Round Lake Shoreline Survey 2014

By Tip of the Mitt Watershed Council

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SUMMARY

Shoreline property management practices can negatively impact water quality and lake ecosystem health. Greenbelts provide many benefits to the lake ecosystem, which are lost when shoreline vegetation is removed. Erosion and shoreline alterations (seawalls, rip-rap, etc.) both have the potential to degrade water quality. Nutrients are necessary to sustain a healthy aquatic ecosystem, but excess inputs from shoreline properties can adversely impact an aquatic ecosystem.

In early June of 2014, the Tip of the Mitt Watershed Council surveyed Round Lake to document and assess shoreline conditions. The following parameters were surveyed for all individual properties: *Cladophora* algae as a biological indicator of nutrient pollution, greenbelt status, erosion, alterations (e.g. seawalls, riprap), nearshore substrate types, and stream inlets and outlets. The survey was funded by the Michigan Department of Environmental Quality Nonpoint Source Program as a step in the development of a nonpoint source pollution management plan for the Burt Lake Watershed.

Survey results provide evidence of poor riparian property management practices that have the potential to degrade the Round Lake ecosystem. Greenbelts were found to be in poor or very poor condition at 44% of shoreline properties. Moderate to severe erosion was documented at 27% of properties and shoreline alterations were noted at 44%. On a positive note, 21% of greenbelts were in excellent condition. In addition, there was little evidence of nutrient pollution; moderate-density *Cladophora* growth was found at just 1 property and no heavy growth was found. Relative to other lakes in the region, Round Lake had high percentages of properties with erosion and poor greenbelts and low percentages with heavy *Cladophora* and altered shorelines.

Numerous best management practices help minimize negative impacts to water quality. Maintaining a buffer of diverse, native plants along the shoreline helps filter pollutants and reduce erosion. Rain barrels, rain gardens, grassy swales, and many other techniques mitigate stormwater runoff impacts. Improving shoreline property management will help protect water quality, strengthen fisheries, and improve the quality of life and recreation on the lakes.

To achieve the full value of this survey, these follow-up actions are recommended: 1) Educate riparian property owners about best management practices that protect water quality; 2) Send survey summaries to all shoreline residents, along with information about what each person can do to help; 3) Contact property owners confidentially to encourage them to participate in identifying and rectifying any problems that exist on their property; and 4) Organize informational sessions to present survey results and best management practices that help protect and improve lake water quality.

INTRODUCTION

Background

Shoreline surveys are an important lake management tool used extensively on lakes in the Northern Lower Peninsula of Michigan. These surveys involve assessing shoreline properties to document conditions or activities that have the potential to affect water quality and the lake ecosystem. Shoreline surveys commonly include an assessment of: *Cladophora* algae growth as a nutrient pollution indicator, erosion, alterations (e.g., seawalls), greenbelts (i.e., shoreline vegetation), emergent aquatic plants, wetlands, and tributary inlets and outlets. Periodic repetition of shoreline surveys is important for: identifying both new and chronic problem sites; determining long-term trends in near-shore nutrient inputs, greenbelts, erosion, and shoreline alterations associated with land-use changes; and assessing the success of remedial actions.

During early June of 2014, the Tip of the Mitt Watershed Council completed a comprehensive survey of the Round Lake shoreline. This survey, the first carried out on Round Lake, was funded by the Michigan Department of Environmental Quality Nonpoint Source Program as a step in the development of a nonpoint source pollution management plan for the Burt Lake Watershed. Follow-up actions are necessary to address problems in shoreline areas identified during the survey. Solutions, such as shoreline plantings and rain garden installation are generally simple and low cost. Prevention of problem situations can also be achieved through outreach and education associated with the survey.

Shoreline Development Impacts

Lake shoreline properties are the critical interface between land and water; where human activity has the highest potential for degrading water quality. Developing shoreline properties for residential, commercial or other uses invariably affects the lake ecosystem. During the development process, the natural landscape is altered in a variety of ways: vegetation is removed; the terrain is graded; utilities are installed; structures are built; and areas are paved. These changes to the landscape and subsequent human activity in the shoreline area have consequences on the aquatic ecosystem. Nutrients from wastes, contaminants from cars and roads, and soils from

eroded areas are among some of the pollutants that end up in and negatively impact the lake following shoreline development.

Nutrients are necessary to sustain a healthy aquatic ecosystem, but excess can result in nuisance and potentially harmful algal and aquatic plant growth. Excessive aquatic macrophyte growth (i.e., vascular aquatic plants) and heavy algal blooms that form mats and scum at the lake's surface can become a recreational nuisance. Algal blooms also pose a public health risk as some species produce toxins, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system). Furthermore, excess algal and aquatic plant growth can degrade water quality by depleting the ecosystem's dissolved oxygen stores. Nighttime respiration, wherein plants compete with other organisms for a limited oxygen supply, coupled with the decomposition of dead algae and plant material by aerobic bacteria, reduces a water body's dissolved oxygen stores. This is particularly problematic in the deeper waters of stratified lakes.

Small lakes, such as Round Lake, are generally less resilient to water quality impacts caused by nutrient pollution than large lakes because small lakes have less water volume and therefore, reduced capacity for diluting pollutants and storing dissolved oxygen. However, the shallow nature of Round Lake reduces stratification, which allows for frequent mixing of the water column and replenishment of dissolved oxygen stores.

Surface waters receive nutrients through a variety of natural and cultural (human) sources. Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff from riparian areas, and atmospheric deposition. Springs, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter and riparian wetlands can discharge nutrients during wet weather. Cultural sources include septic and sewer systems, fertilizer application, and stormwater runoff from roads, driveways, parking lots, roofs, and other impervious surfaces. Poor agricultural practices, soil erosion, and wetland destruction also contribute to nutrient pollution. Furthermore, some cultural sources (e.g., leaking sewer systems and animal wastes) pose a potential health risk due to exposure to bacteria and viruses.

Severe nutrient pollution is detectable through chemical analyses of water samples, physical water measurements, and the utilization of biological indicators (a.k.a., bio-indicators). Chemical analyses of water samples to check for nutrient pollution can be effective, though costlier and more labor intensive than other methods. Typically, water samples are analyzed to determine nutrient concentrations (usually forms of

phosphorus and nitrogen), but other chemical constituent concentrations can be measured, such as chloride, which are related to human activity and often elevated in areas impacted by malfunctioning septic or sewer systems. Physical measurements are primarily used to detect malfunctioning septic and sewer systems, which can cause localized increases in water temperature and conductivity (conductivity measures the water's ability to conduct an electric current, which is determined by the concentration of charged particles). Biologically, nutrient pollution can be detected along the lake shore by noting the presence of *Cladophora* algae.

Cladophora is a branched, filamentous green algae that occurs naturally in small amounts in Northern Michigan lakes. Its occurrence is governed by specific environmental requirements for temperature, substrate, nutrients, and other factors. *Cladophora* is found most commonly in the wave splash zone and shallow shoreline areas of lakes, and can also be found in streams. It grows best on stable substrates such as rocks and logs, though artificial substrates such as concrete or wood seawalls are also suitable. *Cladophora* prefers water temperatures in a range of 50 to 70 degrees Fahrenheit, which means that the optimal time for its growth and thus, detection, in northern Michigan lakes is during the months of May, June, September, and October.

The nutrient requirements for *Cladophora* to achieve large, dense growths are typically greater than the nutrient availability in Northern Michigan lakes. Therefore, shoreline locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake can be identified by noting the presence of *Cladophora*. *Cladophora* growth features are greatly influenced by such factors as current patterns, shoreline topography, size and distribution of substrate, and the amount of wave action on the shoreline. Therefore, the description has limited value when making year to year comparisons at a single location or estimating the relative amount of shoreline nutrient inputs. Rather, the presence or absence of any significant growth at a single site over several years is the most valuable comparison. It can reveal the existence of chronic nutrient loading problems, help interpret the cause of the problems, and assess the effectiveness of any remedial actions. Comparisons of the total number of algal growths can reveal trends in nutrient inputs due to changing land use.

Erosion along the shoreline has the potential to degrade a lake's water quality. Stormwater runoff through eroded areas and wave action along the shoreline carries sediments into the lake and negatively impacts the lake ecosystem in a variety of ways. Sediments clog the gills of fish, aquatic insects and other aquatic organisms. Excessive

sediments smother fish spawning beds and fill interstitial spaces that provide habitat for a variety of aquatic organisms. While moving through the water column, sediments absorb sunlight energy and increase water temperatures. In addition, nutrients adhere to sediments that wash in from eroded areas.

Shoreline greenbelts are essential for maintaining a healthy aquatic ecosystem. A greenbelt consisting of a variety of native woody and herbaceous plant species provides habitat for near-shore aquatic organisms as well as terrestrial animals. Greenbelts naturally function to control erosion by stabilizing the shoreline with plant root structures that protect against wave action and ice. The canopy of the greenbelt provides shade to near-shore areas, which helps to maintain cooler water temperatures and higher dissolved oxygen levels. In addition, greenbelts provide infiltration to reduce overland surface flow carried by stormwater from rain events and snowmelt, as well as filtration of pollutants.

Shoreline property development often results in altering or hardening the lake shoreline. Seawalls, riprap, groins, boathouses, and beach sand are among the most common shoreline alterations utilized to control erosion or improve recreational lake access and use. These changes to the shoreline also entail the loss of shoreline vegetation and myriad benefits associated with greenbelts. Of particular concern is the habitat loss in critical shoreline areas brought on by shoreline alterations.

Tributary streams influence a lake's water quality because they are the primary conduit of water and water-borne pollutants. Inlet streams may provide exceptionally high quality waters that benefit the lake ecosystem, but conversely have the potential to deliver contaminants from throughout the watershed and pollute the lake. Outlet streams flush water out of the lake, providing the means to expel contaminants that have accumulated in the lake ecosystem. The relatively higher nutrient levels in streams, relative to lakes, is important when assessing shore survey data because *Cladophora* growth is often heavier in shoreline areas adjacent to inlet tributaries.

Responsible, low-impact, shoreline property development and management is paramount for protecting water quality. Maintaining a healthy greenbelt, stormwater control with rain gardens, correcting erosion sites, and eliminating fertilizer and pesticide application are among many low-cost best management practices that minimize negative impacts of shoreline property management on lake water quality. Responsible stewardship on the part of shoreline property owners and living in harmony with the lake is vitally important for sustaining a healthy and thriving lake ecosystem.

Study Area

Round Lake is located in the northern Lower Peninsula of Michigan in Emmet County, less than one mile east of Little Traverse Bay. The surface area of Round Lake is approximately 360 acres and the shoreline distance totals four miles (Emmet County GIS, 2012). Round Lake is in northern Bear Creek Township. Developed lakefront properties are served by a sanitary sewer system maintained by the Harbor Springs Area Sewer Authority.

Round Lake consists of a single basin in the shape of a rounded equilateral triangle that measures approximately one mile per side. It' deepest location, in the middle of the basin, is 15 feet. Residential development exists along the lake's mid-western, mid-eastern, and mid-northern shorelines, while the rest of the lake is largely undeveloped.

A small unnamed creek limited to 1000 feet in length flows into the southern tip of Round Lake. This inlet tributary delivers water from Mud and Spring Lakes, which receive polluted runoff from adjacent urban development. Iduna Creek is the only outlet, flowing out of Round Lake's eastern terminus and into the east side of Crooked Lake via 1.25 miles of stream channel.

The Round Lake Watershed extends approximately 3.5 miles from near the Harbor Springs Municipal Airport to the north to the top of a morainal ridge along Country Club Road to the east of the City of Petoskey. Large sand dunes in Petoskey State Park limit the watershed's western expansion (Figure 1). The watershed covers 2,367 acres; approximately 400 acres pertaining to the Mud and Spring Lakes Watershed. Most of the Round Lake Watershed is in Bear Creek Township, with the portion north of Powell Road in Little Traverse Township.

Land cover statistics for the Round Lake Watershed were generated using remotely sensed data from the Coastal Great Lakes Land Cover project (Table 1). Based on 2010 data, a large portion of the watershed's land cover is natural, consisting of forest, grasslands, and wetlands. Of land cover types that typically lead to water quality degradation, there is a moderate amount of urban/residential (15.3%) and agricultural (21.8%) land cover in the watershed. During the 25 year period between 1985 and 2010, agricultural lands decreased slightly (-0.6%) while urban land cover increased (4.6%).

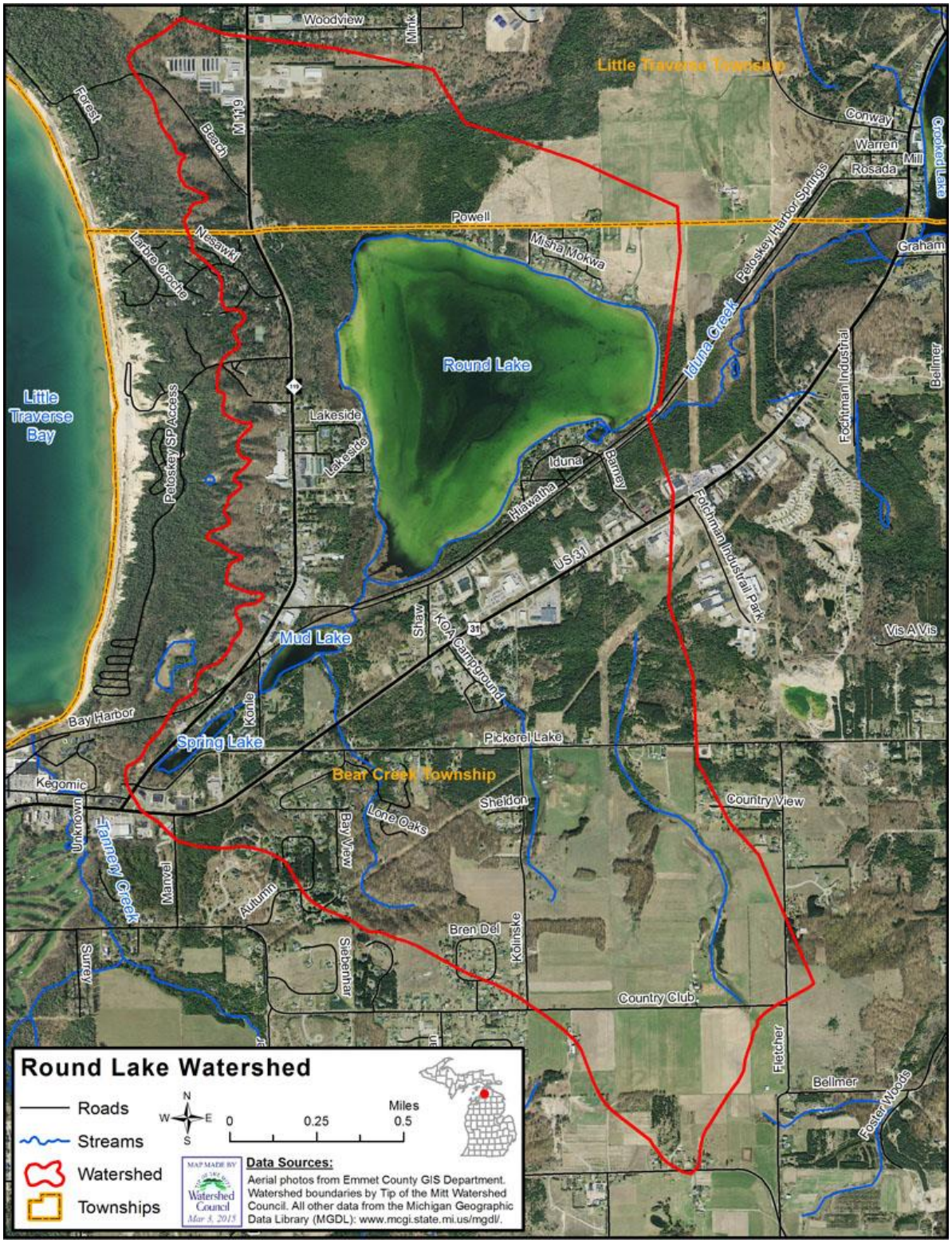


Figure 1. Map of the Round Lake Watershed.

Table 1. Round Lake Watershed land cover statistics (NOAA 1985, 2010).

Land Cover Type	1985 acres	1985 percent	2010 acres	2010 percent	Change (acres)	Change (percent)
Agriculture	528.6	22.3	515.4	21.8	-13.3	-0.6
Barren	2.9	0.1	15.0	0.6	12.1	0.5
Forest	516.8	21.8	516.6	21.8	-0.2	0.0
Grassland	223.6	9.4	111.1	4.7	-112.5	-4.8
Scrub/Shrub	39.8	1.7	48.2	2.0	8.5	0.4
Urban	253.8	10.7	362.5	15.3	108.8	4.6
Water	382.7	16.2	383.6	16.2	0.9	0.0
Wetland	418.8	17.7	414.6	17.5	-4.2	-0.2
TOTAL	2367.0	100.0	2367.0	100.0	ND	ND

Based on water quality data collected in programs coordinated by Tip of the Mitt Watershed Council, Round Lake contains high quality waters typical for this region. As part of the Watershed Council's Comprehensive Water Quality Monitoring Program (CWQM), numerous parameters have been monitored in Round Lake on a triennial basis since 1995. Both dissolved oxygen and pH consistently comply with standards established by the State of Michigan (Table 2). Chloride levels have increased slightly over time, which indicates some degree of impacts from urban, residential and agricultural land use (Figure 2). Typical of high-quality lakes in Northern Michigan, nutrient concentrations on Round Lake are very low. CWQM program data show low phosphorus levels in Round Lake, less than 10 micrograms per liter (µg/L), which have declined consistently since 1995 (Figure 3). Phosphorus is found in short supply in Round Lake relative to nitrogen and therefore, limits the amount of algae and plant growth that occurs in the lake.

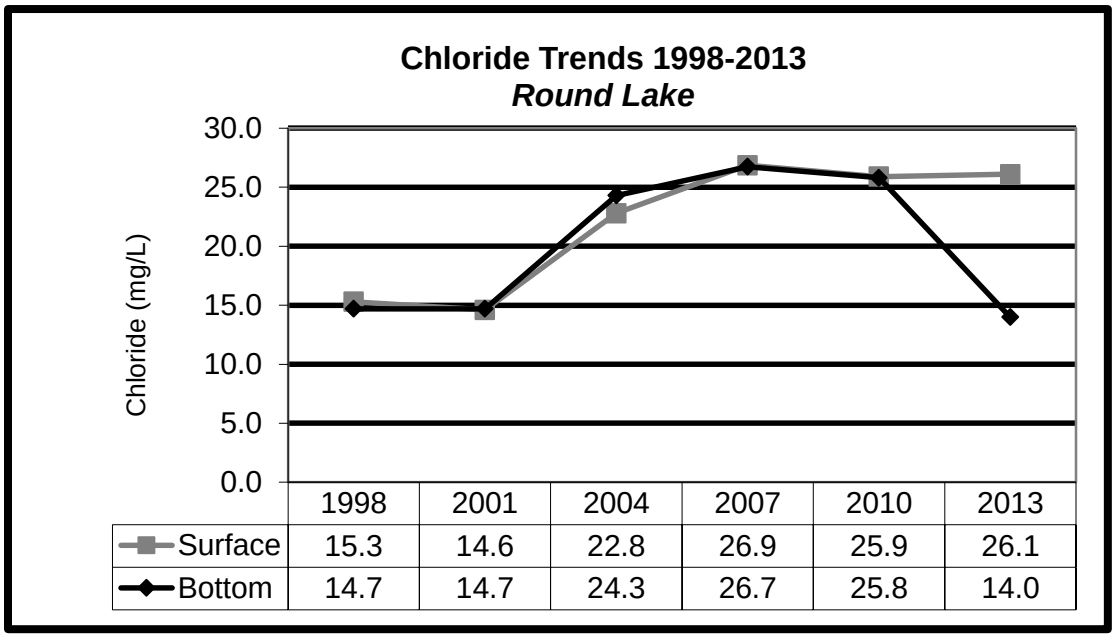
Table 2. Round Lake data from the CWQM program, 1995-2013.

	Dissolved Oxygen	pH	Specific Conductivity	Chloride	Nitrate-Nitrogen	Total Nitrogen	Total Phosphorus
Units*	**mg/L**	**Units**	**µS/cm²**	**mg/L**	**µg/L**	**µg/L**	**µg/L**
Average	11.6	8.3	297	21.0	54.5	500	7.3
Minimum	9.4	7.7	263	14.0	16.7	307	2.9
Maximum	13.6	8.6	328	26.9	88.0	739	11.1

**mg/L = milligrams per liter or parts per million, µg/L = micrograms per liter or parts per billion, µS/cm2 = microSiemens per centimeter squared.*

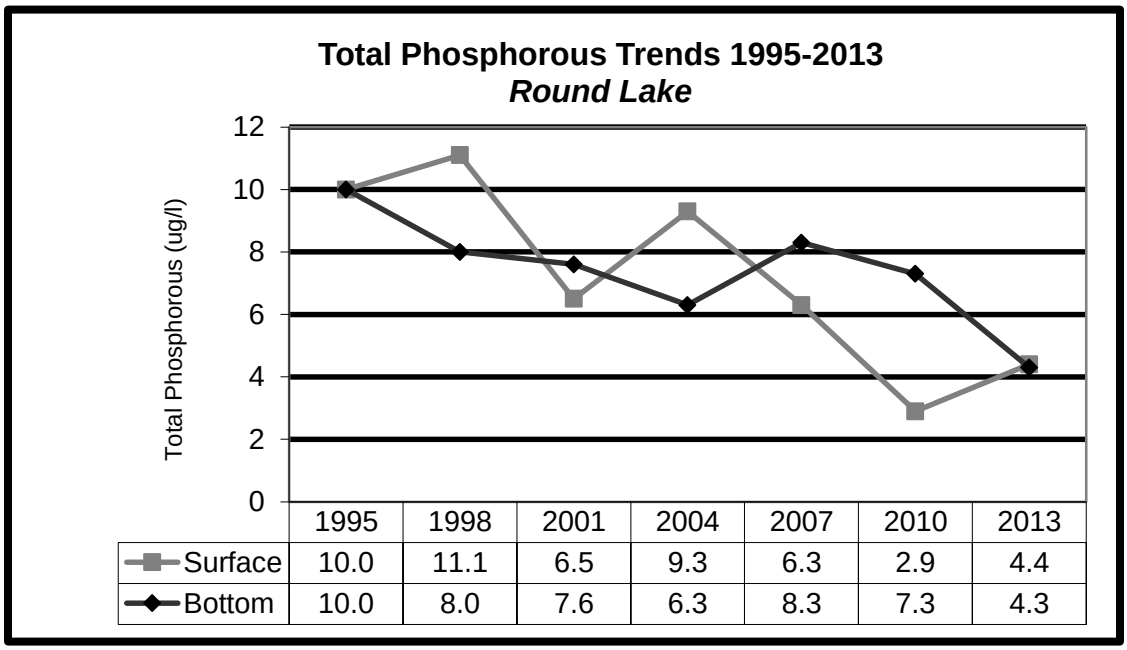
Data from Tip of the Mitt Watershed Council's Volunteer Lake Monitoring Program show Round Lake to be a moderately productive lake. Water clarity was fairly stable

during the period it was monitored, ranging from 9 to 13 feet (Figure 4). Trophic Status Index values calculated using water clarity data from 1997 to 2003 ranged from 40-46, indicating that Round Lake is mesotrophic (Figure 5). Mesotrophic lakes are characterized as having moderate amounts of dissolved nutrients, which typically results in moderate biological productivity in terms of aquatic plants, invertebrates, and fish.



	1998	2001	2004	2007	2010	2013
Surface	15.3	14.6	22.8	26.9	25.9	26.1
Bottom	14.7	14.7	24.3	26.7	25.8	14.0

Figure 2. Chloride concentrations in Round Lake.



	1995	1998	2001	2004	2007	2010	2013
Surface	10.0	11.1	6.5	9.3	6.3	2.9	4.4
Bottom	10.0	8.0	7.6	6.3	8.3	7.3	4.3

Figure 3. Total phosphorus concentrations in Round Lake.

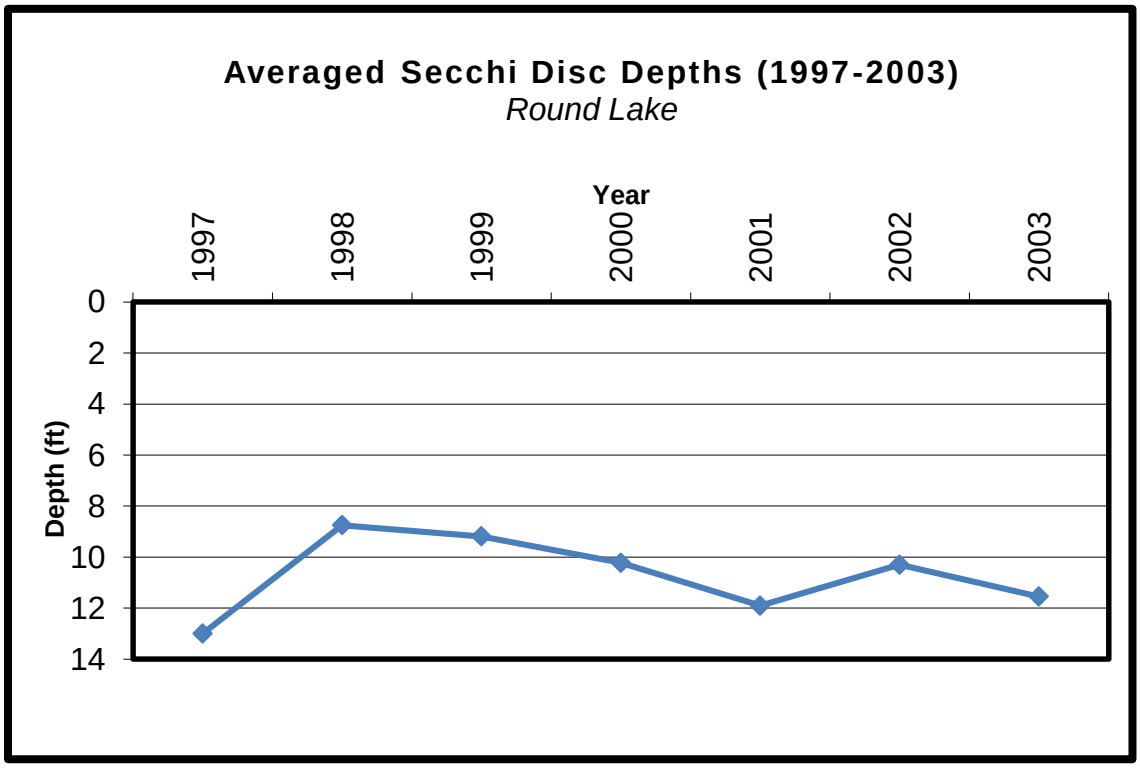
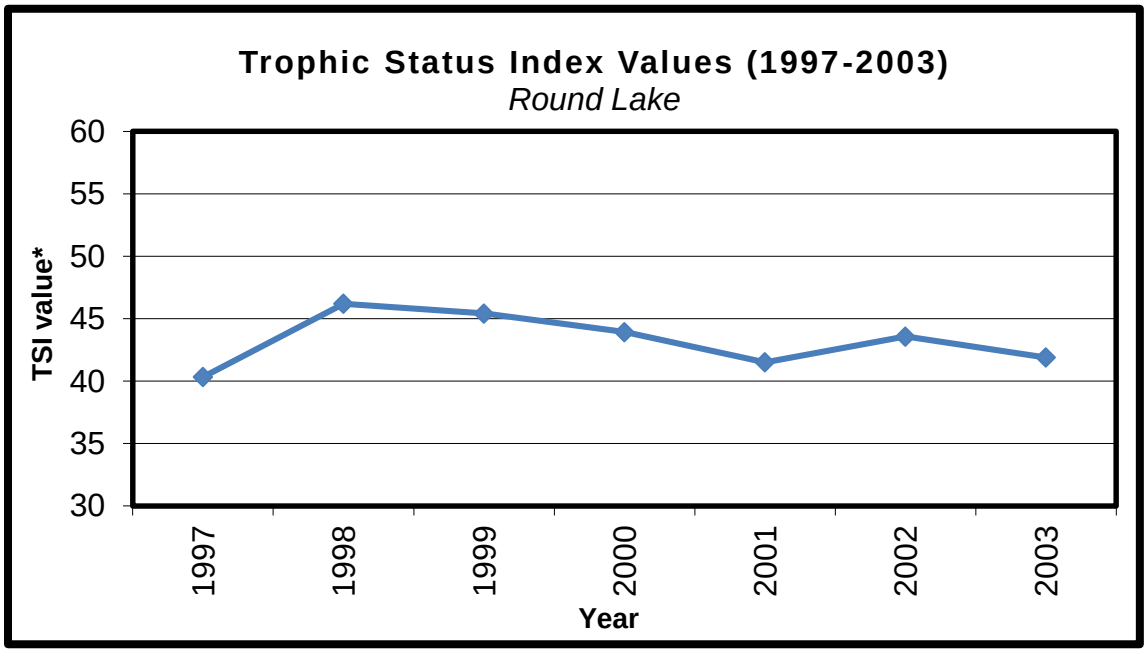


Figure 4. Water transparency in Round Lake.



**0-38 = oligotrophic or low productive system, 39-49 = mesotrophic or moderately productive system, and 50+ =eutrophic or highly productive system*.

Figure 5. Trophic Status Index values for Round Lake.

METHODS

The Round Lake shoreline was comprehensively surveyed in early June of 2014 to document conditions and activities at every lakeshore property that potentially impact water quality. Shoreline conditions were surveyed by traveling in kayak as close to the shoreline as possible (usually within 20 feet) and noting *Cladophora* growth, substrate type, erosion, greenbelt health, shoreline alterations, emergent aquatic plants, and tributary streams. Information for each property was recorded on field datasheets, subsequently inputted into a database, and used in conjunction with GPS data to link field data and photographs with property owner data from county equalization records. In addition, all shoreline properties were photographed with a GPS camera.

Field Survey Parameters

Shoreline property features were documented by noting physical features on a datasheet, such as building descriptions, public access sites, and county road endings, as well as with photographs. Due to datasheet space limits, building descriptions were recorded in an abbreviated cryptic style. For example, *Red 2 sty, brn rf, wht trm, fldstn chim, lg pine* signifies that the property has a red two-story house with a brown roof, white trim, fieldstone chimney, and a large pine tree in the yard. Whenever possible, names of property owners and addresses were included.

Developed parcels were noted on field datasheets and included as a separate column in the database. Properties described as developed indicate the presence of buildings or other significant permanent structures, including roadways, boat launching sites, and recreational properties (such as parks with pavilions and parking lots). Properties with only mowed or cleared areas, seasonal structures (such as docks or travel trailers), or unpaved pathways were not considered developed. Additionally, large parcels that had structures in an area far from the water's edge were not considered developed. The length and area of developed versus undeveloped shoreline was not calculated.

Cladophora algae growth observed in the nearshore area was noted on field datasheets. Many species of filamentous green algae are commonly found growing in the nearshore regions of lakes and positive identification of these species usually requires the aid of a microscope, but *Cladophora* usually has an appearance and texture that is quite distinct. Surveyors were trained to recognize these traits, which were the sole criteria upon

which identification was based. Other species of filamentous green algae can respond to an external nutrient source in much the same way as *Cladophora*, though their value as an indicator species is not thought to be as reliable. When other species occurred in especially noticeable, large, dense growths, they were recorded on the datasheets and described the same as those of *Cladophora*.

When *Cladophora* was observed, it was described in terms of the length of shoreline with growth, the density of growth, and any observed shoreline features potentially contributing to the growth. For example, "MHx30' – seeps" denotes an area of moderate to heavy *Cladophora* growth along approximately 30 feet of the shoreline with groundwater seeps in the vicinity suspected of contributing to the growth. Both shoreline length and growth density were subjective estimates. Growth density is determined by estimating the percentage of substrate covered with *Cladophora* using the following categorization system:

Table 3. Categorization system for *Cladophora* density.

Density Category	**Field Notation**	**Substrate Coverage**
Very Light	(VL)	0% *
Light	(L)	1- 20%
Light to Moderate	(LM)	21-40%
Moderate	(M)	41-60%
Moderate to Heavy	(MH)	61-80%
Heavy	(H)	81-99%
Very Heavy	(VH)	90-100% *

**Very Light is noted when a green shimmer is noticed on hard substrate, but no filamentous growth present. Very Heavy overlaps with heavy and is distinguished by both high percentage of substrate coverage and long filamentous growth.*

Nearshore substrate types were noted during the survey because, among other things, the distribution and size of each *Cladophora* growth is dependent on the amount of suitable substrate present. Therefore, the extent of suitable substrate has to be taken into account when interpreting the occurrence of individual growths, and assessing the overall distribution of *Cladophora* along a particular stretch of shoreline. Substrate types were noted during the survey, using the following abbreviations: *m* = soft muck or marl, s = sand, *g* = gravel (0.1" to 2.5" diameter), *r* = rock (2.5" to 10" diameter), *b* = boulder (>10" diameter), and *w* = woody debris. Substrate types suitable for *Cladophora* growth include *g, r, b,* and *w*. The extent of suitable substrate along the shoreline of individual

properties in terms of distance (i.e., linear footage) was not documented.

Erosion was noted based on shoreline areas that exhibited: areas of bare soil, leaning or downed trees, exposed tree roots, undercut banks, slumping hunks of sod, or excessive deposits of sediments. Similar to *Cladophora*, shoreline erosion was recorded on field datasheets with estimates of its extent and relative severity (minor, moderate, or severe). For example "Mx20'" indicated 20 feet of shoreline with moderate erosion. Additional information about the nature of the erosion, such as possible causes, was also noted.

Greenbelts were rated based on the length of shoreline with a greenbelt and the average depth of the greenbelt from the water's edge landward into the property. Ratings for length ranged from zero to four while depth ranged from zero to three and were based on the following:

Length	0: None, 1: 1-10%, 2: 10-25%, 3: 25-75%, 4: >75%
Depth	0: None, 1: <10 ft, 2: 10-40 ft, 3: >40 ft

Greenbelt ratings for length and depth were summed to produce an overall greenbelt score. Greenbelt scores ranged from 0 to 7, representing the greenbelt status or health. Scores of 0 were considered very poor, 1-2: poor, 3-4: moderate, 5-6: good, and 7: excellent.

Shoreline alterations were surveyed and noted with the following abbreviated descriptions:

SB = steel bulkhead (i.e., seawall)	BB = boulder bulkhead
CB = concrete bulkhead	RR = rock rip-rap
WB = wood bulkhead	BR = Mixed boulder/rock riprap
BH = permanent boathouse	BS = beach sand
G = groin	DP = discharge pipe

Abbreviations were sometimes mixed or vary from what is listed above.

Tributary streams were noted on the field datasheets and included in a separate column in the database. Additional information regarding shoreline property features or shoreline conditions recorded on field datasheets was included in the database in a

“comments” column. Emergent aquatic plants in nearshore areas, such as bulrush and cattail, were also noted in the comments column of the field datasheet.

Data Processing

Upon completing field work, all field data were transferred to a computer. Information from field datasheets was inputted into a Microsoft Excel® workbook. Digital GPS photographs were uploaded to a computer at the Watershed Council office and processed for use.

Field data were linked to the Emmet County property data in a GIS with the aid of GPS photographs. The linked field and equalization data allows shoreline conditions documented during the survey to be referenced by property identification number or property owner name. Occasionally, errors occur wherein field data are not linked to the appropriate parcel.

In order to display survey results without pinpointing specific parcels, a new map layer was developed using the parcel map data layer acquired from the county equalization department and a Round Lake shoreline layer. The new map layer consists of a narrow 100-meter band following the shoreline, split into polygons that contain field and equalization data. This data layer was overlaid with other GIS data from the State of Michigan to produce maps displaying survey results, including a “shoreline health” map coalescing greenbelt, erosion, and *Cladophora* results.

Final products include a comprehensive database, a complete set of GPS digital photographs, GIS data layers of shoreline parcels that include both county equalization and shore survey data, and a map displaying results. The shoreline survey database contains a sequential listing of properties beginning at the public boat launch and traveling counter-clockwise around the entire perimeter of the lake. The database contains all data collected in the field and identification numbers in the database correspond to those in GIS data layers and on hard-copy maps. GPS photographs were renamed using the same identification numbers and are linked to a GIS data layer.

RESULTS

This survey documented shoreline conditions at 71 properties on Round Lake. Approximately 72% (51) of shoreline properties on Round Lake were considered to be developed. The length of shoreline per parcel varied from less than 20 feet to over 2300 feet.

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline at 40 properties (56%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline at 15 properties, representing 21% of the total or 38% of properties with suitable habitat (Table 4). At properties where *Cladophora* growth was observed, approximately 87% were classified as light or very light growth and no properties had heavy or very heavy growth.

Table 4. *Cladophora* density results.

Cladophora Density	**Number of Properties**	**Percent of Properties***
Very Heavy	0	0
Heavy	0	0
Moderate to Heavy	0	0
Moderate	1	7
Light to Moderate	1	7
Light	9	60
Very Light	4	27
TOTAL	15	100

**Percent of properties with Cladophora growth.*

Greenbelt scores on Round Lake ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt). Approximately 41% of greenbelts were found to be in good or excellent condition (Table 5). Conversely, 44% of shoreline property greenbelts rated in the poor or very poor categories.

Some form of shoreline alteration was noted at 31 shoreline properties (44%) on Round Lake (Table 6). Riprap accounted for 61% of shoreline alterations, while seawalls, including seawalls combined with riprap or other structures, accounted for 23%. Beach sand, whether from fill or vegetation and topsoil removal to expose underlying sand, was documented at just 4 properties.

Table 5. Greenbelt rating results.

Greenbelt Rating	Number of Properties	Percent of Properties
0 = Very Poor*	17	24
1-2 = Poor	14	20
3-4 = Moderate	11	15
5-6 = Good	14	20
7 = Excellent	15	21
TOTAL	71	100

**Very poor indicative of a property with no vegetation beyond mowed turf grass at the lake edge.*

Table 6. Shoreline alteration results.

Alteration Type	Number of Properties	Percent of Properties
Riprap (small rock)	16	52
Riprap (boulder and rock)	2	6
Riprap and beach sand*	1	3
Seawalls	4	13
Seawall and beach sand*	2	6
Seawall and riprap	1	3
Beach sand*	3	10
Other†	2	6
TOTAL	31	100

**Beach sand includes sand fill or exposing sand by removing vegetation.*
†Other includes rock groins, boat ramps, boat houses, or modifications.

Erosion was noted at 30 properties (42%) on the Round Lake shoreline (Table 7). Over half (57%) of shoreline properties with erosion were classified as moderate in terms of severity, while two properties were experiencing severe erosion. Minor erosion was documented at 37% of properties with erosion.

Table 7. Shoreline erosion results.

Erosion Category	Number of Properties	Percent of Properties
Minor	11	37
Moderate	17	57
Severe	2	7
TOTAL	30	100

Tributary streams were documented at 11 properties. The actual number could be higher or lower because tributaries are sometimes missed during the survey and those located between land parcels can mistakenly be tallied for both properties.

Maps were developed to display and examine patterns in the occurrence of *Cladophora* growths, erosion, and poor greenbelts on the Round Lake shoreline. All properties with observed *Cladophora* growth occurred on the northern shore of the lake, with the heaviest growth occurring to the west of the MDNR boat launch. Clusters of properties with moderate to severe shoreline erosion were found in the three developed lakeshore areas, toward the middle of the north, west, and southeast shorelines (Figure 6). Groupings of properties with shoreline alteration and poor greenbelts corresponded with those of erosion sites.

Figure 6. Survey results: degraded shoreline areas.

DISCUSSION

Development of shoreline parcels negatively impacts a lake's water quality due to a multitude of factors. Among the most serious impacts are: 1) loss of vegetation that would otherwise provide habitat and food in nearshore areas, absorb and filter pollutants in stormwater runoff, and stabilize shoreline areas to prevent erosion, 2) increased impervious surface area such as roofs, driveways and roads, which leads to greater inputs of stormwater runoff and associated pollutants, and 3) waste and byproducts of human activity such as septic leachate, fertilizers and decomposing yard waste that potentially reach and contaminate the lake water. Results from the 2014 survey indicate that poor greenbelts, shoreline alterations, and erosion pose the greatest threats to the water quality and overall health of Round Lake in shoreline areas.

Relative to shore surveys conducted on other lakes in the region, Round Lake was well below the average in terms of the percentage of properties with *Cladophora* growth and heavy *Cladophora* growth (Table 8). *Cladophora* found on the north shore could be the result of nutrient pollution from fertilizers, runoff from impervious surfaces, and sewer system leakage in shoreline residential areas. However, it could also be due to natural factors, such as springs and seeps flowing into and delivering extra nutrients to the lake. In instances where human-caused nutrient pollution is occurring, the source has to be identified in order to address the problem. Trained personnel can identify specific nutrient input sources on individual properties, though efforts are sometimes impeded by wind, wave action, currents, groundwater paths, and other factors.

Although the percentage of poor greenbelts on Round Lake riparian properties was about average for lakes in this region (Table 8), nearly one of every four properties was found to have virtually no shoreline vegetation beyond turf grass. Lakeshore vegetation removal and the consequent loss of nearshore habitat and food sources impacts aquatic fauna ranging from minute crustaceans to top predator fish. Furthermore, the lack of vegetation leads to greater amounts of shoreline erosion and less filtration of pollutants. In spite of the number of properties with greenbelts in poor condition, approximately 21% of properties on Round Lake received a perfect score, indicating exemplary greenbelt health. Properties with healthy, intact greenbelts provide a model for improvement for other shoreline properties. Improvements in the quality of

Table 8. Shore survey statistics from Northern Michigan lakes.

Lake Name	Survey Date	*Cladophora**	Heavy Algae*	Erosion*	Poor Greenbelts*	Alterations*
Black Lake	2005	20%	21%	ND	ND	ND
Burt Lake	2009	47%	29%	4%	36%	46%
Charlevoix	2012	22%	19%	14%	34%	79%
Crooked Lake	2012	29%	26%	14%	51%	65%
Huffman Lake	2006	60%	22%	ND	ND	76%
Huron, Duncan Bay	2013	41%	2%	19%	45%	63%
Huron, Grass Bay	2013	0%	0%	4%	0%	8%
Lance Lake	2014	19%	0%	12%	35%	31%
Larks Lake	2006	4%	0%	ND	12%	29%
Mullett Lake	2008	59%	50%	7%	64%	58%
Pickerel Lake	2012	27%	33%	15%	52%	64%
Round Lake	2014	21%	0%	27%	44%	44%
Silver Lake	2014	3%	0%	70%	53%	65%
Six Mile Lake	2008	14%	5%	5%	34%	30%
Thumb Lake	2007	4%	0%	ND	ND	39%
Walloon Lake	2010	46%	24%	7%	36%	75%
Wildwood Lake	2014	5%	0%	22%	45%	50%
AVERAGE		25%	14%	17%	39%	51%

**Percentages are in relation to number of parcels on the lake shore, except for "heavy algae", which is the percent of only parcels that had Cladophora growth. Erosion is the percentage of parcels with moderate to severe erosion and poor greenbelts include those in the poor or very poor categories. ND=no data.*

greenbelts throughout the shoreline would invariably have positive impacts on the lake's water quality and ecosystem in general.

Shoreline erosion on Round Lake was above average for lakes in this region and is therefore, a concern (Table 8). Erosion documented on these properties consisted of two primary types: erosion occurring under shallow-rooted turf grass with no natural vegetation buffer and eroding beach sand. Regardless of the cause, corrective actions to address existing erosion, preferably using bioengineering techniques, as well as preventative measures, such as improving riparian vegetation (greenbelt) conditions, will benefit the Round Lake ecosystem.

The percentage of properties with shoreline alterations on Round Lake was lower than the regional lake average, but approaching 50% (Table 8). Approximately one half of shoreline alterations consisted of small riprap, which is one of the least damaging types

in regards to lake ecosystem health (Table 6). Conversely, 23% of noted alterations were seawalls or seawalls mixed with riprap or beach sand. Seawalls are now frowned upon by water resource managers due to negative impacts that range from near-shore habitat loss to ice-induced erosion in neighboring shoreline areas. Reducing the length of altered shoreline, particularly in terms of seawalls, will improve the water quality and bolster the ecosystem of Round Lake.

Shoreline trends cannot be evaluated because no prior data exists for Round Lake. However, the 2014 survey lays the foundation for future comparisons. Specific changes and general trends relating to follow-up actions that correct problems in shoreline areas will be apparent when future surveys are conducted. In addition, water quality monitoring by TOMWC and other organizations will provide necessary data for assessing environmental conditions and changes occurring in the lake brought on by changes in shoreline property management.

Numerous best management practices have been developed to minimize water quality and aquatic ecosystem degradation, which can be utilized during, or retroactively after shoreline property development. A buffer of diverse, native plants can be maintained along the shoreline to filter pollutants and reduce erosion. Impacts from stormwater runoff generated from roofs, roads, and driveways can be reduced using rain barrels, rain gardens, grassy swales, and many other techniques. Mulch can be composted far from the shoreline and fertilizers applied sparingly, if at all. Improving shoreline property management will help protect water quality, strengthen the fisheries, and improve the quality of life and recreation on Round Lake.

Recommendations:

The full value of a shoreline survey is only achieved when the information is used to educate riparian property owners about preserving water quality, and to help them rectify any problem situations. The following are recommended follow-up actions:

1. Keep the specific results of the survey confidential (e.g., do not publish a list or map of sites where shoreline erosion was found) as some property owners may be sensitive to publicizing information regarding their property.

2. Send a general summary of survey results to all shoreline residents, along with a packet of informational brochures produced by the Watershed Council and other organizations, to provide information about dangers to the lake ecosystem and public health as a result of poor shoreline property management practices. Also, provide practical, feasible, and effective actions to protect water quality.

3. Organize and implement informational sessions to present findings of the survey to shoreline residents and provide ideas and options for improving shoreline management practices that would help protect and improve lake water quality.

4. Confidentially inform owners of properties with moderate to heavy *Cladophora* growths, moderate to severely eroded shorelines, and poor or very poor greenbelt scores of specific results for their property. Encourage riparians to work with the Watershed Council to identify and correct problems. Send riparians a questionnaire to fill out and return (or make available electronically) to help interpret causes of the growth and provide recommendations for addressing problems. If property owners need further assistance, they can contract with the Watershed Council or other qualified organizations or businesses to perform site assessments to evaluate and remedy problems with nutrient pollution, erosion, and greenbelts.

5. Utilize the internet to share survey information. A general summary report and this detailed report can be posted on a web page because they do not contain any property-specific information. Property-specific information can be shared via a web page by randomizing and encrypting the shoreline survey database and providing property owners with a code number that refers specifically to survey results from their property. In addition, questionnaires about property

characteristics could be filled out through free internet services linked to the web site. The Watershed Council is available to assist with this approach.

6. Verify links made between shore survey results and land parcel data to ensure that information is being properly reported. Shoreline residents can assist the Watershed Council in determining if house descriptions in survey database match correctly with county land owner information. By doing so, property owners will receive the correct information regarding their parcel. This information is also useful for empowering lake groups to monitor shoreline activities, recruit new members, and compile and manage other water resource information.

7. Recruit volunteers to monitor Round Lake with the Tip of the Mitt Watershed Council Volunteer Lake Monitoring Program. The information collected by volunteers is extremely valuable for assessing water quality, determining trends, and guiding lake management efforts.

8. Ensure that shoreline survey results are incorporated into the development of the 2016 nonpoint source pollution management plan for the Burt Lake Watershed.

9. Repeat some version of the survey periodically (ideally every 3-5 years), coupled with the follow-up activities described previously, in order to promote water quality awareness and good management practices on an ongoing basis, as well as identify chronic problem areas. During each subsequent survey, more details about shoreline features are added to the database, which can be utilized for other water resource management applications.

LITERATURE AND DATA REFERENCED

Carlson R. E. 1977. A Trophic State Index For Lakes. Limnology and Oceanography, 22 (2):361- 369.

Emmet County. 2012. Emmet County Digital Orthophotography. Emmet County Equalization Department Petoskey, MI. http://www.emmetcounty.org/equalizationgis-56/?glmPage=equalization.

Emmet County Equalization Department. 2014. Emmet County Equalization Data. Petoskey, MI. http://www.emmetcounty.org/equalizationgis-56/?glmPage=equalization.

Michigan Geographic Data Library. 2014. Michigan Geographic Data. Michigan Department of Information Technology, Center for Geographic Information. Lansing, MI. http://www.mcgi.state.mi.us/mgdl/

Michigan Department of Natural Resources and Environment. 2014. Lake Maps by County. Lansing, MI. http://www.michigan.gov/dnr/0,4570,7-153-10364_52261-67498--,00.html.

National Oceanic and Atmospheric Administration (NOAA). 2010. Coastal Great Lakes Land Cover Project. NOAA Coastal Services Center. Charleston, SC. http://www.csc.noaa.gov/crs/lca/greatlakes.html.

National Oceanic and Atmospheric Administration (NOAA). 1985. Coastal Great Lakes Land Cover Project. NOAA Coastal Services Center. Charleston, SC. http://www.csc.noaa.gov/crs/lca/greatlakes.html.

Tip of the Mitt Watershed Council. 2013. Comprehensive Water Quality Monitoring Program data. Petoskey, MI. www.watershedcouncil.org.

Tip of the Mitt Watershed Council. 2014. Volunteer Lake Monitoring Program data. Petoskey, MI. www.watershedcouncil.org.