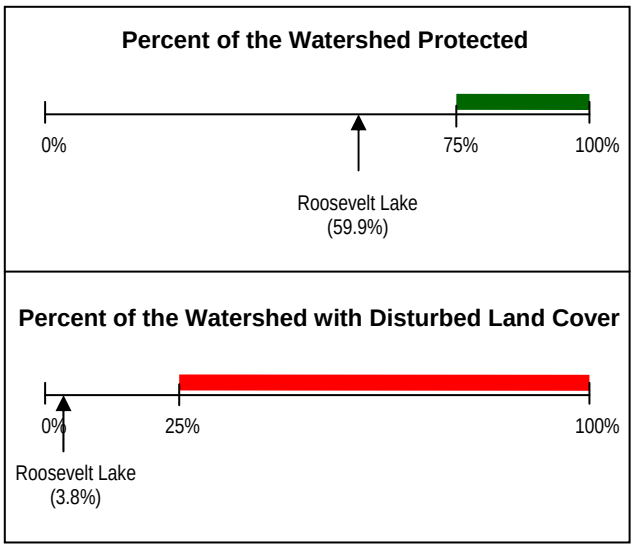


Figure 19. Roosevelt Lake lakeshed's percentage of watershed protected and disturbed.

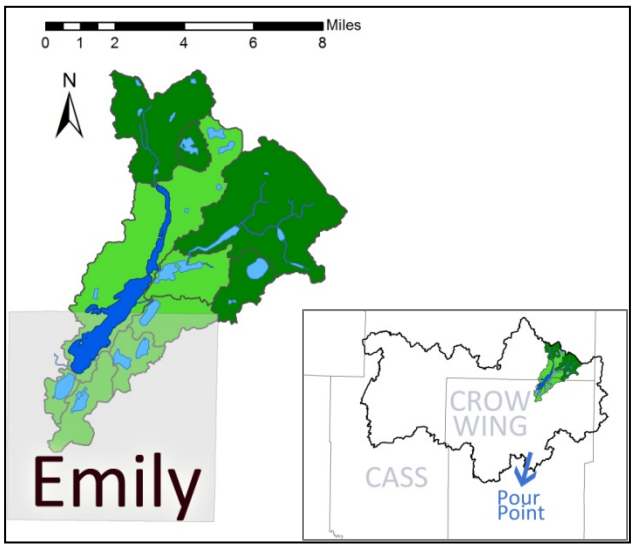


Figure 20. Upstream lakesheds that contribute water to the Roosevelt lakeshed. Color-coded based on management focus (Table 12).

Conservation Easement Potential

In an ever-growing society, today's landscapes are being urbanized more and more to sustain the ever-growing population and behavior of recreational usage. In Minnesota, the land of ten thousand lakes, it is only natural to develop properties within the boundaries and beauty of our lakes and streams. Conservation efforts to limit or slow down the development process can only assist in the preservation of the lakeshed and inevitably the water quality of water bodies found within. Figure 21 identifies parcels within the lakeshed that are large enough to warrant the investigation of parcel conservation practices and purchase.

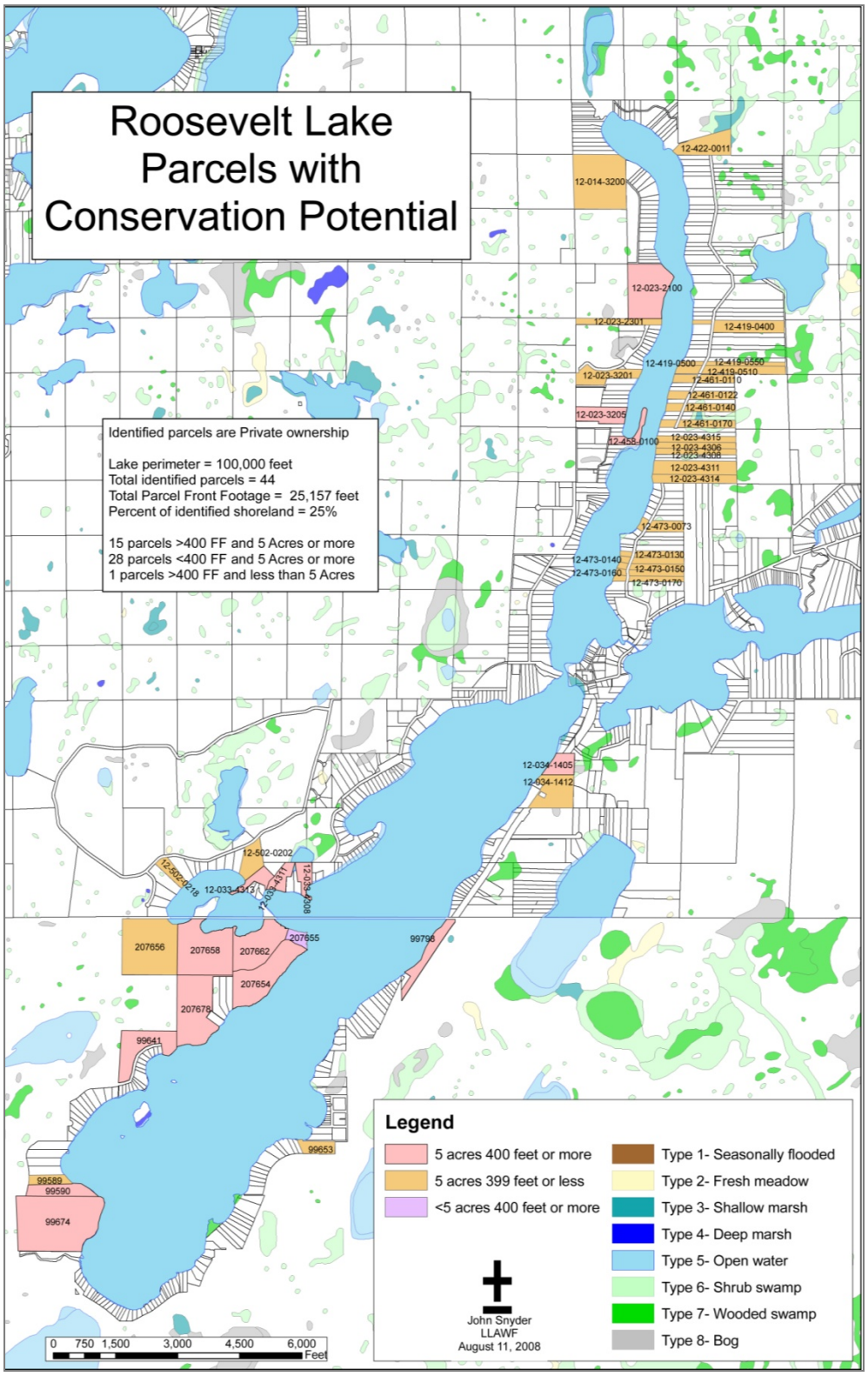


Figure 21. Lake parcels with conservation potential (developed by John Snyder, LLAWF)

Roosevelt Lake, Status of the Fishery (as of 07/10/2006)

Roosevelt Lake is a 1,585 acre lake located at Outing, Minnesota. Maximum depth is 129 feet and 25 % of the surface area is less than 15 feet deep. It is a lake with moderate to heavy shoreline development. Water clarity is good, with a secchi disc reading of 10 feet.

Lake trout have been stocked since 1982. Since 1995 they have been stocked every other year instead of yearly. A total of 17 lake trout were sampled in 2006 in gill nets, the trout ranged in size from 7.5 to 8.6 inches. All of these fish were stocked in the spring of 2006. Stocking success and survival of lake trout has been very poor in the last ten years, recent surveys have found no fish stocked from previous years, also little if any return to the angler has been observed. Good oxygen levels in the cooler water preferred by lake trout has been limited or completely absent in recent years, thus quality habitat is lacking for lake trout. The stocking of lake trout is being evaluated and may be halted in future years.

The walleye fishery is doing well with high angler satisfaction and a modest net catch of 2.6/gill net, very similar to the 2000 population assessment. Black crappie numbers were good, and fish up to 11.0 inches were observed. A spring electro fishing assessment of the bass population indicated a very high population of largemouth bass with sizes ranging from 3.9 to 16.1 inches observed. The average size was 11.4 inches. Smallmouth bass were observed in moderate numbers with fish up to 19.6 inches captured.

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=11004300

Key Findings / Recommendations

Monitoring Recommendations
The Citizen Lake Monitoring Program is very active on this lake, which has equipped this lake with extensive transparency data. At a minimum, transparency monitoring at sites 204 and 206 in the North Bay and 206 in the south bay 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.

Phosphorus and chlorophyll a monitoring should continue at site 206 in the south bay and 206 in the north bay, as the budget allows, to track future water quality trends. If land use becomes a concern, the inlets could be monitored for phosphorus coming into the lake. The inlets to Roosevelt Lake drain from different lakesheds, so inlet monitoring will show the effectiveness of upstream restoration/protection projects in different regions of the watershed.

Overall Conclusions
Overall, Roosevelt Lake has good water quality, and good lakeshed protection. It is a mesotrophic lake (TSI=43) with an improving trend in transparency in the south bay and no trend in transparency in the north bay.

Thirty-seven percent (37%) of the lakeshed is in public ownership, and 60% of the lakeshed is protected, while 4% of the lakeshed is disturbed (Figure 19). There is a lot of public forest, wetland complex land (tax forfeit) on the north end of the lakeshed and west of the lake that provide good protection for the lake. When subtracting out the water area, 82% of the lakeshed is forested (Table 10). The main development areas are immediately adjacent to the lake.

Priority Impacts to the lake
The priority impact to Roosevelt Lake is the surrounding development and any future development. The north bay is very narrow and has heavy first and second tier development. The south bay is not as heavily and densely developed (Figure 21). The combination of less development, and the flushing of water out the outlet to the south, could be contributing to the improving trend in the southern bay. Land area around the south bay is subdivided into parcels, though most of it is undeveloped.

The concern with increased development is the conversion of forested land to a land use with increased impervious surfaces, such as roofs, driveways, and well groomed lawns. Phosphorus loading will increase when land use changes from forested to developed. In addition, inputs to the lake will increase as housing becomes denser due to septic systems, lawn maintenance, removing shoreline vegetation, etc. A way to mitigate this issue is through the installation of Best Management Practices (BMPs).

In additional to housing development, roads are also an impervious surface that can increase pollutant loading. There are numerous roads near the shoreline, including State Highway 6. BMPs could also be installed to mitigate the impacts of roads in the lakeshed.

Roosevelt Lake is stocked with Lake Trout, which requires cold, oxygenated water. Lake Trout populations in recent years have been declining due to limited oxygen at the bottom of the lake and haven't been stocked since 2006 (DNR Fisheries report, page 19). In addition, Roosevelt Lake is designated by the DNR as a Cisco Refuge Lake. Ciscos need cold oxygenated water to survive as well. The 2006 DNR Fisheries Survey indicated a large number of Ciscos were caught. In the future, the loss of Lake Trout and Ciscos could indicate eutrophication in the lake or climate change. These fish populations should be watched in future years as water quality indicators.

Best Management Practices Recommendations
The management focus for Roosevelt Lake should be to protect the water quality and the lakeshed. Protection efforts should be focused on managing and/or decreasing the impact caused by additional development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, smart development, shoreline restoration, rain gardens, and septic system maintenance. Although it may not be possible to decrease the impervious area in the lakeshed, it is possible to reduce the impact of the impervious surface by retaining stormwater instead of allowing it to runoff into the streams.

Road salt should be applied on Old Highway 6 following the MPCA's best management practices: http://www.pca.state.mn.us/sbiz41. Monitoring the runoff from Highway 6 during spring thaw could better pinpoint if that is a chloride source or not.

There are some large parcels around the lake that could be protected with conservation easements (Figure 21). The Minnesota Land Trust can help property owners set up conservation easements and have cost-share funding available. The Minnesota DNR can help set up Aquatic Management Areas that also protect land.

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.

Organizational contacts and reference sites

Roosevelt & Lawrence Area Lakes Association (RALALA)	http://www.minnesotawaters.org/index.php?uberKey=1327&page=6755
Crow Wing County Environmental Services Department	Crow Wing County Land Services Building 322 Laurel St. Suite 14, Brainerd, MN 56401 218-824-1125 http://www.co.crow-wing.mn.us/index.aspx?nid=211
Crow Wing Soil and Water Conservation District	Crow Wing County Land Services Building 322 Laurel St. Suite 13, Brainerd, MN 56401 218-828-6197 http://www.co.crow-wing.mn.us/swcd/
Cass County Environmental Services Department	303 Minnesota Avenue W, P.O. Box 3000, Walker, MN 56484-3000 (218) 547-7241 http://www.co.cass.mn.us/esd/home_esd.html
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

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