Lake Lizzie 56-0760-00 OTTER TAIL COUNTY

Lake Water Quality

Summary

Lake Lizzie is located 6 miles northeast of Pelican Rapids, MN in Otter Tail County. It is a long and narrow lake covering 3,734 acres (Table 1).

Lake Lizzie has two inlets and one outlet, which classifies it as a drainage lake. The Pelican River enters Lizzie from Pelican Lake to the north and exists to the south where it flows through Prairie Lake, and eventually joins the Otter Tail River at Fergus Falls. A culvert under County Road 4 connects North Lida to South Lizzie.

Water quality data have been collected on Lake Lizzie consistently from 2002-2012 (Tables 2 & 3). These data show that the lake is mesotrophic (TSI = 44) with moderately clear water conditions most of the summer and excellent recreational opportunities.

The Lake Lizzie Association is involved in many activities, including water quality monitoring, and is a member of the Otter Tail Coalition of Lake Associations (COLA).

Table 1. Lake Lizzie location and key physical characteristics.

Location Data

MN Lake ID:	North: 56-0760-01 South: 56-0760-02
County:	Otter Tail
Ecoregion:	North Central Hardwood Forests
Major Drainage Basin:	Red River
Latitude/Longitude:	North: 46.6432, -96.0136 South: 46.6130, -96.0018
Invasive Species:	Zebra mussels

Physical Characteristics

Surface area (acres):	North: 1902	South: 1831
Littoral area (acres):	North: 815	South: 1831
% Littoral area:	North: 43	South: 100
Max depth (ft), (m):	North: 65	South: 9
Inlets:	North: 1	South: 1
Outlets:	South: 1	
Public Accesses:	North: 1	

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

Data Availability

Transparency data		Excellent data source from 2002-2012.
Chemical data		Excellent data source from 2002-2012.
Inlet/Outlet data		No inlet or outlet data is available.

Recommendations **For recommendations refer to page 20.**

Lake Map

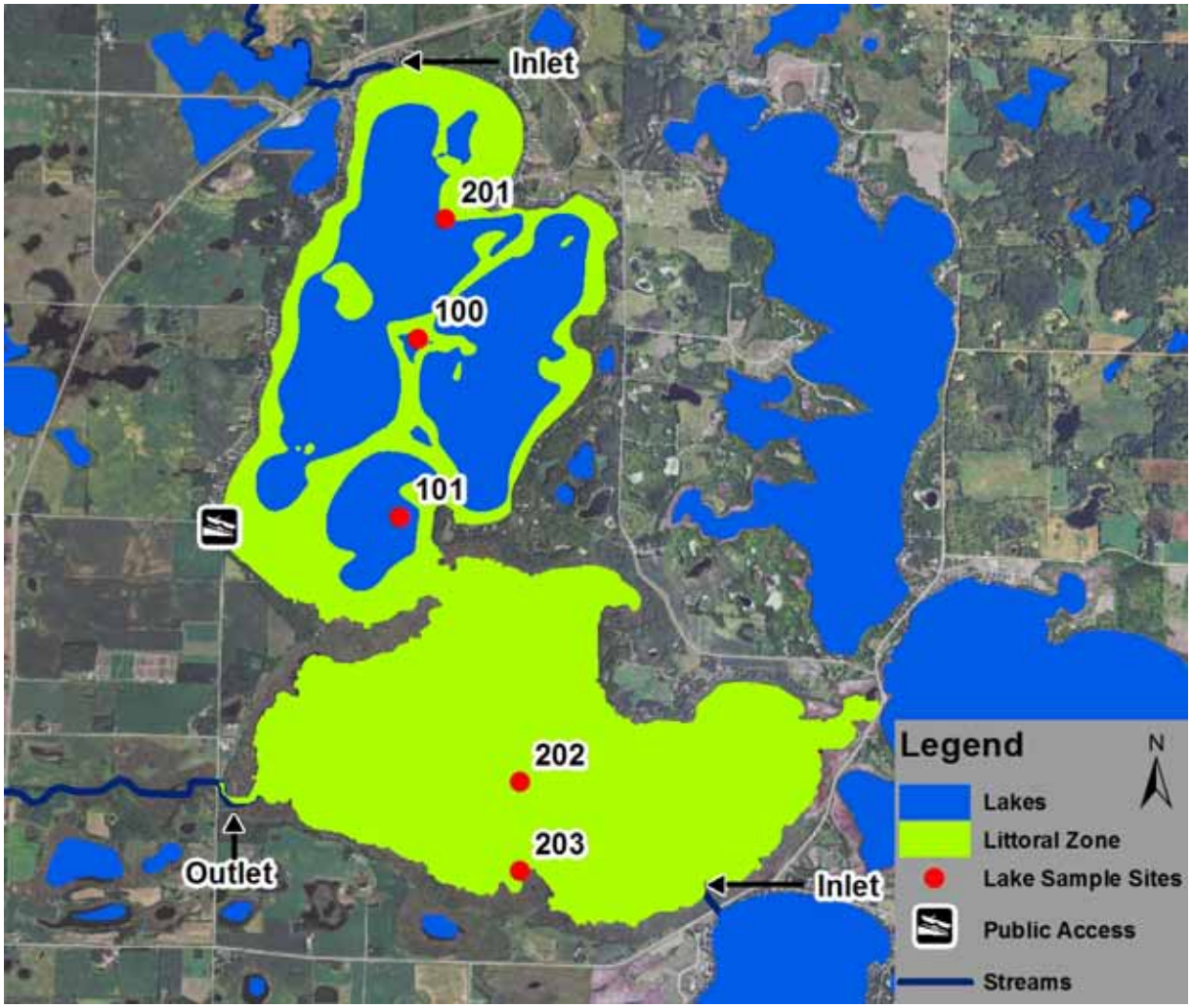


Figure 1. Map of Lake Lizzie with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic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

Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Minnesota Pollution Control Agency Lake Monitoring Program (MPCA) and RMB Environmental Laboratories Lakes Program (RMBEL).

Lake Site	Depth (ft)	Monitoring Programs
100*	NA	MPCA: 1951, 1961, 1979
101	53	MPCA: 1980
201	50	RMBEL: 2002-2012
202	5	MPCA: 2002 (only 1 data point)
203	5	MPCA: 2008 (only 1 data point)

*Lake site 100 is a location in the middle of the lake assigned to data collected at unknown coordinates.

Average Water Quality Statistics

The information below describes available chemical data for Lake Lizzie through 2012 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 201. All additional chemical data is from site 201 and reflects mean values from 1980.

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.

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)	16.4	23 – 50	> 40	Results are better than the expected range for the ecoregion.
[3]Chlorophyll *a* (ug/L)	5.6	5 – 22	> 14	
Chlorophyll *a* max (ug/L)	13.0	7 – 37		
Secchi depth (ft)	12.2	4.9 – 10.5	< 1.4	
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)	0.76	<0.60 – 1.2		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	193	75 – 150		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	7	10 – 20		Indicates clear water with little to no tannins (brown stain).
pH	8.4	8.6 – 8.8		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)	6.3	4 – 10		Within the expected range for the ecoregion.
Total Suspended Solids (mg/L)	NA	2 – 6		No data available.
Specific Conductance (umhos/cm)	NA	300 – 400		No data available.
Total Nitrogen : Total Phosphorus	46:1	25:1 – 35:1		Indicates the lake is phosphorus limited, which means that algae growth is limited by the amount of phosphorus in the lake.

[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	Primary Site 201
Total Phosphorus Mean (ug/L):	**16.4**
Total Phosphorus Min:	9
Total Phosphorus Max:	38
Number of Observations:	57
Chlorophyll *a* Mean (ug/L):	**5.6**
Chlorophyll-a Min:	<1
Chlorophyll-a Max:	13
Number of Observations:	57
Secchi Depth Mean (ft):	**12.2**
Secchi Depth Min:	7.5
Secchi Depth Max:	20.3
Number of Observations:	57

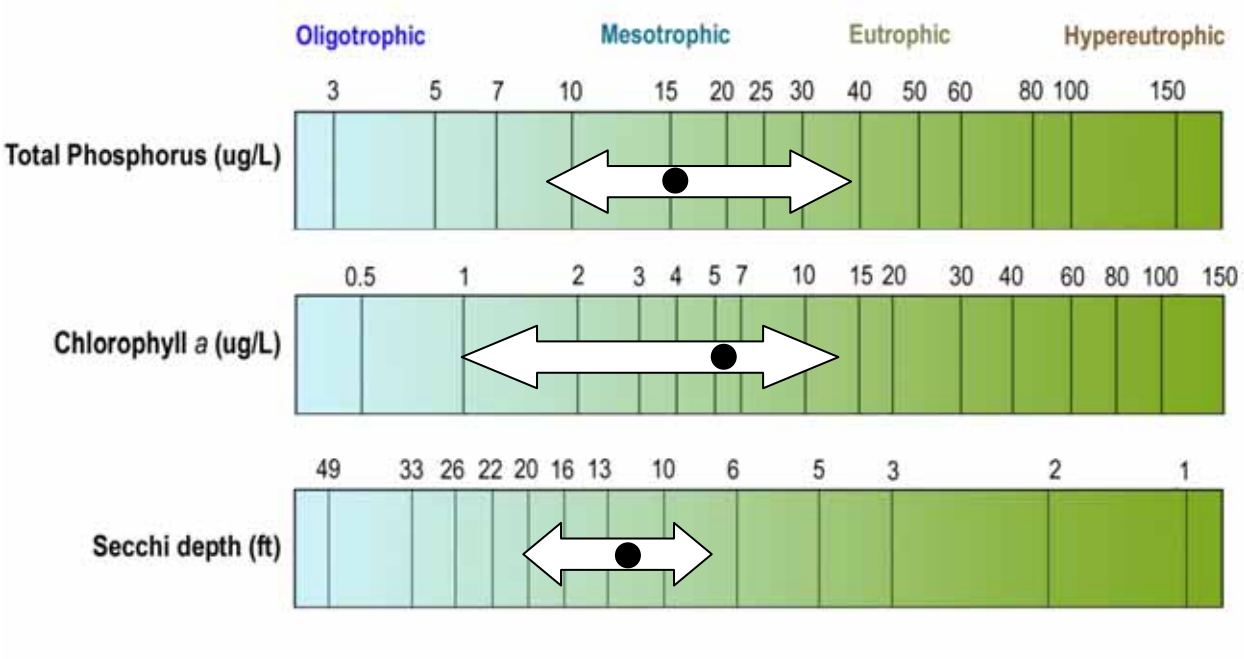


Figure 2. Lake Lizzie total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. 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 Lake Lizzie ranges from 9.0 to 19.0 feet (Figure 3). The transparency hovered fairly close around the long-term mean until 2012, when it was much higher. This could be due to Zebra mussels being established in the lake in 2009. Transparency monitoring should be continued annually at site 201 in order to track water quality changes.

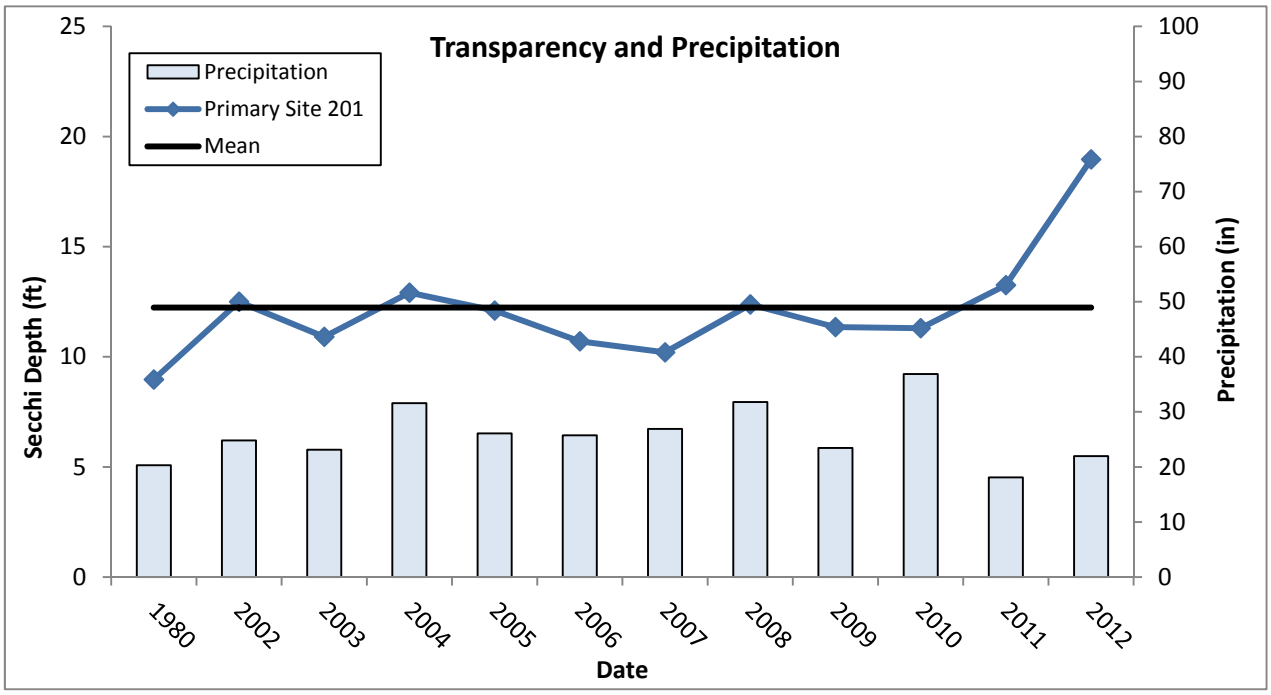


Figure 3. Annual mean transparency compared to long-term mean transparency.

Lake Lizzie transparency ranges from 7.5 to 20.3 feet at the primary site (201). Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Lake Lizzie 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.

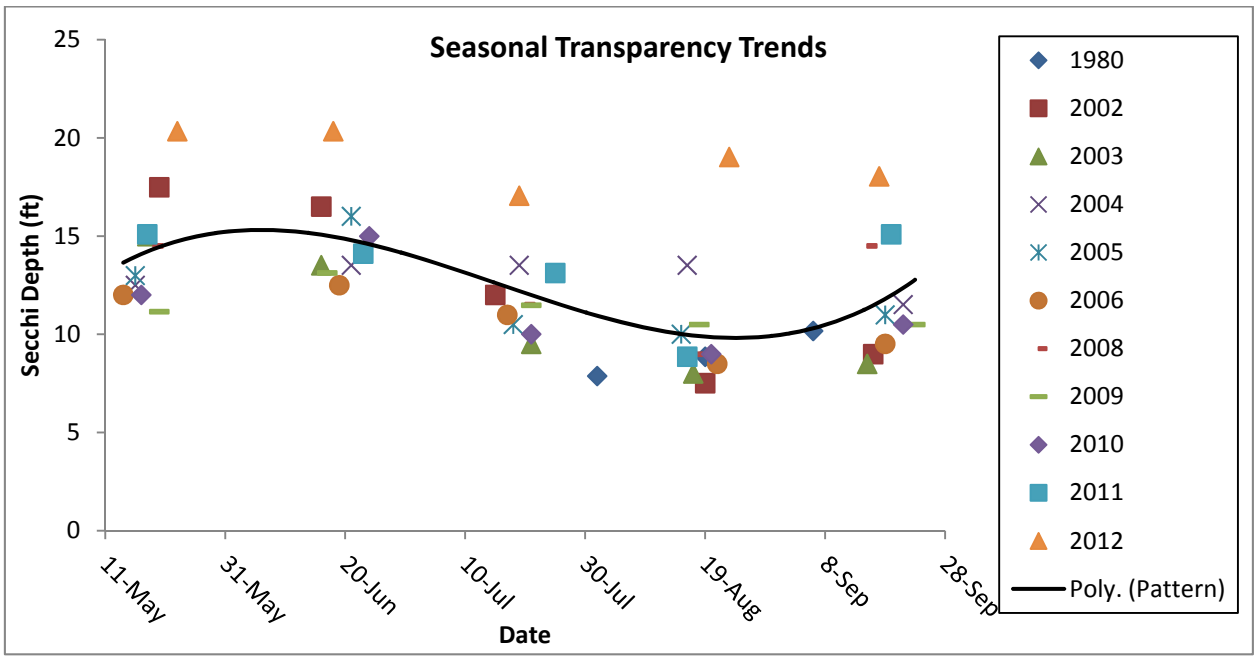


Figure 4. Seasonal transparency dynamics and year to year comparison (Primary Site 201). The black line represents the pattern in the data.

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. Lake Lizzie was rated as being "not quite crystal clear" 65% of the time by samplers at site 201 between 2008 - 2012 (Figure 5).

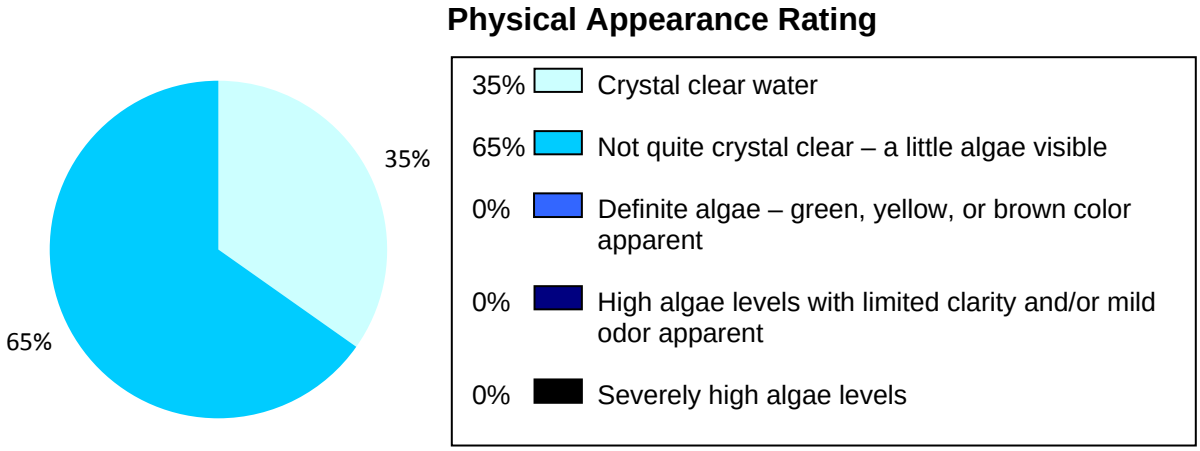


Figure 5. Lake Lizzie physical appearance ratings by samplers.

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Lake Lizzie was rated as being "beautiful" 100% of the time from 2008-2012 (Figure 6).

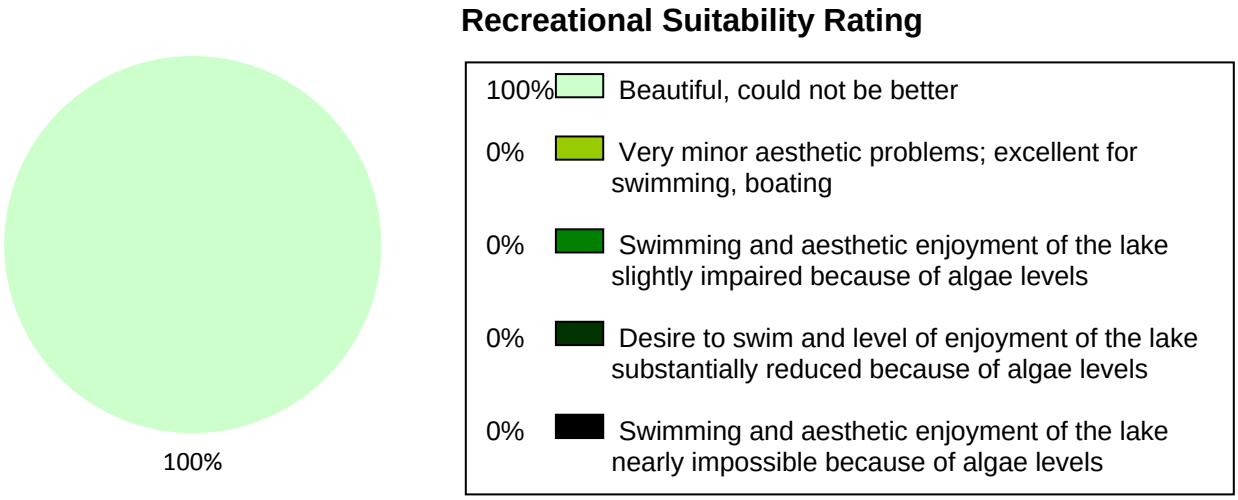


Figure 6. Recreational suitability rating, as rated by the volunteer monitor.

Total Phosphorus

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

Total phosphorus was evaluated in Lake Lizzie in 2002-2012. The data do not indicate much seasonal variability. The majority of the data points fall into the mesotrophic range (Figure 7).

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

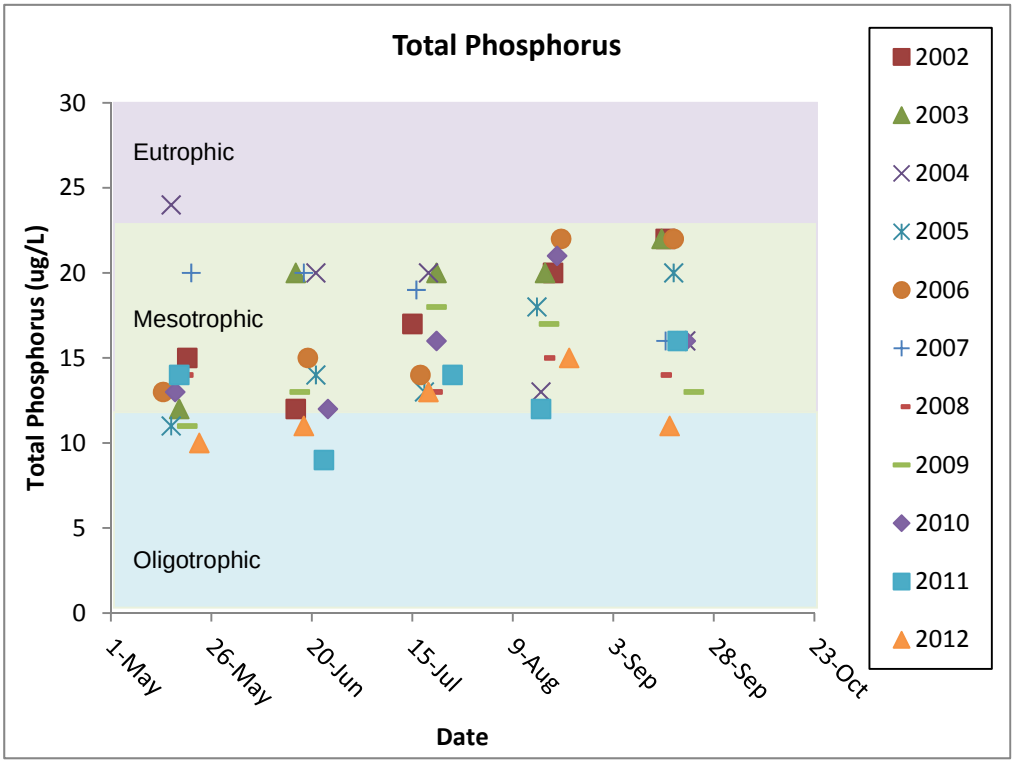


Figure 7. Historical total phosphorus concentrations (ug/L) for Lake Lizzie site 201.

Chlorophyll *a*

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to deter mine 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.

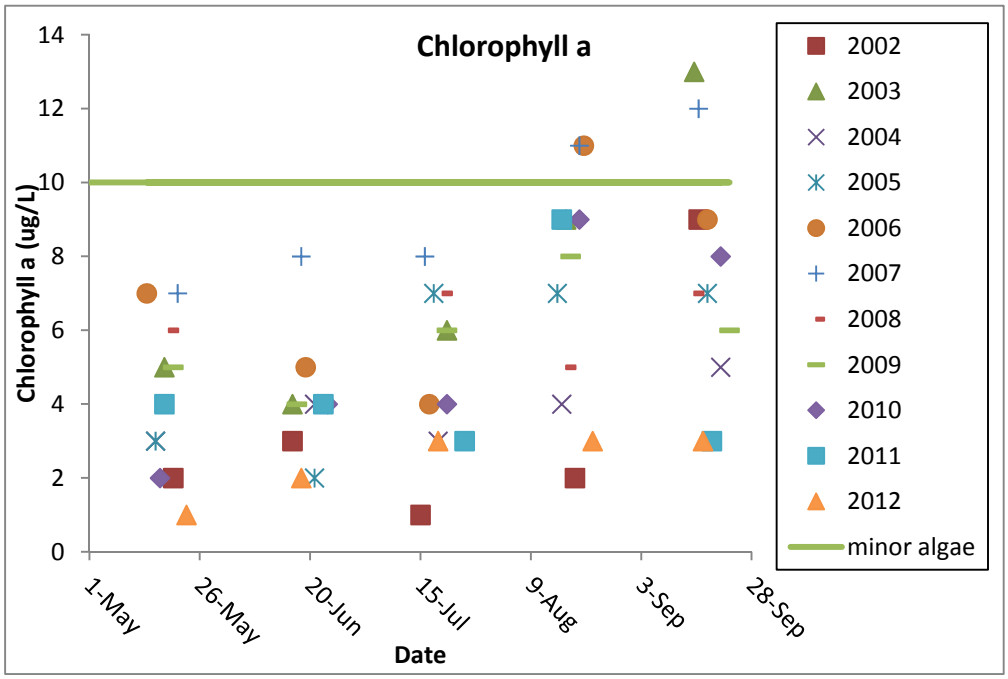
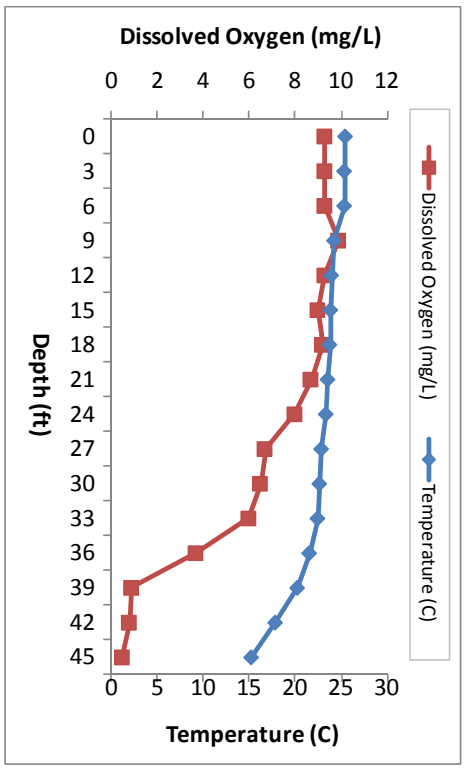


Figure 8. Chlorophyll *a* concentrations (ug/L) for Lake Lizzie at site 201.

Chlorophyll *a* was evaluated in Lake Lizzie from 2002-2010 (Figure 8). Chlorophyll *a* concentrations remained below 10 ug/L on all sample dates except for four, indicating clear water most of the summer. 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.

Lake Lizzie is a moderately deep lake, with a maximum depth of 65 feet. Dissolved oxygen and temperature profiles from data collected in 2013 by DNR Fisheries show stratification developing mid-summer. The thermocline occurs at approximately 33 feet, which means that gamefish will be scarce below this depth.

Figure 9. Dissolved oxygen and temperature profile for Lake Lizzie, 2013.

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 Lake Lizzie 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 site 201.

Trophic State Index	Site 205
TSI Total Phosphorus	44
TSI Chlorophyll-a	47
TSI Secchi	41
TSI Mean	44
Trophic State:	Mesotrophic

Numbers represent the mean TSI for each parameter.

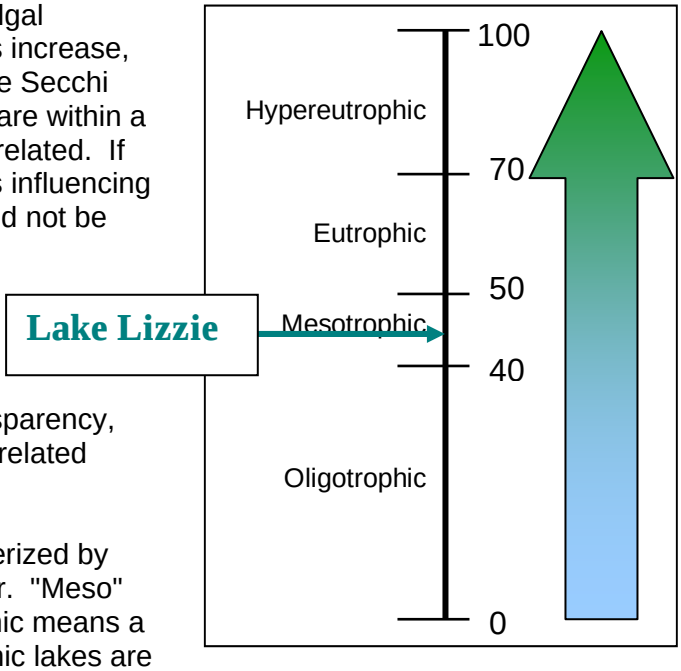


Figure 10. Trophic state index chart with corresponding trophic status.

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.

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

Table 8. Trend analysis for Lake Lizzie.

Lake Site	Parameter	Date Range	Trend	Probability
201	Total Phosphorus	2002-2012	Improving	95%
201	Chlorophyll *a*	2002-2012	No trend	--
201	Transparency	2002-2012	Improving	80%

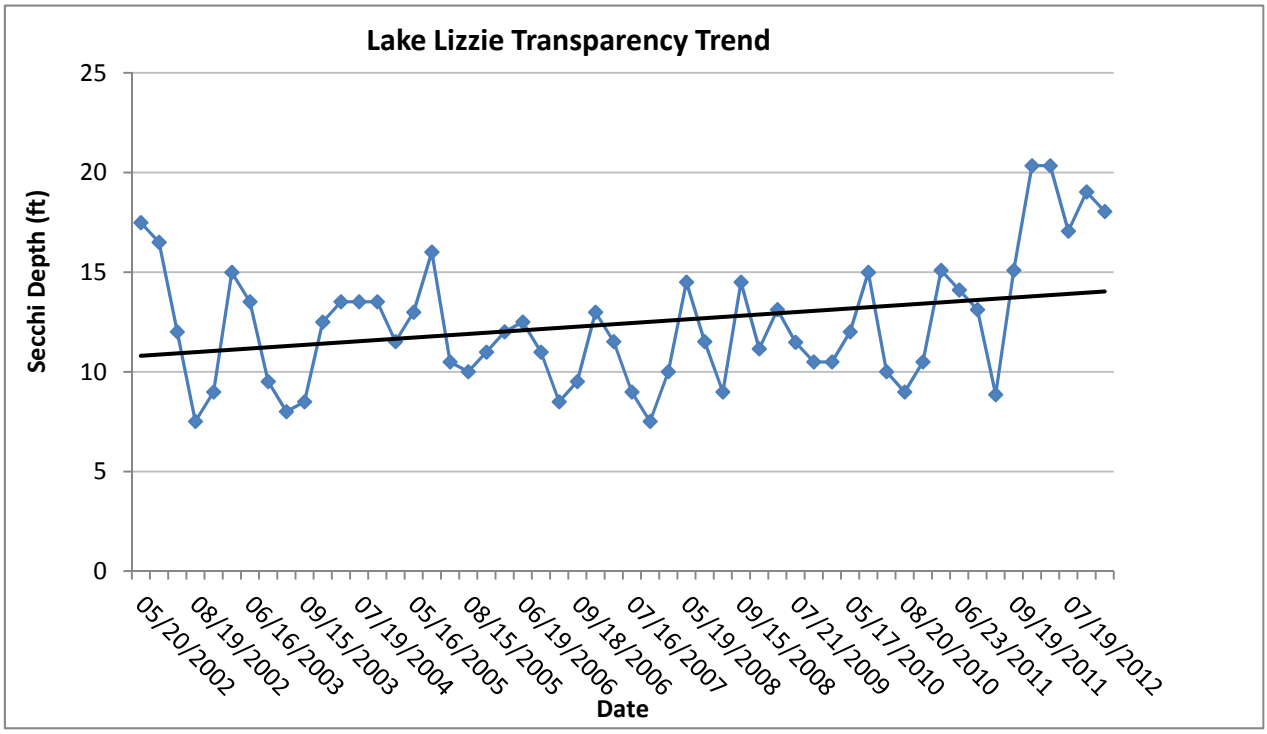


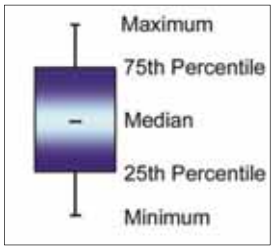
Figure 11. Transparency (feet) trend for site 201 from 2002-2006, 2008-2012.

Lake Lizzie shows evidence of improving water quality trends (Figure 11). These trends could be a result of the Zebra mussel infestation in 2009. 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.

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



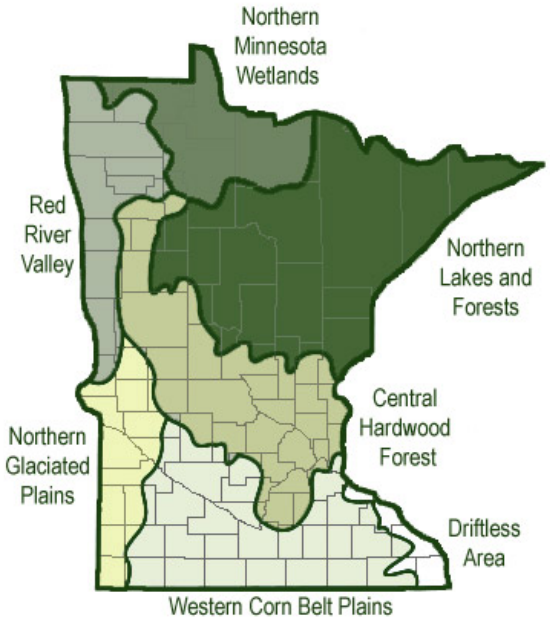


Figure 12. Minnesota Ecoregions.

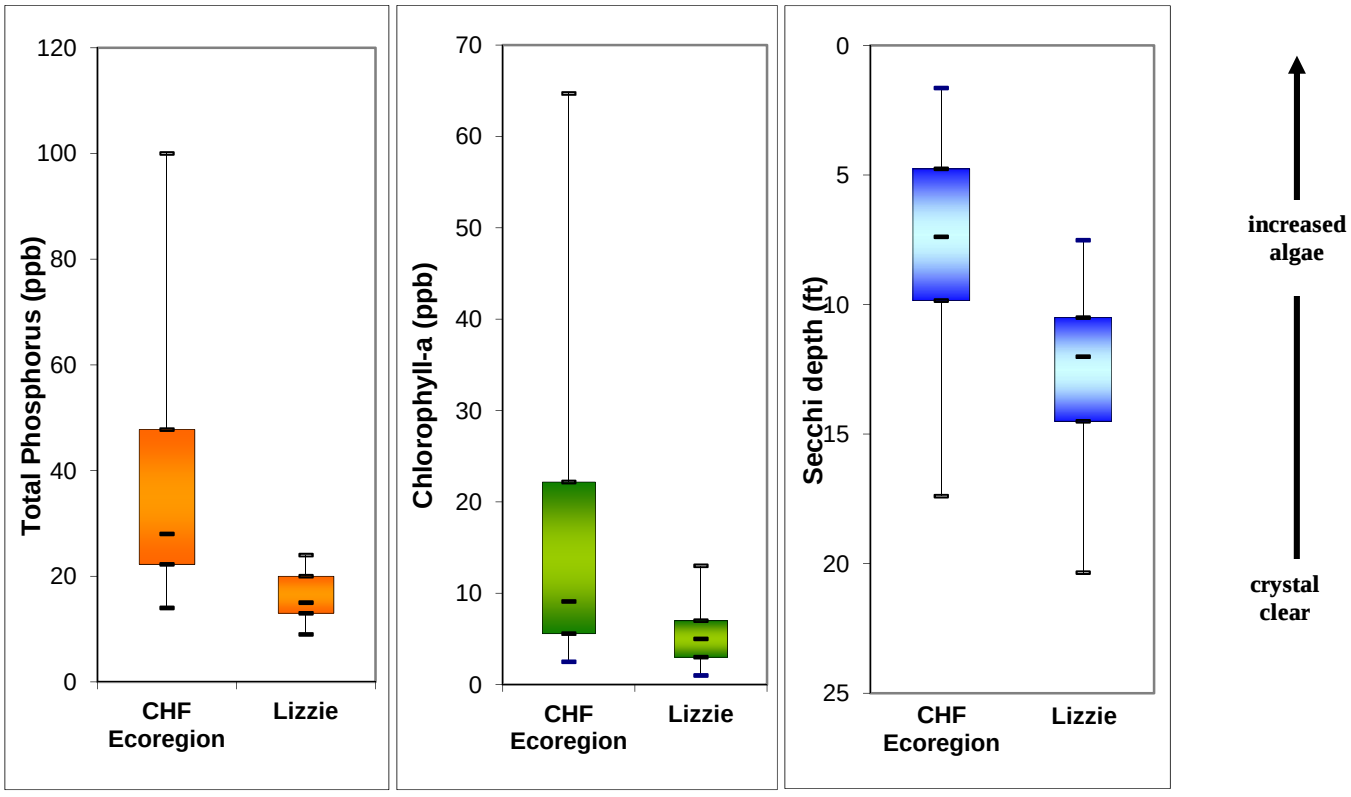


Figure 13. Lake Lizzie ranges compared to Central Hardwood Forest Ecoregion ranges. The Lake Lizzie total phosphorus and chlorophyll *a* ranges are from 57 data points collected in May-September of 2002-2012. The Lake Lizzie Secchi depth range is from 57 data points collected in May-September of 2002-2012.

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 Otter Tail River Major Watershed is one of the watersheds that make up the Red River Basin, which drains north to Lake Winnipeg (Figure 14). This major watershed is made up of 106 minor watersheds. Lake Lizzie is located in minor watershed 56026 (Figure 15).

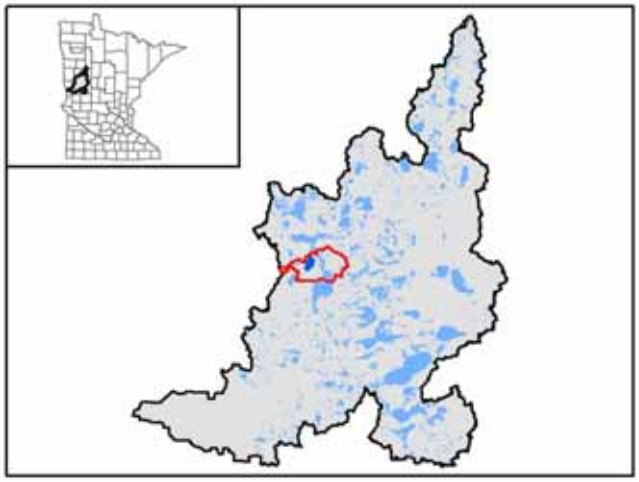


Figure 14. Otter Tail River Watershed.

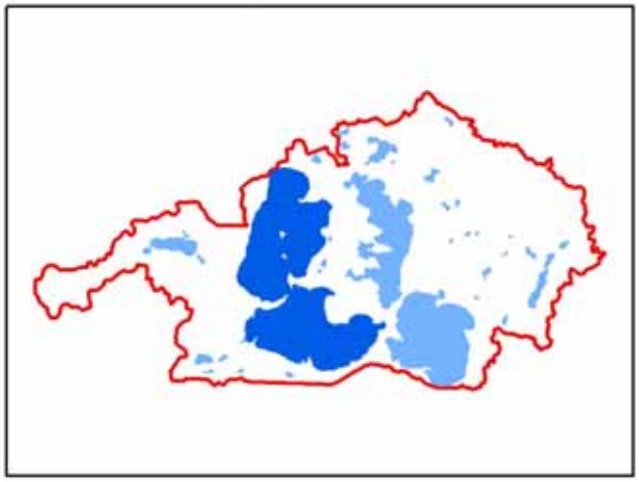


Figure 15. Minor Watershed 56026.

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. Lake Lizzie falls within lakeshed 5602603 (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 Lake Lizzie's watershed, containing all the lakesheds upstream of the Lake Lizzie lakeshed, see page 17. The data interpretation of the Lake Lizzie lakeshed

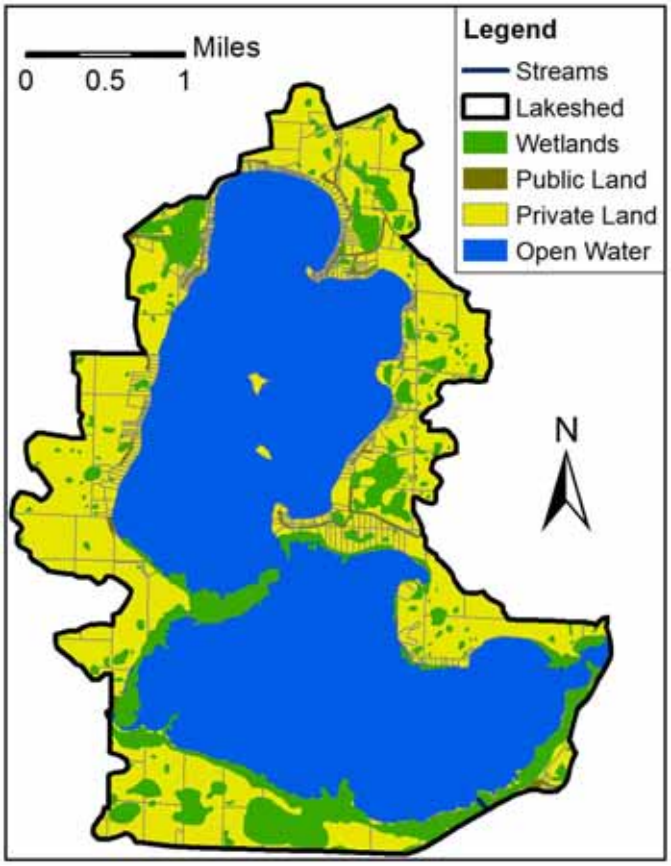


Figure 16. Lake Lizzie lakeshed (5602603) with land ownership, lakes, wetlands, and rivers illustrated.

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

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. Lake Lizzie lakeshed vitals table.

Lakeshed Vitals			**Rating**
Lake Area (acres)	North: 1,902	South: 1,831	descriptive
Littoral Zone Area (acres)	North: 815	South: 1,831	descriptive
Lake Max Depth (feet)	North: 65	South: 9	descriptive
Lake Mean Depth (feet)	North: 19	South: 5	
Water Residence Time	Not available, but most likely short due to the Pelican River running through the lake.		
Miles of Stream	0.13		descriptive
Inlets	North: 1	South: 1	
Outlets	South: 1		
Major Watershed	56 – Otter Tail River		descriptive
Minor Watershed	56026		descriptive
Lakeshed	5602603		descriptive
Ecoregion	North Central Hardwood Forests		descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	2:1		
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	52:1		
Wetland Coverage (NWI)	14%		
Aquatic Invasive Species	Zebra Mussels		
Public Drainage Ditches	None		
Public Lake Accesses	1		
Miles of Shoreline	North: 8.7	South: 10.8	descriptive
Shoreline Development Index	North: 1.4	South: 1.8	
Public Land to Private Land Ratio	0.03:1		
Development Classification	Recreational Development		
Miles of Road	16		descriptive
Municipalities in lakeshed	None		
Forestry Practices	None		
Feedlots	2		
Sewage Management	Individual Subsurface Sewage Treatment Systems (last lake-wide inspection conducted by the county in 2004)		
Lake Management Plan	None		
Lake Vegetation Survey/Plan	DNR, 2005		

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.

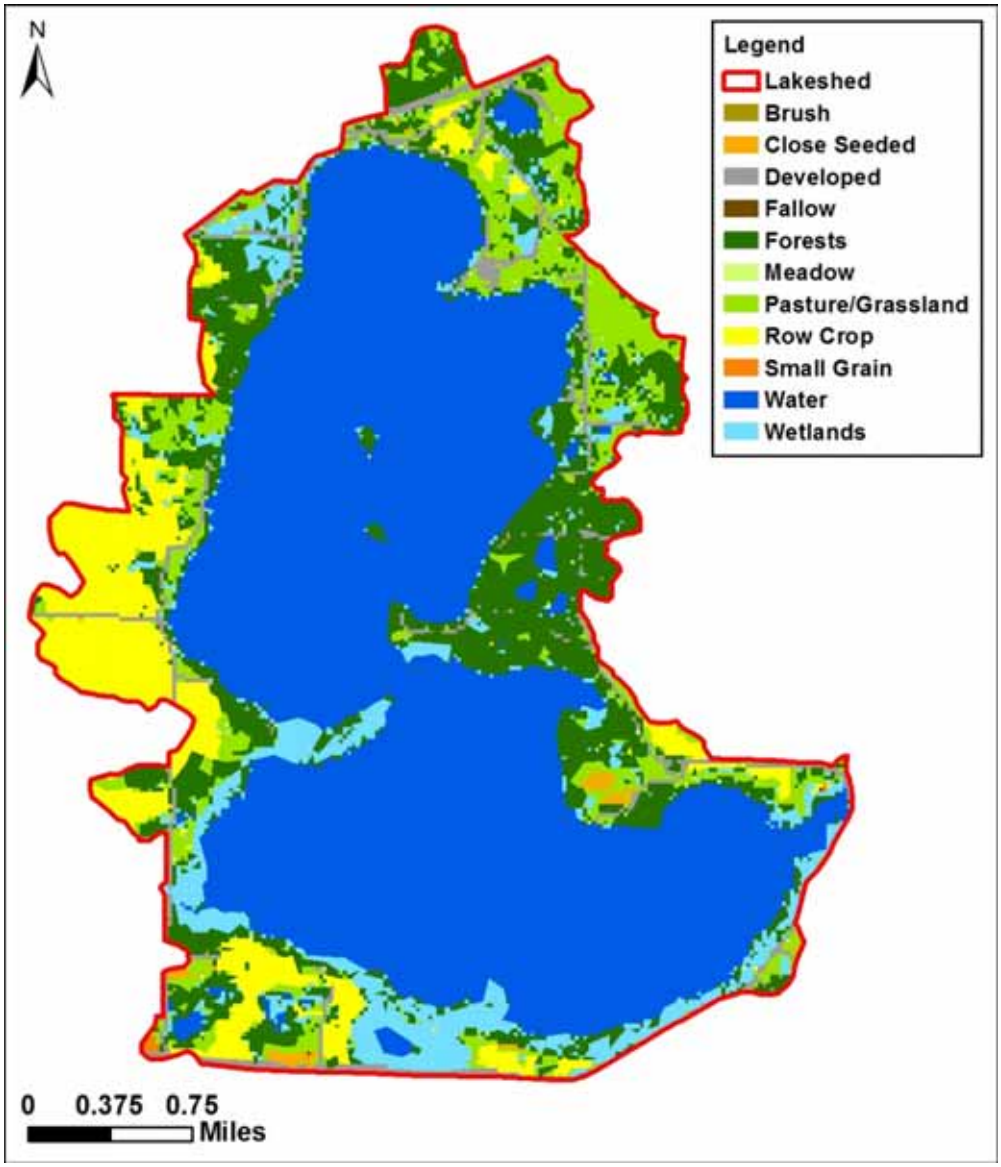


Figure 17. Lizzie lakeshed (5602603) land cover (NASS, 2012).

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 allowing nutrients and sediment to move towards the lowest point, typically the lake. 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). Even though the entire lakeshed has the potential to drain towards the lake, the land use occurring directly around the lakeshore will most likely have the greatest impact to the lake.

Developed land cover (Table 10) mostly describes impervious surface. In impervious areas, such as roads and houses, the land is unable to absorb water and it runs off the landscape carrying with it any nutrients or sediment in its path. The higher the impervious intensity the more area that water cannot penetrate in to the soils. Impervious areas can contribute 0.45 – 1.5 pounds of phosphorus per year in runoff. Lake Lizzie has 3.6% of its lakeshed classified as developed (Table 10). This doesn't sound like much area, but if it is mainly concentrated on the lakeshore, the runoff from impervious areas can run directly into the lake.

Table 10. Land cover in the Lizzie lakeshed.

Runoff Potential	Category	Specific Landcover	Acres	Percent
High	Agriculture	**Row Crop**	580.58	8.50%
High	Urban	**Developed**	245.25	3.59%
High	Agriculture	**Close Seeded**	25.15	0.37%
High	Agriculture	**Small Grain**	5.79	0.08%
High	Agriculture	**Fallow**	1.26	0.02%
Low	Forest	**Woods**	1109.61	16.24%
Low	Water	**Water**	3794.45	55.54%
Low	Agriculture	**Pasture/Grassland**	565.89	8.28%
Low	Wetlands	**Wetlands**	486.04	7.11%
Low	Agriculture	**Meadow**	17.52	0.26%
Low	Grass/Shrub	**Brush**	0.75	0.01%
Total area with low runoff potential			5974.26	87.44%
Total area with high runoff potential			858.03	12.56%
Total			6832.29	100.00%

Agricultural land use has the potential to contribute nutrients to a lake through runoff, but the amount of phosphorus runoff depends on the type of agricultural land use. Generally, the highest concentration of agricultural nutrient runoff comes from animal feedlots. There is one animal feedlot in the Lake Lizzie lakeshed (Table 9). The second highest agricultural runoff generally comes from row crops. There are some row crops along the western shore of Lake Lizzie, although it looks like there is some forested buffer and wetlands between the row crops and the lake (Figure 17). This buffer is important for filtering the runoff and helping it infiltrate into the ground. Pasture land has less nutrient runoff, and most likely doesn't impact the lake as much as other agricultural uses. Therefore, the statistics in Table 10 are valuable for evaluating runoff in the lakeshed. Overall, 87% of the Lake Lizzie lakeshed is classified in low nutrient runoff land uses (Table 10).

The University of Minnesota has online records of land cover statistics from years 1990 and 2000 (http://land.umn.edu). Although this data is 12 years old, it is the only data set that is comparable over a decade's time. In addition, a lot of lake development occurred from 1990 to 2000 when the US economy was booming. Table 11 describes Lake Lizzie's lakeshed land cover statistics related to development 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 impervious area has increased, which has implications for storm water runoff into the lake. The increase in impervious area is consistent with the increase in urban acreage.

Table 11. Lizzie's lakeshed land cover statistics and % change from 1990 to 2000 (http://land.umn.edu).

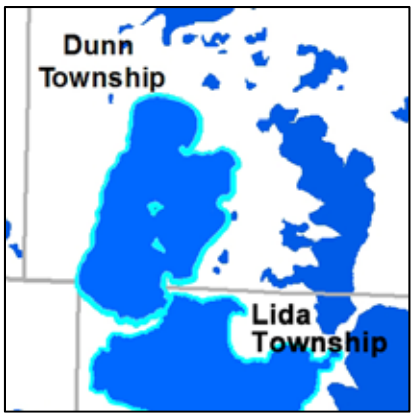
Land Cover	1990 Acres	Percent	2000 Acres	Percent	Comments
Urban	234	6.38%	285	4.17%	Increase of 51 acres
Total Impervious Area*	35	2.12%	68	2.24%	Increase of 33 acres

*Percent Impervious Area Excludes Water Area

Demographics

Lake Lizzie 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 Otter Tail County as a whole, Lida and Dunn townships have a higher extrapolated growth projection (Figure 18).
(source:http://www.demography.state.mn.us/resource.html?Id=19332)



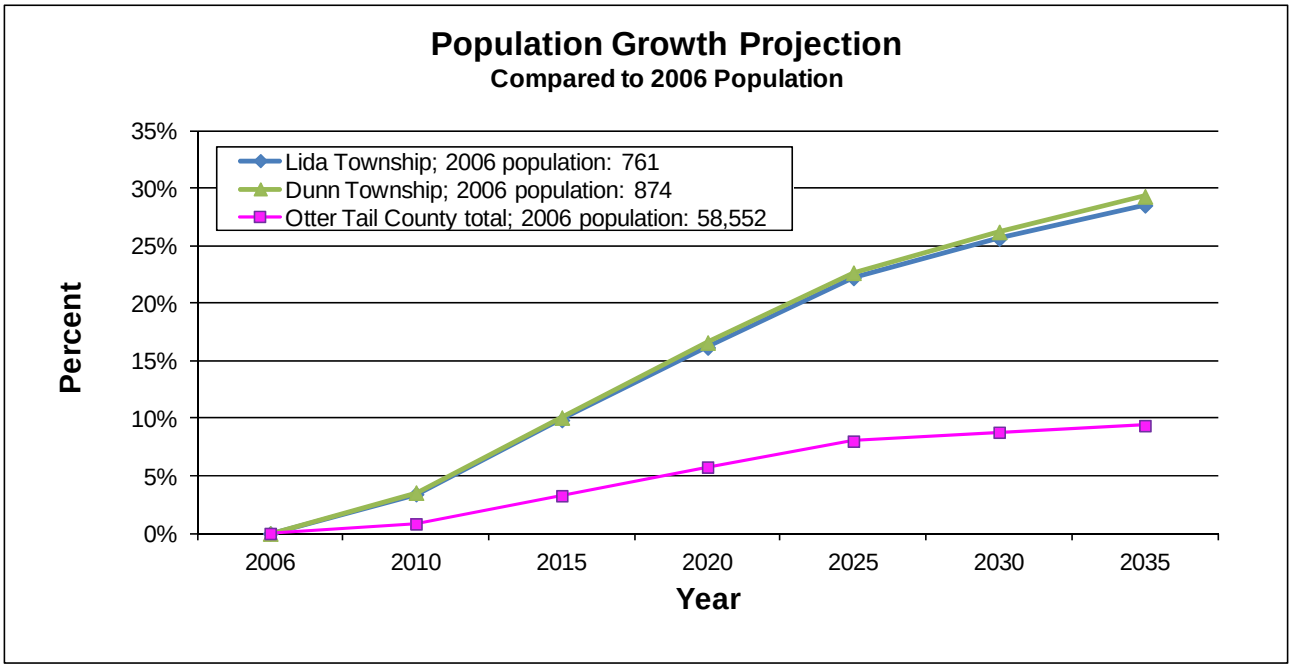


Figure 18. Population growth projection for Lida and Dunn Townships, Otter Tail County.

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 Lake Lizzie's lakeshed is privately owned and forested or used for agricultural production (Table 11). This land can be the focus of development and protection efforts in the lakeshed.

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

	Private (42%)					57%	Public (1%)		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	3.4	14.5	13.2	4.4	6.5		0.9	0.1	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	104 – 345	257 – 890	81		40		6.2	0.5	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 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.

Lake Lizzie's lakeshed is classified with having 67.0% of the watershed protected and 19.1% 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. 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 Lake Lizzie, whether through direct overland flow or through a creek or river. There are 58 lakesheds upstream of the Lake Lizzie lakeshed.

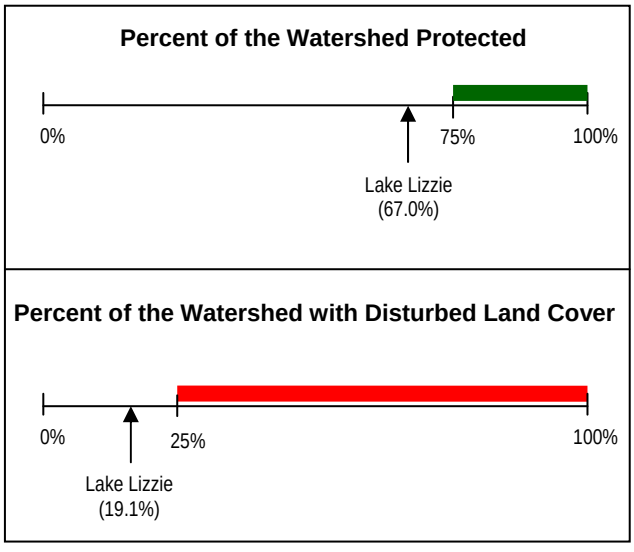


Figure 19. Lake Lizzie's lakeshed percentage of watershed protected and disturbed.

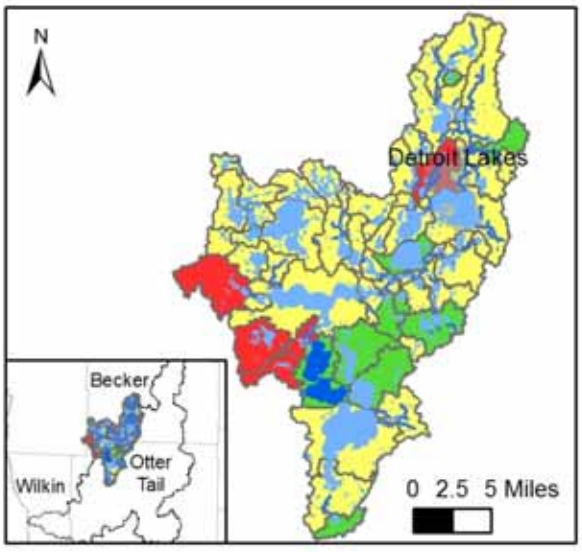


Figure 20. Upstream lakesheds that contribute water to the Lake Lizzie lakeshed. Color-coded based on management focus (Table 12).

Status of the Fishery (DNR, as of 08/30/2010)

Lake Lizzie Lake is a 4,035-acre mesotrophic (moderately fertile) lake located in northwestern Otter Tail County approximately six miles northeast of Pelican Rapids, MN. Lake Lizzie Lake is located within the Otter Tail River Watershed. Lake Lizzie Lake is connected to Pelican Lake and Prairie Lake via the Pelican River. The Pelican River inlet is located along the northwest shoreline of the lake while the outlet is located along the southwest shoreline. Lake Lizzie Lake is also connected to North Lida Lake by an unnavigable culvert under County Road 4. The immediate watershed is composed primarily of agricultural land interspersed with hardwood woodlots.

The maximum depth of Lake Lizzie Lake is 66 feet; however, 75% of the lake is less than 15 feet in depth. The secchi disk reading at the time of the survey was 8.8 feet. Previous secchi disk readings have ranged from 6.5 to 11.5 feet. A majority of the north and west shorelines of Lake Lizzie Lake has been developed. Homes and cottages compose the majority of the development. A public water access is located along the west shoreline of the lake.

Shoreline development is limited in the southern portion of the lake. Hardstem bulrush, common cattail, and phragmites are prevalent throughout this section of the lake. Large stands of hardstem bulrush are also scattered along various shorelines of the northern portion of the lake and around several midlake islands. Emergent aquatic plants such as bulrush and common cattail provide valuable fish and wildlife habitat, and are critical for maintaining good water quality. They protect shorelines and lake bottoms, and can actually absorb and break down polluting chemicals. Emergent plants provide spawning areas for fish such as northern pike, largemouth bass, and panfish. They also serve as an important nursery area for all species of fish. Because of their ecological value, emergent plants may not be removed without a DNR permit.

Lake Lizzie Lake is a popular angling lake during both the open water and ice fishing seasons. The lake is best known for its excellent bluegill, black crappie, largemouth bass, northern pike, and walleye fishing. Data from recent lake surveys indicate these species are abundant and have good size distributions.

Bluegill abundance has remained stable in the recent series of surveys. Bluegill size structure has also remained consistently good. Thirty-four percent of the bluegills in the trap net sample were at least 7.0 inches in length. Bluegills attain an average length of 7.8 inches at eight years of age.

Northern pike abundance has also remained consistently stable. Age data indicate that pike reproduction is consistently good. Northern pike ranged in length from 9.7 to 31.7 inches with an average length and weight of 17.7 inches and 1.2 pounds. Pike attain an average length of 21.2 inches at four years of age.

Summer test-net indices are not reliable indicators of largemouth bass and black crappie abundance or size structure; however, angler reports for these species have been positive.

Walleye abundance has remained very stable over the recent series of lake surveys. The 2006 and 2008 year classes of walleye appear to be strong and should provide consistently good fishing for several years. Walleyes ranged in length from 8.7 to 26.9 inches with an average length and weight of 15.4 inches and 1.4 pounds. Walleyes attain an average length of 15.0 inches at four years of age.

To maintain the excellent fishing this lake presently has to offer, it is imperative to preserve the quality of the fish habitat. In 1999, the DNR constructed and placed smallmouth bass spawning structures in Lake Lizzie Lake to increase the available spawning habitat for this species. Anglers can also maintain the quality of fishing in Lake Lizzie Lake by practicing selective harvest. Selective harvest encourages the release of medium to large-size fish while allowing the harvest of

more abundant smaller fish for table fare. Releasing the medium to large fish will ensure that lake will have enough spawning age fish on an annual basis and will provide anglers with more opportunities to catch large fish in the future.

Lake Lizzie Lake is also a popular waterfowl hunting lake. Many hunters pursue ducks and geese in the southern portion of the lake.

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=56076001

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.

Overall Summary
The north bay of Lake Lizzie is mesotrophic lake (TSI = 44) with evidence of improving trends in water quality. The total phosphorus, chlorophyll *a* and transparency ranges are better than the ecoregion ranges. The south bay does not have enough data for assessment.

The majority of Lake Lizzie's lakeshed is in land uses that are beneficial to water quality, forests and wetlands (Table 11). Nineteen percent (19%) of the lakeshed is disturbed by development and agriculture. The threshold of disturbance where water quality tends to decline is 25%. Lake Lizzie is under this threshold; however, most of the agricultural land is in pasture, which has much less runoff potential than row crops. A more accurate estimate of disturbed land is 12.5% (Table 10), which is well below the 25% threshold.

Zebra mussels were first discovered in Lake Lizzie in 2009. They most likely came from Pelican Lake upstream. In the past two years, Lake Lizzie has had record high transparency readings, which could be due to Zebra mussels clarifying the lake.

Lake Lizzie has a large watershed (Figure 20). The Pelican River flows through Detroit Lakes and Pelican Lake before it flows through Lake Lizzie and eventually joins the Otter Tail River at Fergus Falls. The large amount of water moving through Lake Lizzie via the Pelican River causes the lake to have a low residence time, which means it is continually flushed out. This low residence time helps remove the phosphorus from the large watershed and runoff.

Priority Impacts to the Lake
The priority impact to Lake Lizzie is expansion of residential housing development around the lakeshore and second tier development. A majority of the first tier around the north bay of the lake is developed in the first tier. From 1990-2000, the urban acreage around the lake increased by 51 acres and the impervious acreage increased by 33 acres. Lida and Dunn Townships are projected to grow by 15% in the next decade (Figure 18). In addition, the conversion of seasonal cabins to year-round homes usually increases the impervious surface of a lake lot, which increases runoff to the lake.

Zebra mussels could affect the lake's water quality and fishery. At this time there is nothing that can be done about the Zebra mussels in the lake.

Best Management Practices Recommendations
The management focus for Lake Lizzie should be to protect the current water quality and lakeshed. In areas that are already developed, shoreline restoration, rain gardens, and septic system maintenance will help protect the current water quality.

Because a lot of undeveloped private land still exists, especially around the southern basin of Lake Lizzie, 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 in Fergus Falls.

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 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

Organizational contacts and reference sites

Lake Lizzie Association	No website
DNR Fisheries Office	1509 1st Avenue North, Fergus Falls, MN 56537 218-739-7576 http://www.dnr.state.mn.us/areas/fisheries/fergusfalls/index.html
Regional Minnesota Pollution Control Agency Office	714 Lake Ave., Suite 220, Detroit Lakes, MN 56501 218-847-1519, 1-800-657-3864 http://www.pca.state.mn.us/yhiz3e0
West Otter Tail Soil and Water Conservation District	506 Western Ave N, Fergus Falls, MN 56537 218-739-1308 ext.3 http://www.eotswcd.org/