CHAPTER 3: EXISTING WATER QUALITY INFORMATION AND RESULTS FOR THE GOOD HARBOR BAY WATERSHED

3.1 WATER QUALITY DATA AND REPORTS

Significant data and summary reports have been produced which describe the water quality of the Good Harbor Bay watershed throughout the year. Following are information sources used in the following water quality summary:

- Leelanau County Inland Lakes Project: A Study of Development and Water Quality Within the Little Traverse and Lime Lake Watersheds, Leelanau County, MI, Steinburg et al, 1994
    - A study completed in partial fulfillment of the requirements for the degree of Master of Science and Master of Landscape Architecture University of Michigan School of Natural Resources and Environment
- Report of the Leelanau Watershed Council, Water Quality Monitoring Program (A synthesis of data from 1990 - 1995) – T. Keilty (7/1997)
- A summary of water quality parameters that were sampled from 1990-1995 in several Leelanau County lakes, including Lime and Little Traverse Lakes. Parameters included: TP, Nitrate+Nitrite Nitrogen, Chlorophyll-a, and SD.
- Report of the Leelanau Watershed Council, Nutrient Data and Budgets for Leelanau County Streams and Lakes 1990 – 1996 – R. Canale and W. Nielsen (9/1997)
    - This study summarized the nutrient budgets (inflow and outflow) of several Leelanau County lakes, including Lime and Little Traverse Lake. This study is over ten years old, but is the only study of the nutrient flux in these lakes.
- Michigan Department of Natural Resources, Historical Review and Management Prescription for Little Traverse Lake Fishery, (1/2002).
- Michigan Department of Natural Resources, Historical Review and Management Prescription for Lime Lake Fishery, (1/2002).
- Report of the Leelanau Watershed Council, Water Quality Monitoring (A Synthesis of data from 1990 through 2001) - T. Keilty and M. Woller (2/2002)

- An update (1990-2001) of a 1997 report summarizing water quality parameters sampled from several Leelanau County lakes, including Lime and Little Traverse Lakes. Parameters included: TP, TN, Chlorophyll-a, and SD.
  - While seemingly a long period of monitoring, the researchers in these studies indicate the program is just emerging from its infancy. The data have changed over this period because of the colonization of exotic zebra mussels which have affected the lake's ecology. The authors recommended more targeted studies for emerging issues.
- Predicting Blue-Green Algal Blooms & Potential Toxin Production in Zebra Mussel Infested Oligotrophic Lakes (Leelanau Watershed Council, Leelanau Conservancy for MDEQ) – M. Woller and T. Keilty (2004)
- A study of the influence of zebra mussels on the plankton populations of several Leelanau County lakes, including Lime and Little Traverse.
  - The authors cited literature sources that documented zebra mussels selectively consume green algae and reject cyanobacteria. This mechanism causes the decline in diversity of plankton and potential for cyanobacteria blooms causing a commensurate increase of microcystin (a hepatotoxin) excreted by the cyanobacteria Microcystis aeruginosa.
- Microcystin Production and Fate in Zebra Mussel Infested Oligotrophic Lakes, Prepared for Michigan Department of Environmental Quality, M. Woller and T. Keilty (3/2006)
  - This study report documented concentration and fate of microcystins generated by cyanobacterial blooms in several Leelanau County lakes, including Lime and Little Traverse Lakes. The report recorded concentration of microcystin (an hepatotoxin) in the water, sediments, macroinvertebrates and fish. The authors hypothesized potential for persistence and bioaccumulation of microcystin based on literature and results of their work.

3.2 LIME LAKE AND LITTLE TRAVERSE LAKE WATER QUALITY SUMMARY

Leelanau Conservancy Watershed Council Database – (1990-2014)

This database contains chemical and physical water sampling results of Leelanau County lakes and streams starting from 1990 through the 2014[1]. This database is available as a result of a water quality program started by Dr. Tim Keilty in 1989 and other dedicated volunteer's in 1989. The program and database is hosted and supported by the Leelanau Conservancy. Lime and Little Traverse Lakes and their tributary streams are included in the database. Parameters on the seven major lakes in Leelanau County include: TP, nitrates, nitrites, Kjeldhal nitrogen, ammonia, chlorophyll a, conductivity, oxygen reduction potential, temperature, conductivity, pH and SD. The major tributaries (streams) to each of the major lakes are also sampled for Total Phosphorus and discharge. The database provides an overview of trends over time. The stream samples include an estimate of discharge and average of phosphorous loading to Lime and Little Traverse Lakes from Shetland, Shalda and Lime Creeks. Zebra mussels were introduced to Little Traverse Lake in 1998 and showed established populations by 2002. In Lime Lake zebra mussels were introduced in 2002 (Woller-Skar 2009).

A report completed on Lime and Little Traverse Lake in partial fulfillment of the requirements for the degree of Master of Science and Master of Landscape Architecture University of Michigan School of Natural Resources and Environment in 1994 was referenced for this water quality section. It is titled: Leelanau County Inland Lakes Project: A Study of Development and Water Quality Within the Little Traverse and Lime Lake Watersheds, Leelanau County, MI, Steinburg et al, 1994. Keilty and Woller 2002 and Canale and Neilsen 1997 are also referenced.

[1] There was no data available for the Lakes in 2013.

Nutrients (Phosphorus – P and Nitrogen – N)

Total phosphorus (TP) is an essential nutrient for plant growth, but it tends to be low in northern lakes. Keilty and Woller (2002) provided information that indicated Lime and Little Traverse Lakes are oligotrophic, or high quality, clear lakes with low productivity. Oligotrophic lakes are typified by total phosphorus (TP) concentrations ranging from 3ug/L to 17ug/L, and Total nitrogen (TN) concentrations between 307ug/L and 1630ug/L. An N:P ratio of greater than 10 typically indicates that the lake is a Phosphorus limiting system. Table 14 below shows that from 1990-2014, TP concentrations for Lime and Little Traverse Lakes fell within Wetzel's oligotrophic classification (Wetzel 2001 and Keilty and Woller 2002) reported nitrate/nitrite (N) concentrations as opposed to Wetzel's classification using TN (which also includes organic and ammonia nitrogen). The ranges of the nitrate/nitrite values below show the lakes nitrogen levels also likely fall into the oligotrophic range for Lime Lake and Little Traverse Lake (Table 14).

Table 14- Lime and Little Traverse Lakes Water Quality Summary Data

Lime Lake		Little Traverse Lake	
Parameter	**Result**	**Parameter**	**Result**
TP	4.3	**TP**	5.1
N	216	**N**	125.8
N:P Ratio	50.9	**N:P Ratio**	23.6

The trophic state of lakes is indicative of their biological productivity, or the amount of living material supported within them, primarily in the form of algae. The least productive lakes are called 'oligotrophic'. These are typically cool and clear, and have relatively low nutrient concentrations. The most productive lakes are called 'eutrophic' and are characterized by high nutrient concentrations which result in algal growth, cloudy water, and low dissolved oxygen levels. Those lakes with a trophic status that falls along the continuum somewhere between oligotrophy and eutrophy are termed 'mesotrophic' (Adapted from http://www.epa.gov/greatlakes/glindicators/water/trophicb.html).

Using long term data from the water quality database, allows for monitoring the Trophic Status Index or TSI for all the lakes in Leelanau County. The Trophic Status Index (TSI) was calculated for all lakes for 2014 (Figure 16). Both Lime and Little Traverse Lake have a TSI < 35. The ratio of N/P is also an important factor in lake biology because microorganisms typically require about 10 times more nitrogen than phosphorus (Keilty and Woller 2002). Both Little Traverse Lake and Lime Lake have N/P ratios greater than 10 (see Figure 17).

Keilty and Woller (2002) also report a slight decline of TP from the water column, and attribute it to zebra mussel filtering of plankton in Little Traverse Lake, but no zebra mussels were reported in Lime Lake in 2002. Other factors they cite as possible reasons for phosphorus reduction are education efforts to riparian owners to reduce phosphorus containing substances such as fertilizer and detergents.

Figure 16: Trophic Status Index for all Lakes in Leelanau County (2014)

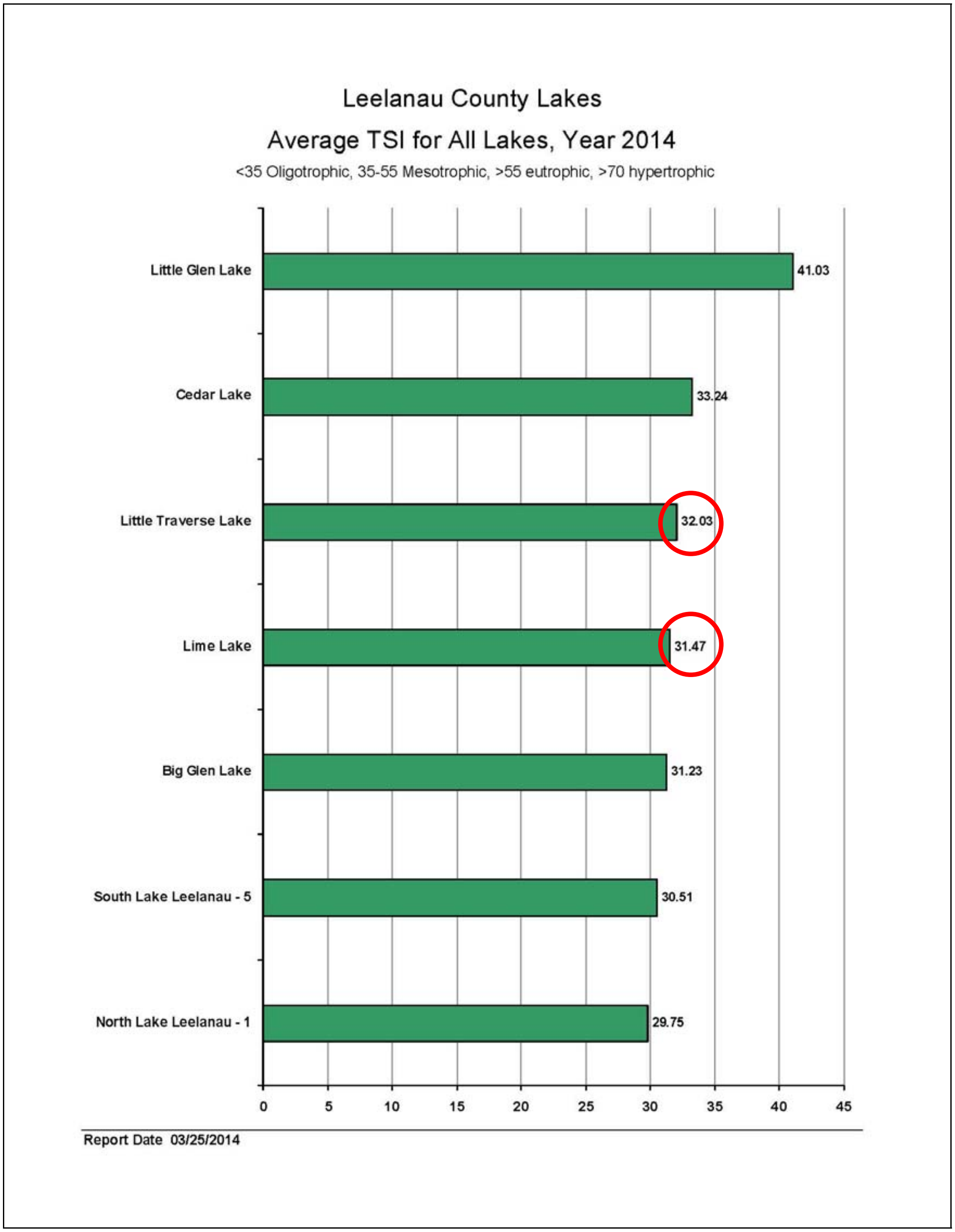
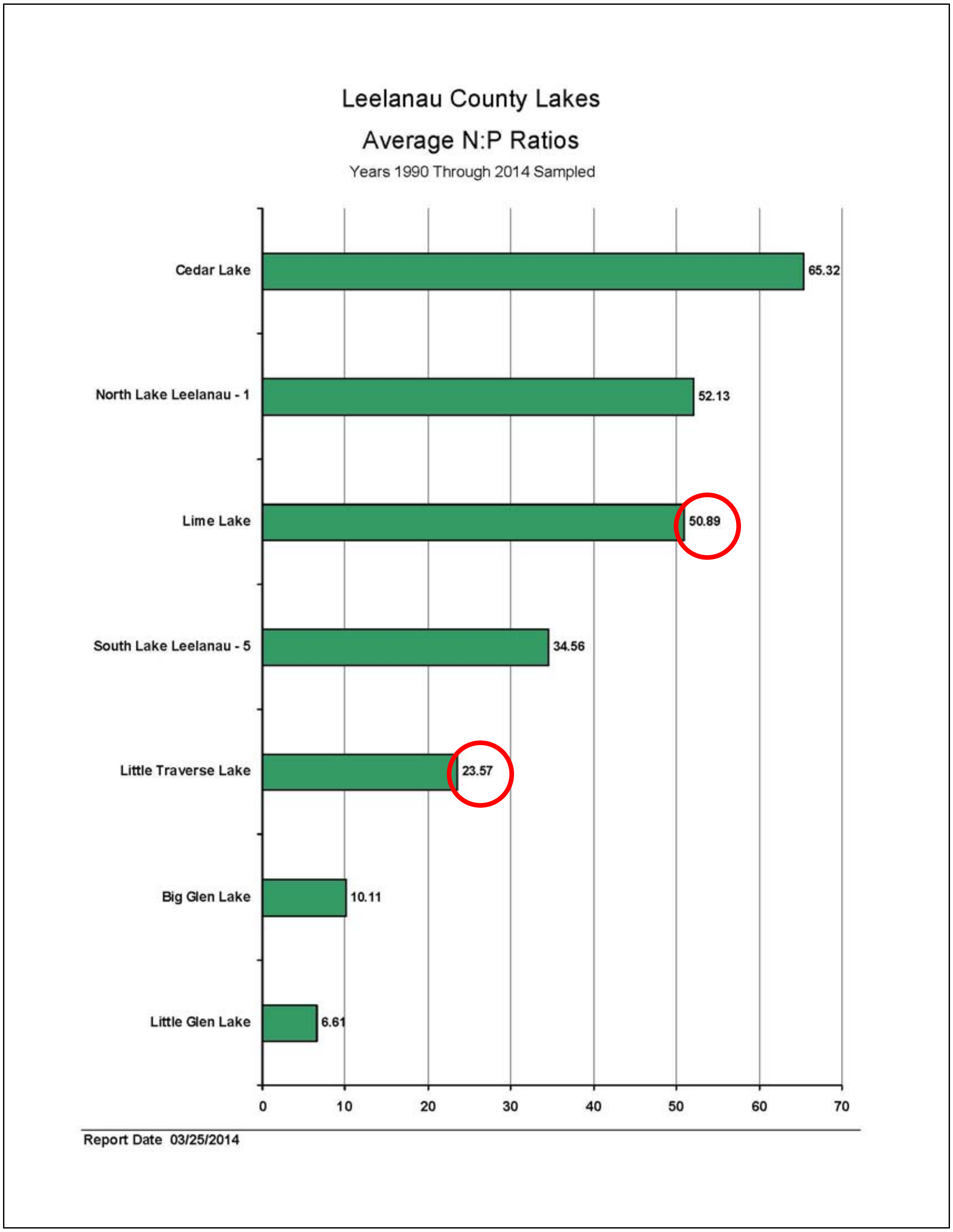


Figure 17: N:P Ratio for all Lakes in Leelanau County (1990-2014)



Lime Lake

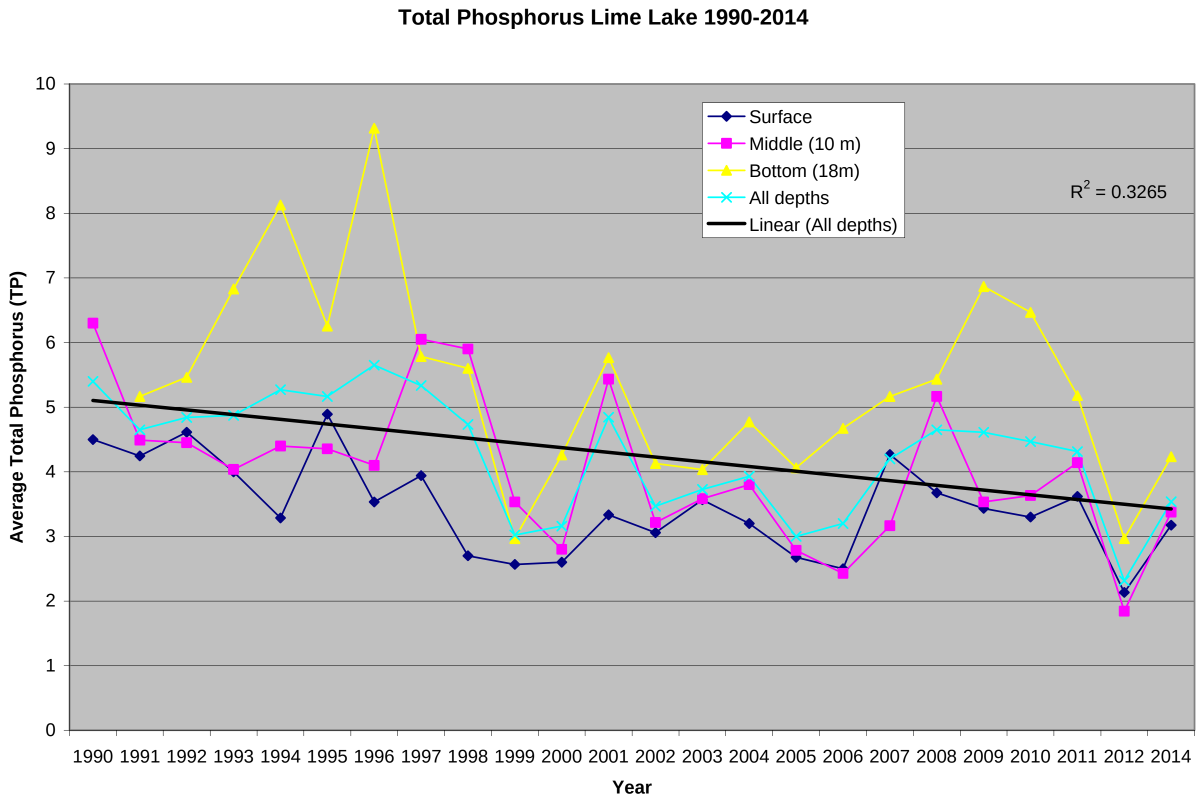
Lime lake was sampled for Total Phosphorus (TP) at three different depths 165 times for a total of 402 measurements from 1990-2014. Total Phosphorus (TP) for Lime Lake has averaged 4.3 ug/L at all depths (Table 15). This is the lowest observed average TP value for all of our lakes, placing Lime Lake in the ultra-oligotrophic range. Many who spend time in Lime Lake in the summer may notice the cloudy, lime green aspect of the water. This is due to the hard water calcareous nature of the system, and it undoubtedly results in some summertime co-precipitation of phosphorus with calcium carbonate, ultimately removing phosphorus from the system (Keilty and Woller 2002). All of the Lakes in Leelanau county experience this, but Lime Lake and nearby Glen Lake seem to be the most remarkable in this regard (Keilty and Woller 2002).

Table 15: Lime Lake Total Phosphorus (TP) and Nitrogen (NOx) results (1990-2014) at 0, 10 and the bottom (18 m), n =165

	0m	10m	18m	All depths
Parameter	***Result***	***Result***	***Result***	***Result***
TP (mg/L)	3.5	4.0	5.5	4.3
NOx (ug/L)	231.8	213.3	203.6	216.0

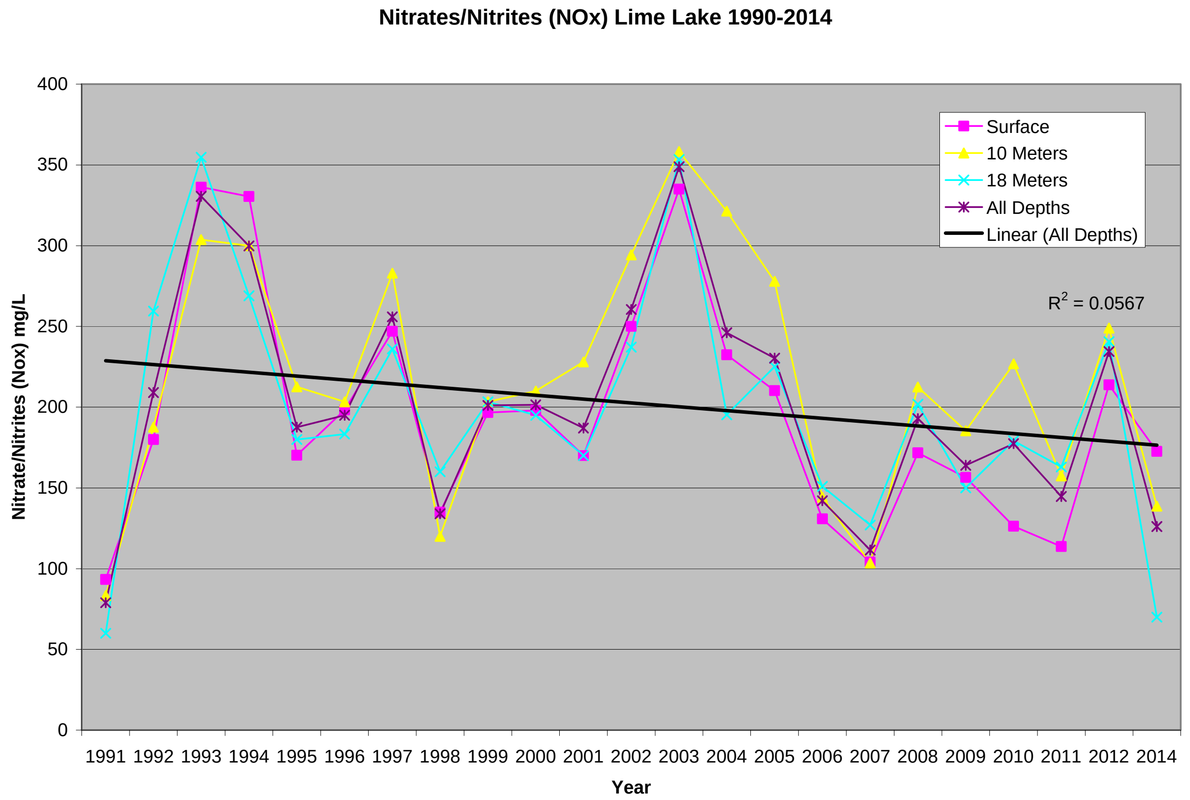
When looking at the TP values over the various depths (surface -0m, middle-10m and the bottom, 18m) from 1990-2014, there a slight decrease from 1990 (Figure 18). These levels are quite a bit higher than what was observed in Little Traverse Lake at 5.08 ug/L (Figure 20, page 90). While zebra mussel populations were observed as early as 1998 in LTL, they were not established in LTL until 2002 (Woller-Skar 2009). Efforts by riparian owners to reduce Phosphorus inputs undoubtedly have had an effect further enhanced by subsequent zebra mussel filtering.

Figure 18: Lime Lake Total Phosphorus (1990-2014)



Nitrate levels in Lime Lake averaged 215.9 ug/L for 364 observations, sampled 165 times (Table 16 above. Figure 19) resulting in an N:P ratio of 50.9. However, groundwater comprises an estimated 53% of the water coming into Lime Lake, while groundwater only comprises 16% of water coming into Little Traverse Lake (Canale and Neilsen 1997). It is believed that there are more extensive submergent weed beds in Little Traverse Lake and that these macrophytes may be assimilating much of the nitrate during the growing season (Keilty and Woller 2002).

Figure 19: Lime Lake Nitrate/Nitrites from 1990-2014



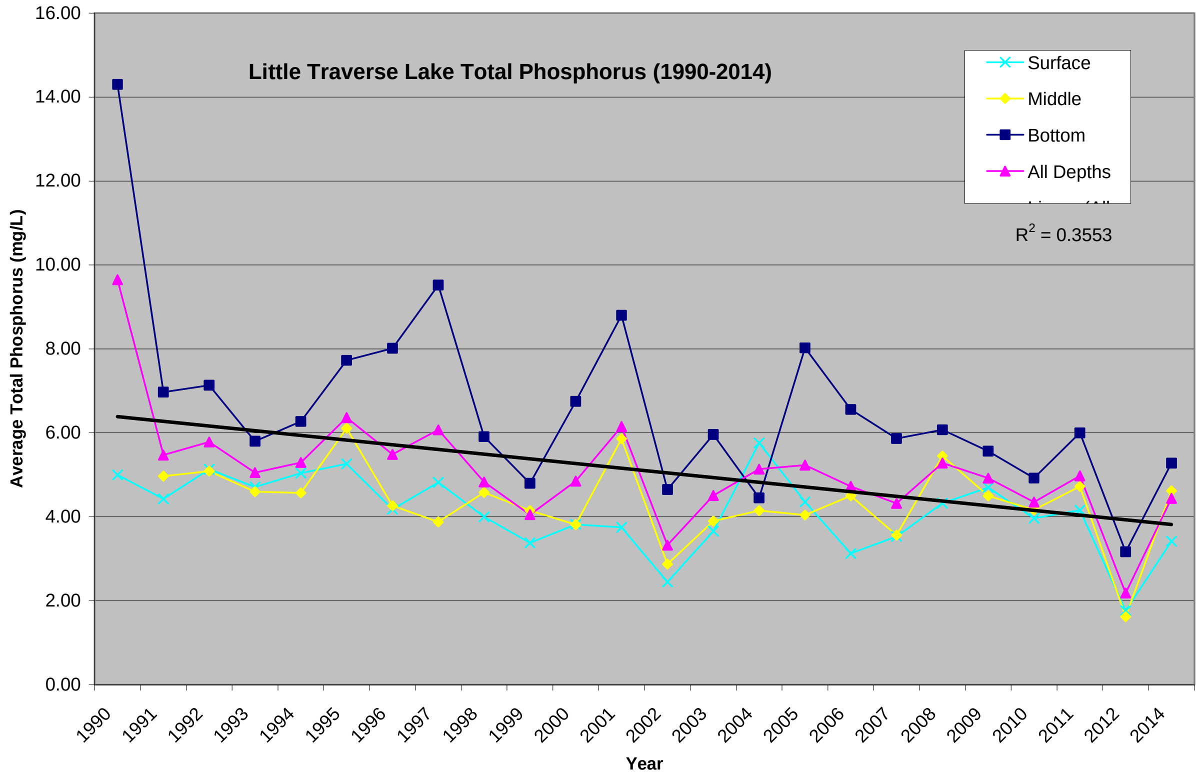
Little Traverse Lake

The Total Phosphorus (TP) in Little Traverse Lake has averaged 5.08 ug/L for 218 sampling dates for a total of 462 measurements from 1990-2014 (Table 16). By this standard, the lake would be considered oligotrophic. When looking at the average TP values over the various depths (surface -0m, middle-7m and the bottom, 12-14m) from 1990-2014, there is a slight decrease from 1990 (Figure 20).

Table 16: Little Traverse Lake TP and Nitrogen (NOx) at 0, 7 and the bottom (12-14 m) (1991-2014), n =218

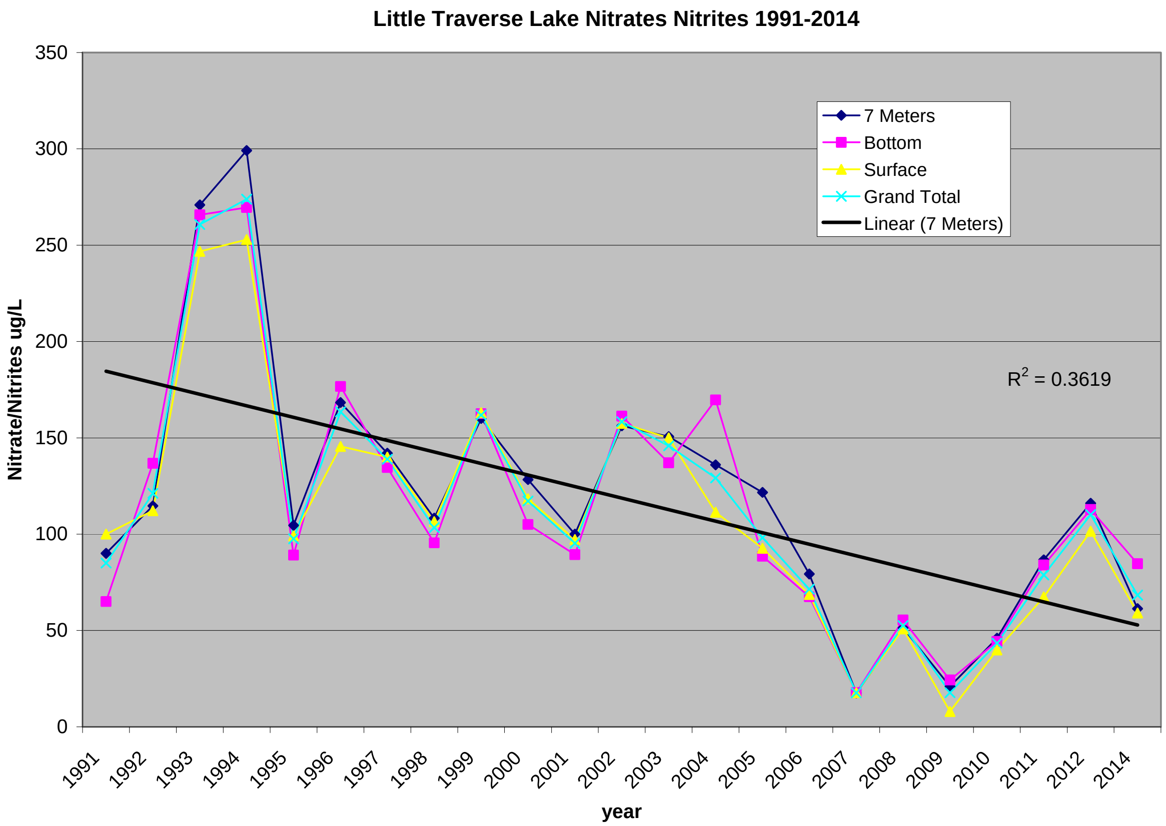
	0	7	bottom	All depths
Parameter	***Result***	***Result***	***Result***	***Result***
TP (ug/L)	6.5	4.4	4.3	5.1
NOx (ug/L)	124.7	130.0	117.6	123.8

Figure 20: Total Phosphorus Results (1990-2014) Little Traverse Lake



Nitrate nitrogen in Little Traverse Lake has average 123.8 ug/L for 218 sample dates for a total of 430 measurements from 1990-2014, resulting in an overall N:P ratio of 23.58. Levels of nitrate nitrogen have decreased with respect to time as demonstrated with the negative slope associated with the regression line (Figure 21).

Figure 21: Nitrate/Nitrites from 1990-2014 in Little Traverse Lake



Chlorophyll a

Both Lime and Little Traverse Lake are within ranges of chlorophyll a for oligotrophic lakes (0.3 – 4.5 ug/L) (Keilty and Woller, 2002) (Figures 22 & 23). The authors show decline of chlorophyll a from the water column, and attribute it to zebra mussel filtering of plankton in Little Traverse Lake, however in 2000 there was no evidence of zebra mussels in Lime Lake. By 2002 zebra mussels were noticed in Lime Lake (Woller Skar 2009).

Chlorophyll a in Lime Lake averaged 1.7 ug/L for 116 measurements from 1993-2014 (Figure 21). This is lower than the average from Keilty and Woller's data from 1990-2000 (2.58 ug/L). Chlorophyll a in Little Traverse Lake averaged 2.25 ug/L for 163 measurements from 1993-2014 (Figure 23).

Figure 22: Average Chlorophyll a for Lime Lake (1990-2014)

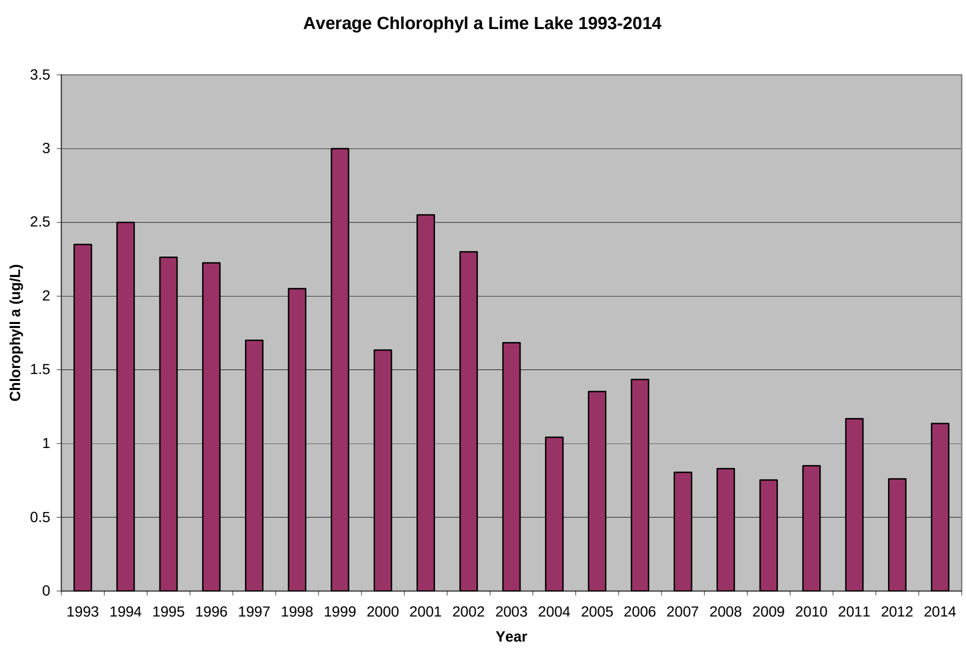
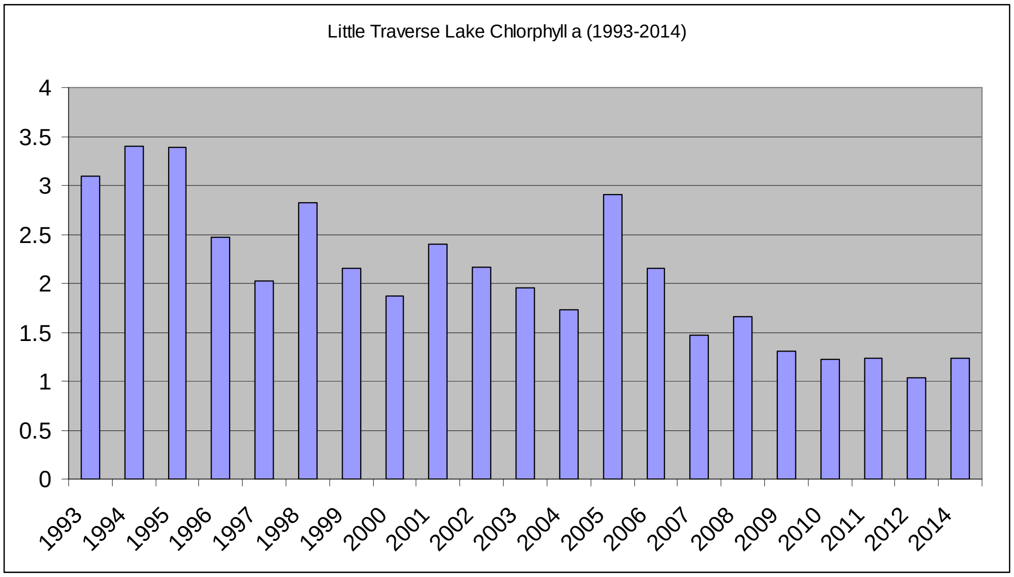


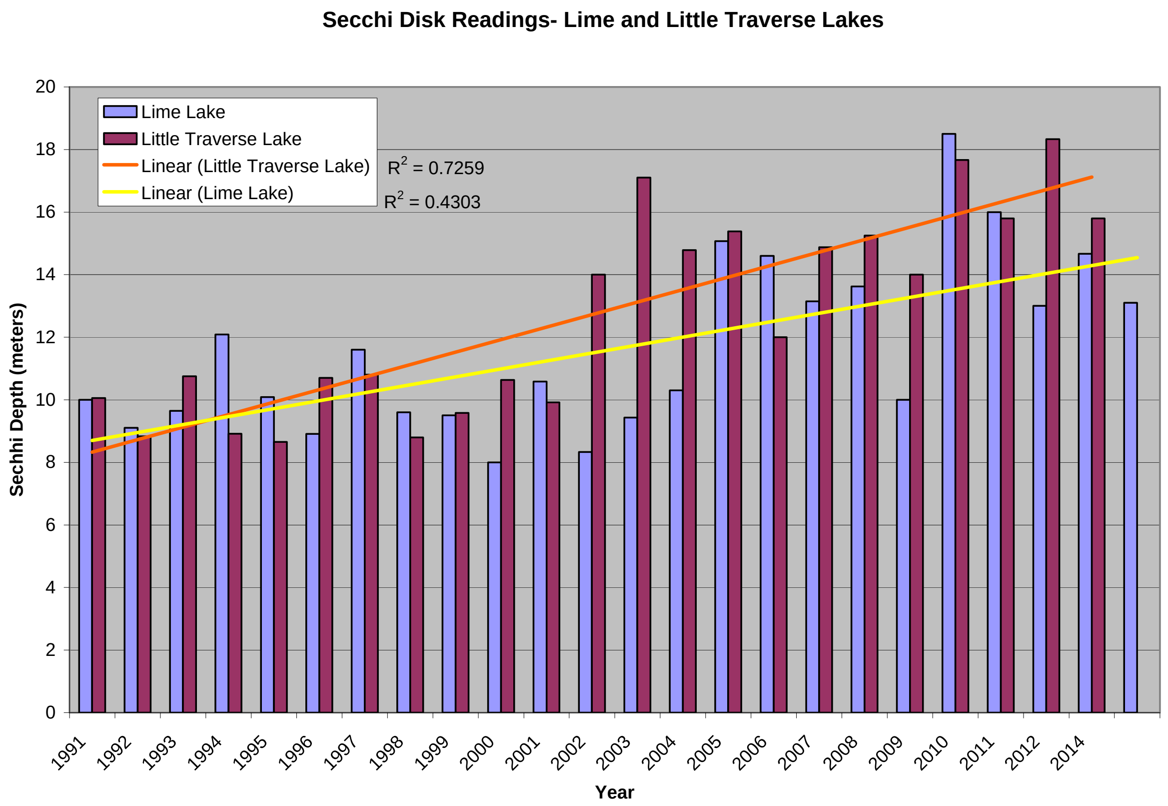
Figure 23: Average Chlorophyll a for Little Traverse Lake (1990-2014)



Secchi Disk

The Secchi disk is a measure of water transparency, which is directly linked to inorganic suspended solids and plankton abundance. Transparency and secchi disk depth measurements vary throughout year, with generally greater depths observed in spring and fall. The figure below shows average annual measurements from Lime and Little Traverse Lake from 1990-2014 which generally show an increase in secchi readings (or higher water clarity) for the averages of the two periods (Figure 24). This is mostly likely directly related to zebra mussel colonization. For example, in the spring of 2002, the secchi disc reading in Little Traverse Lake was 10m.

Figure 24: Average Secchi Disk Readings for Lime and Little Traverse Lakes (1990-2014)

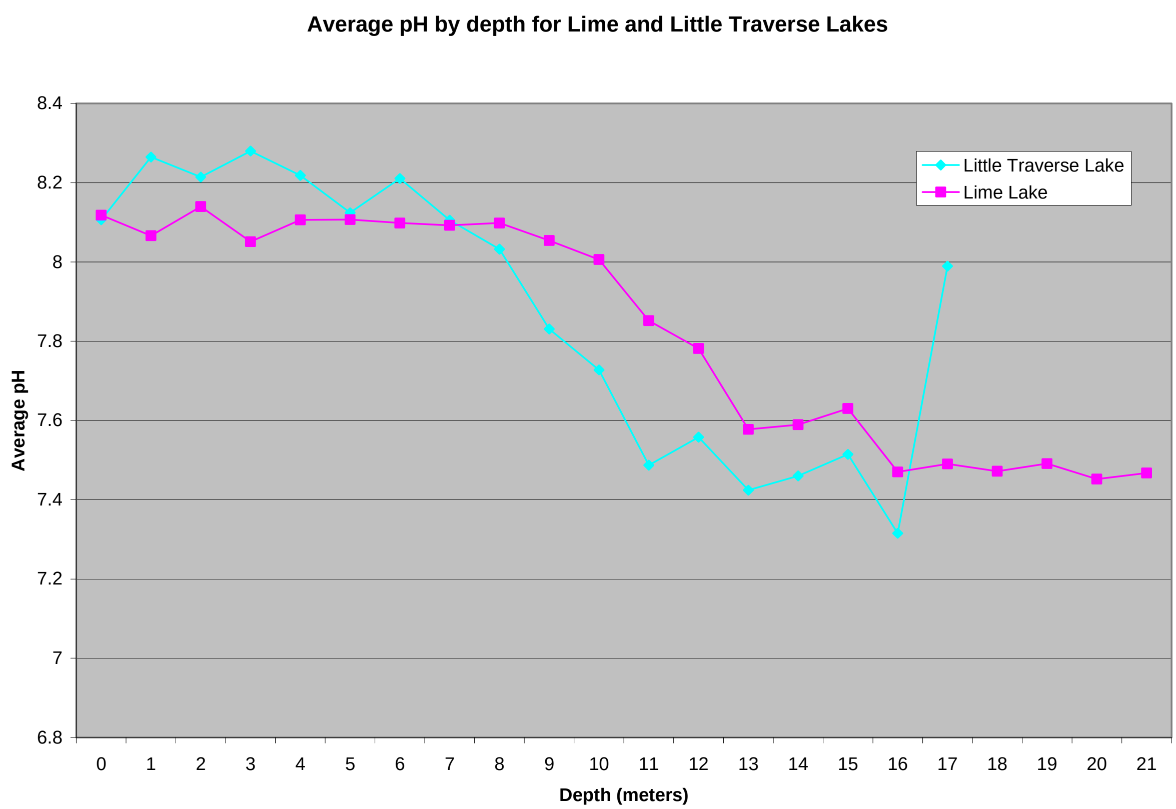


<u>General Characteristics: (Depth, Temperature, Dissolved Oxygen – DO, Conductivity, pH, Secchi Disk, Oxidation/Reduction Potential)</u>

Temperature and Dissolved Oxygen are intimately linked in northern temperate lakes such as Lime and Little Traverse Lake, because of the formation of a vertical temperature gradient during summer periods. Because cooler water is denser than warmwater it settles to the bottom of the lake. As the sun continues to heat the lake surface layer, the warm/cool water density gradient becomes too great to allow mixing of surface and bottom water. The upper layer of warmwater is called the epilimnion, the transition zone the thermocline, and the cooler bottom water the hypolimnion. This lack of vertical mixing creates environments where near-bottom oxygen can be reduced or depleted. Near bottom oxygen depletion occurs in both Lime and Little Traverse Lake. These conditions favor the release of Phosphorus from the sediments, consistent with observed data.

The pH was sampled for each of the lakes at various depths from the surface to the bottom. The pH of both Lime and Little Traverse Lake tend to stratify during the summer because of the photosynthetic activity of the plankton. The epilimnion tends to be higher, above a pH of 8.0 and the hypolimnion tends to have pH near 7.5 (Figure 25).

Figure 25: Average pH by depth (meters) for Lime and Little Traverse Lakes



Hydrolab profile data, secchi disk transparency data, and water samples have been collected 3-6 times per year on Lime Lake between 1990-2014, Water samples were collected at the surface, 10, and 18 meters, while 50 ml Chlorophyll a samples have been collected at 1 meter since 1993. Profile and water chemistry data indicate that the water quality of Lime Lake is also good and stable characteristic of a northern dimietic oligotrophic lake (Table 17) (Keilty 1997). Although consistently exhibiting oxygen depletion prior to fall overturn, the internal phosphorus input is probably small. Concentrations in the hypolimnion are elevated relative to the overlying water, particularly in the early and late summer periods and it is unlikely that a significant amount of Phosphorus precipitates when O_2 returns (Keilty 1997). The data from 1990-2014 appear as expected, normal, while higher concentrations in the early summer are more difficult to interpret.

Hydrolab profile data, secchi disk transparency data, and water samples have been collected 3-6 times per year on Little Traverse Lake between 1990-2014, Water samples were collected at the surface, 7, and 14 meters, 50 mI Chlorophyll a samples have been collected since 1993. Profile and water chemistry data indicate that the water quality of Little Traverse Lake is also good and very different from other lakes (Keilty 1997) (Table 17). Although consistently exhibiting oxygen depletion prior to fall overturn, the numbers suggest there is some internal phosphorus input from the oxygen depleted hypolimnion each summer (Keilty 1997).

Table 17: Hydrolab profile data for Little Traverse Lake and Lime Lake (1990-2012)

Lime Lake		*Little Traverse Lake*	
Parameter	**Result**	**Parameter**	**Result**
Depth ft (maximum)	67	Depth ft (maximum)	54
Depth ft (mean)	17.8	Depth ft (mean)	9.6
Temperature (F) Surface	63.9	Temperature (F) Surface	65.1
Temperature (F) Bottom	49.9	Temperature (F) bottom	55.4
Dissolved Oxygen (surface)	9.3	Dissolved Oxygen (surface)	9.29
Dissolved Oxygen (bottom)	5.5	Dissolved Oxygen (bottom)	4.4
Conductivity (surface)	0.289	Conductivity (surface)	0.318
Conductivity (deepest)	0.302	Conductivity (deepest)	0.359
pH (surface)	8.11	pH (surface)	8.10
pH (deepest)	7.46	pH (deepest)	7.4
Secchi Disc (range)	8m-18.5m	Secchi Disc (range)	8.7m-18.3m
Secchi Disc (average)	11.6m	Secchi Disc (average)	12.7m

<u>Nutrient Loading for Nitrogen and Phosphorus --</u>

A study of Leelanau County lakes, including Lime and Little Traverse Lake was completed by Canale and Nielsen (1997). The research covered the period 1992 – 1995. It quantified contributions of nitrogen and phosphorus to the lakes by atmospheric deposition, groundwater, septic systems and tributaries. Outputs included evaporation and outflows. The mass balance between inputs and outputs was assumed to remain in the sediments or ecosystem biomass. Another report by Dr. Tim Keilty and Meg Woller was written in 2002 and summarizes the water quality data for all Leelanau County Lakes from 1990-2000 (Keilty and Woller 2002). Since 2000, water quality sampling in the major lakes and tributaries has continued and a database was created in 2008. However, this data was not formally summarized in an updated report, specifically for Lime or Little Traverse Lake until the GHB watershed planning process started.

Lime Lake Nutrient Budget

Lime Lake nutrient loading is summarized in Table 18 using data from 1992-1997 (Canale and Nielsen 1997). It is estimated Lime Lake received 38,587 pounds of TN and 579 pounds of TP annually. Fourteen percent of TP input to Lime Lake is contributed by its major tributary, Lime Creek. Another 25% comes from atmospheric deposition, 18% from internal loading, 20% from groundwater, and 23% from septic systems. About 60.4% of the TN and 70% of TP are retained in the system.

Algae require about 10 times more nitrogen compared to phosphorus for growth and reproduction. The N:P ratios of both the inputs and outputs from Lime Lake are well above ten, therefore phosphorus is the limiting nutrient in Lime Lake (Neilson 1997). Approximately 70% of the phosphorus input to Lime Lake is retained in the sediments. This value is consistent with observations from other lakes with similar water quality. Approximately 74% of the phosphorus input to the lake is from either streams, groundwater, septic systems, or lake sediments. This suggests that improvements or possible future degradations in lake water quality are strongly linked to local watershed activities.

Table 18: Lime Lake Nutrient Budget

	Flow	Total Nitrogen		Total Phosphorus			N:P Ratio
	(cfs)	(ug/L)	Lb/yr	(ug/L)	Lb/yr	% Total	N:P
Lime Creek	5.31	1099	11,484	7.8	82	14	140.9
Atm Deposition	2.47		4,971		151	25	33
Septic Systems			1,670		131	23	12.7
Internal Loading			1,040		104	18	10
Groundwater	8.79	1,124	19,22	6.4	111	20	175.6
TOTAL	**16.57**		**35,587**		**579**		**66.6**
OUTPUT							
Shetland Creek	23.79	550	14,925	6.3	171		87.3
Evaporation	2.47						
Groundwater	0.31	550	336	3.6	2		152.8
TOTAL	**16.57**		**15,261**		**173**		**88.1**
NUTRIENT RETENTION			**60.4%**		**70.1%**		

Little Traverse Lake Nutrient Budget

Little Traverse Lake nutrient loading is summarized in Table 19 (Canale and Nielsen 1997). It is estimated that Little Traverse Lake received 21,024 pounds of TN and 236 pounds of TP annually. Thirty percent of TP input to Little Traverse Lake is contributed by its major tributary, Shetland Creek. Another 22% comes from atmospheric deposition, 6% from internal loading, 10% from groundwater, and 32% from septic systems.

Algae require about 10 times more nitrogen compared to phosphorus for growth and reproduction. The N:P rations of both the inputs and outputs from Little Traverse Lake are well above ten, therefore phosphorus is the limiting nutrient in Little Traverse Lake (Canale and Neilson 1997). Approximately 64% of the input to Little Traverse Lake is retained in the sediments. This value is consistent with observations from other lakes with similar water quality. Approximately 78% of the phosphorus input to the lake is from either streams, groundwater, septic systems, or lake sediments. Note that almost 1/3 of the phosphorus loading is expected from septic drain fields. This suggests that improvements or possible future degradations in lake water quality are strongly linked to local watershed activities.

Table 19: Little Traverse Lake Nutrient Budget

	Flow	***Total Nitrogen***		***Total Phosphorus***			**N:P Ratio**
INPUT	(cfs)	(ug/L)	Lb/yr	(ug/L)	Lb/yr	% Total	N:P
Shetland Creek	15.87	550	17,176	6.2	194	30	88.7
Atm Deposition	2.36		4,748		144	22	33
Septic Systems			2,649		208	32	12.7
Internal Loading			410		41	6	10
Groundwater	3.52	1573	10,896	10	69	10	157.3
TOTAL	**21.75**		**35,879**		**656**		**54.7**
OUTPUT							
Shalda Creek	19.13	551	20,743	6.2	233		88.9
Evaporation	2.36						
Groundwater	.26	551	282	6.2	3		88.9
TOTAL	**21.75**		**21,024**		**236**		**88.9**
NUTRIENT RETENTION			**41.4%**		**64.0%**		

(Canale and Neilsen 1997 report)

3.3 LIME LAKE AND LITTLE TRAVERSE LAKE SHORELINE SURVEY SUMMARY

Lime Lake Shoreline Greenbelt Survey Summary Report

Purpose

The purpose of the Lime Lake shoreline and greenbelt survey was to evaluate the current condition of the existing shoreline and to establish a baseline of shoreline conditions for future evaluations.

Background

The Good Harbor Bay Watershed plan is a work in progress. The shoreline greenbelt survey will serve as a point of information in determining recommendations and actions as part of water quality protection planning. Other watershed plans have established that major threats to high water quality are sediments from erosion and storm water runoff and nutrients from fertilizers, storm water runoff, and leaking septic systems.

Survey Method

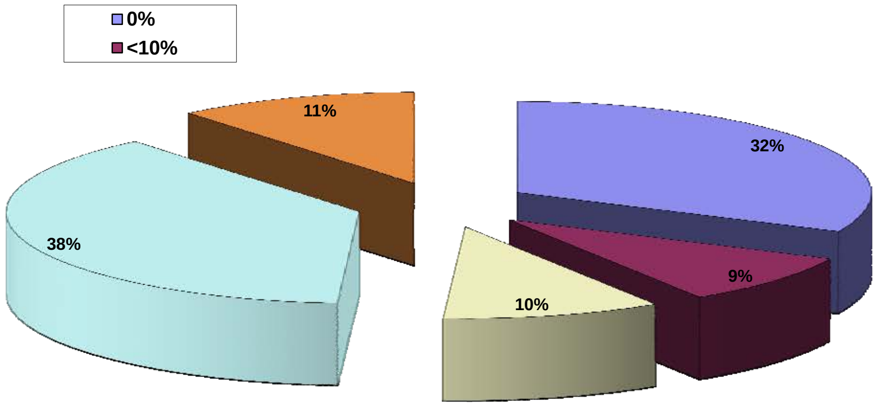
The shoreline survey of the entire Lime Lake coastline was conducted during the summer of 2013. Lime Lake is located within Cleveland Township, Leelanau County, Michigan.

All properties were surveyed with data recorded on survey sheets, including GPS readings and photos taken. Funding was provided by the Lime Lake Association.

Summary of Data

Looking at the data gathered from the Lime Lake Shoreline and Greenbelt survey, 42% of the shoreline of Lime Lake is natural and 58% is landscaped. About 66% of the shoreline of Lime Lake is developed, and only 34 % is natural. Vegetation coverage was also documented and the results show about 32% of the shoreline had no vegetation coverage (Figure 26). This could be an area of concern and where educational efforts could be focused.

Figure 26: Vegetation Coverage for Lime Lake



Little Traverse Lake Shoreline Greenbelt Survey Summary Report

The purpose of the Little Traverse Lake shoreline and greenbelt survey was to evaluate the current condition of the existing shoreline and to establish a baseline of shoreline conditions for future evaluations.

Background

The Good Harbor Bay Watershed plan is a work in progress. The shoreline greenbelt survey will serve as a point of information in determining recommendations and actions as part of water quality protection planning. Other watershed plans have established that major threats to high water quality are sediments from erosion and storm water runoff and nutrients from fertilizers, storm water runoff, and leaking septic systems.

Survey Method

The shoreline survey of the entire Little Traverse Lake coastline was conducted during the summer of 2013. Little Traverse Lake is located within Cleveland Township, Leelanau County, Michigan.

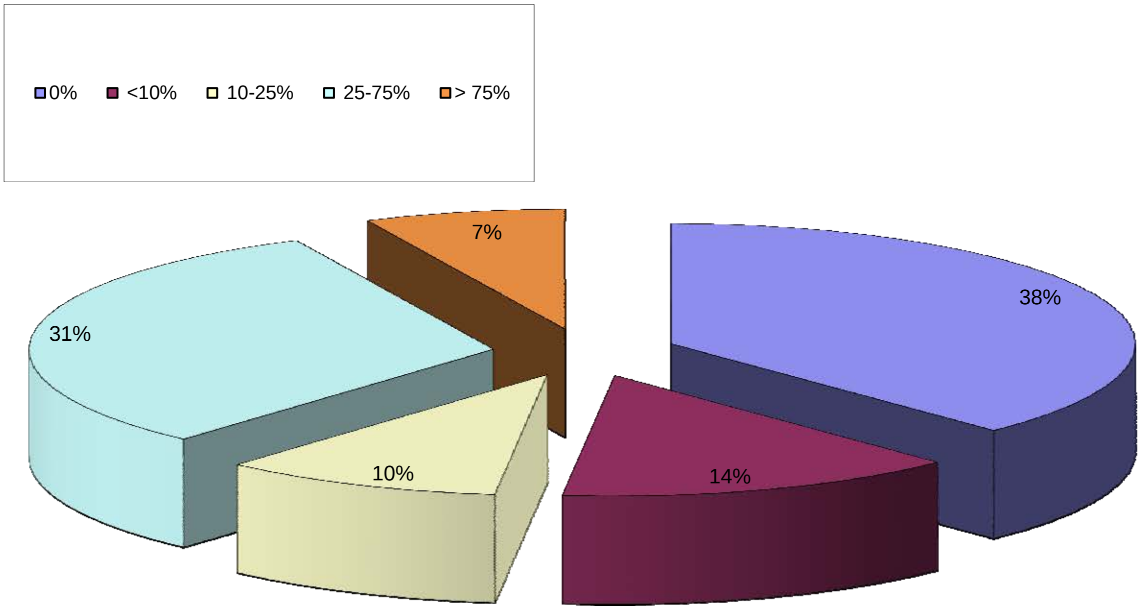
All properties were surveyed with data recorded on survey sheets, including GPS readings and photos taken. Funding was provided by the Little Traverse Lake Property Owners Association.

Summary of Data

Looking at the data gathered from the Little Traverse Lake Shoreline and Greenbelt survey, below is the summary of the study:

A) 54.5% of the shoreline of Little Traverse Lake is natural and 45.5% is landscaped
B) 51.7% of the shoreline of Little Traverse Lake is developed and 48.3% is undeveloped
C) Vegetation coverage of the shoreline of Little Traverse Lake are shown in Figure 27.

Figure 27: VEGETATION Coverage for Little Traverse Lake



3.4 SLEEPING BEAR DUNES NATIONAL LAKESHORE WATER QUALITY SUMMARY

Water resources at Sleeping Bear Dunes National Lakeshore (SLBDLNS) are abundant, diverse, and of high quality. They include 27 named inland lakes, five rivers and streams, 65 miles of Lake Michigan shoreline and nearshore waters, as well as an abundance of bogs, springs, and interdunal wetlands (see Figure 14, Page 53 for the SLDNLS boundaries within the Good Harbor Bay Watershed). Although studies of these waters precede 1940, for the purpose of this watershed management plan only the current water quality monitoring program is included. The following is a brief overview of the water quality monitoring program at SLBE.

The water quality monitoring program at SLBE is part of a larger initiative to establish consistent, scientifically sound water quality monitoring within regions of the National Park Service (NPS). Since 2007, water quality monitoring at SLBE has been done in conjunction with the NPS Great Lakes Inventory and Monitoring Network (GLKN). While developing a monitoring protocol for inland lakes a national review panel, assembled by the National Park Service – Water Resources Division, recommended a suite of five parameters be measured for all NPS monitored inland lakes. In addition to these five mandated parameters (temperature, pH, specific conductance, dissolved oxygen, and flow/water level) a measure of water clarity (Secchi depth or transparency tube depth) was added to the core suite. The core suite was ranked highest among potential vital signs for aquatic systems of GLKN parks, although it was recognized that these measurements were less diagnostic of water quality degradation than biotic communities and other water quality variables, such as nutrient concentrations.

Inputs of excess nutrients, invasion and spread of exotic species, and contaminants from atmospheric fallout and surface runoff, and how these stressors affect the chemical and biological functions of lakes are key issues of concern to the NPS. By monitoring an advanced suite of parameters (nitrogen and phosphorus species, dissolved organic carbon, major ions, dissolved silica, and chlorophyll-a), data can be collected for a more thorough understanding of changes in lakes over time. The primary objective of this monitoring program is to monitor water quality in order to describe the current status and to detect trends of common limnological parameters within sampled lakes. The hope is to be able to provide early warnings of change, work with researchers to understand the causes of change, and provide interpretation of our results to the public.

Starting in 2007, SLBDNL has focused its water quality monitoring efforts on ten inland lakes: Manitou, Florence, Shell Tucker, Narada Bass Loon, Round, Otter, and North Bar. Each lake, excluding Narada, is sampled three times during the field season by park natural resources staff. At each lake a multi-probe datasonde is used to collect depth profiles of temperature, pH, conductivity, and dissolved oxygen. Additional measurements recorded on-site include water clarity, water level relative to a benchmark, and a list of physical and environmental conditions. Additionally, water samples are collected and shipped to a contract laboratory facility for analyses of the advanced suite of parameters, including: nutrients (total phosphorus, total nitrogen, nitrate+nitrite-nitrogen, ammonium-nitrogen, dissolved silica), major ions (calcium, sodium, magnesium, potassium, sulfate, and chloride), dissolved organic carbon, alkalinity, and chlorophyll-a.

Of the 27 inland lakes at least partially within the SLBDNL boundary, very few fall within the Good Harbor Bay Watershed. In fact, Shell and Bass Lakes are the only inland lakes within the watershed that is part of the water quality monitoring program at SLBDNL. . All the information collected through SLBE's inland lakes water quality monitoring program is submitted to the U.S. Environmental Protection Agency (EPA) and made available to the public through the EPA's STORET database. For additional information on natural resources within the National Lakeshore, please visit the SLBE website at: www.nps.gov/slbe.