Mullett Lake Shoreline Survey 2008

By Tip of the Mitt Watershed Council

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SUMMARY

During June and July of 2008 the Tip of the Mitt Watershed Council conducted a shoreline survey on Mullett Lake that was funded by the Mullett Lake Area Preservation Society and National Fish and Wildlife Foundation. Watershed Council staff surveyed the entire shoreline to document conditions that potentially impact water quality. The parameters surveyed include: algae as a bio-indicator of nutrient pollution, greenbelt status, shoreline erosion, shoreline alterations, nearshore substrate types, and stream inlets and outlets.

Shoreline property management practices have the potential to negatively impact water quality in many ways. Nutrients are necessary to sustain a healthy aquatic ecosystem, but excess can adversely impact an aquatic ecosystem, and indirectly poses a danger to human 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.

Data collected during the shoreline survey indicate that human activity along the shores of Mullett Lake is negatively impacting the lake ecosystem and water quality. Nutrient pollution, as indicated by the presence of *Cladophora* algae, was noted at 59% of shoreline properties, erosion was documented at 12% of properties, greenbelts were found to be in poor condition at 64% of properties, and shoreline alterations were found at 58% of properties. Relative to other lakes, Mullett Lake had high percentages of parcels with *Cladophora*, heavy algae growth, and poor greenbelts. Problems were documented throughout the lake with no discernable pattern in occurrence. Changes need to be made in shoreline property management to prevent degradation of lake water quality and to protect and improve the lake ecosystem.

In spite of strong indicators of nutrient pollution occurring in nearshore areas, water quality data show decreasing nutrient concentrations. The water quality data does not necessarily reflect what is occurring in nearshore areas because it is collected far removed from the shoreline in open water. Furthermore, interpreting such data is confounded by the alteration of the lake's nutrient cycling caused by invasive zebra mussels.

To achieve the full value of this survey, the association should engage in follow-up activities aimed at educating riparian property owners about preserving water quality, and to help them rectify any problem situations. Summary information about the survey should be sent to all shoreline residents along with information about what each person can do to help, but specific information for individual properties should remain confidential. Individual property owners should be contacted confidentially and encouraged to participate in identifying and rectifying any problems that may exist on their property. An informational session should be organized to present survey results and provide information about best management practices on shoreline properties that help protect and improve lake water quality. Shoreline surveys should be repeated every 3-5 years as shoreline ownership, management, and conditions continually change.

INTRODUCTION

Background:

During the summer of 2008, a shoreline survey was conducted on Mullett Lake by the Tip of the Mitt Watershed Council to document shoreline conditions that potentially impact water quality. The entire shoreline was surveyed to document the following: algae as a nutrient pollution indicator, erosion, shoreline alterations, greenbelts, and tributary inlets and outlets. This survey was funded by the Mullett Lake Area Preservation Society and the National Fish and Wildlife Foundation.

The Mullett Lake Watershed Management Plan (TOMWC, 2002) expressly recommends a comprehensive shoreline survey as an action to protect the lake. Shoreline inventory recommendations in the plan were developed to reduce the impacts of nonpoint source pollution.

According to records at Tip of the Mitt Watershed Council, only one other shoreline survey has been carried out on Mullett Lake. In 1989, densely developed areas were surveyed by Watershed Council staff, using the presence of algae and a septic leachate detector to identify nutrient pollution problems. In addition, the entire shoreline was surveyed to document adjacent wetlands. The project was funded by the Michigan Department of Natural Resources and the United States Environmental Protection Agency.

The 2008 survey provides another comprehensive data set documenting shoreline conditions on Mullett Lake; a valuable data set that can be used as a lake management tool. Combined with follow-up activities, such as questionnaires and on-site visits, sources of nutrient pollution to the lake can be identified and controlled. Subsequently, a reduction in nutrient loading can often be achieved by working with homeowners to solve problems. These solutions are often simple and low cost, such as regular septic system maintenance, proper lawn care practices, and wise land use along the shoreline. Prevention of problem situations can also be achieved through the publicity and education associated with the survey. Periodic repetition of shoreline surveys is important for identifying new and chronic problem sites, determining long-term trends of near-shore nutrient inputs associated with land-use changes, and for assessing the success of remedial actions.

Shoreline development impacts:

Lake shorelines represent the critical interface between land and water; where human activity has the greatest potential for degrading water quality. Developing shoreline properties for residential, commercial or other uses invariably has impacts on the aquatic ecosystem. During the development process, the natural landscape is altered in a variety of ways; vegetation is removed, the terrain is graded, utilities 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 impact the lake following shoreline development.

Nutrient pollution can have adverse impacts on aquatic ecosystems and indirectly poses a danger to human health. Nutrients are necessary to sustain a healthy aquatic ecosystem, but excess will stimulate unnatural plant growth. Increased abundance of aquatic macrophytes (higher or vascular plants) can become a nuisance to recreation in shallow areas (typically less than 20 feet of depth). An increase in algal blooms also has the potential to become a recreational nuisance when algal mats and scum are formed on the lake's surface. Additionally, algal blooms 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).

Excess growth of both macrophytes and algae has the potential to degrade water quality by depleting the ecosystem's dissolved oxygen stores. During nighttime respiration, plants compete with other organisms for a limited oxygen supply. Furthermore, the decomposition of dead algae and plant material has the potential to deplete dissolved oxygen supplies due to the aerobic activity of decomposers, particularly in the deeper waters of stratified lakes.

In general, large, deep lakes such as Mullett are less sensitive to nutrient pollution. Large lakes with greater water volume have a bigger buffer and thus greater resistance to nutrient pollution. The large lakes tend to have greater dissolved oxygen stores and the greater volume allows for greater dilution of nutrients. By contrast, small lakes generally have smaller stores of dissolved oxygen, a lesser ability to dilute nutrients and therefore, are more susceptible to the indirect impacts of nutrient pollution. Small lakes with extensive shallow areas are at even greater risk as there are more habitats to support excessive aquatic macrophyte growth. Mullett Lake is one of the largest and deepest inland lakes in the State of Michigan (17,200 acres, maximum depth = 144 feet) and thus, comparatively resilient to nutrient pollution. Additionally, Mullett Lake is a drainage lake with inflows and an outflow, which provides a mechanism to flush excess nutrients out of the system. In spite of Mullett Lake's resilience to nutrient pollution, unnaturally high nutrient concentrations can occur and cause problems in localized areas, particularly near sources in shoreline areas.

Surface waters receive nutrients through a variety of natural and cultural (human) sources. Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff, organic inputs from the riparian (shoreline) area and atmospheric deposition. Springs, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter and wetland seepages may discharge nutrients at certain times of the year. 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., malfunctioning septic systems and animal wastes) pose a potential health risk due to bacterial and viral contamination.

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, 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 (i.e., the water's ability to conduct an electric current). Biologically, nutrient pollution can be detected along the lake shore by noting the presence of *Cladophora* algae.

Cladophora is a branched, filamentous green algal species 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. It 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 from late May to early July and from September to October.

The nutrient requirements for *Cladophora* to achieve large, dense growths are typically greater than the nutrient availability in the lakes of Northern Michigan. Therefore, shoreline locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake can be identified by noting the presence of *Cladophora*. Although the size of the growth on an individual basis is important in helping to interpret the cause of the growth, growth features of *Cladophora* are greatly influenced by such factors as current patterns, shoreline topography, size and distribution of substrate, and the amount of wave action the shoreline is subject to. 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 input due to changing land use.

Erosion along the shoreline has the potential to degrade the lake's water quality. Stormwater runoff through eroded areas carries sediments into the lake and 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, which can lead to nuisance aquatic plant growth and large algae blooms.

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 function as erosion control devices, 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 is particularly important for lakes with cold-water fisheries. In addition, greenbelts provide a mechanism to reduce overland surface flow and absorb pollutants carried by stormwater from rain events and snowmelt.

Tributaries have great potential for influencing a lake's water quality as they are one of the primary conduits through which water is delivered to a lake from its watershed. Inlet streams may provide exceptionally high quality waters that benefit the lake ecosystem, but conversely have the potential to deliver polluted waters that degrade the lake's water quality. Outlet streams flush water out of the lake, providing a mechanism to remove contaminants that have accumulated in the lake ecosystem. With regards to shore surveys, noting the location of inlet tributaries is very helpful when evaluating shoreline algae conditions because nutrient concentrations are generally higher in streams than in lakes. The relatively higher nutrient levels delivered from streams often lead to naturally heavier *Cladophora* and other algae growth along the shoreline.

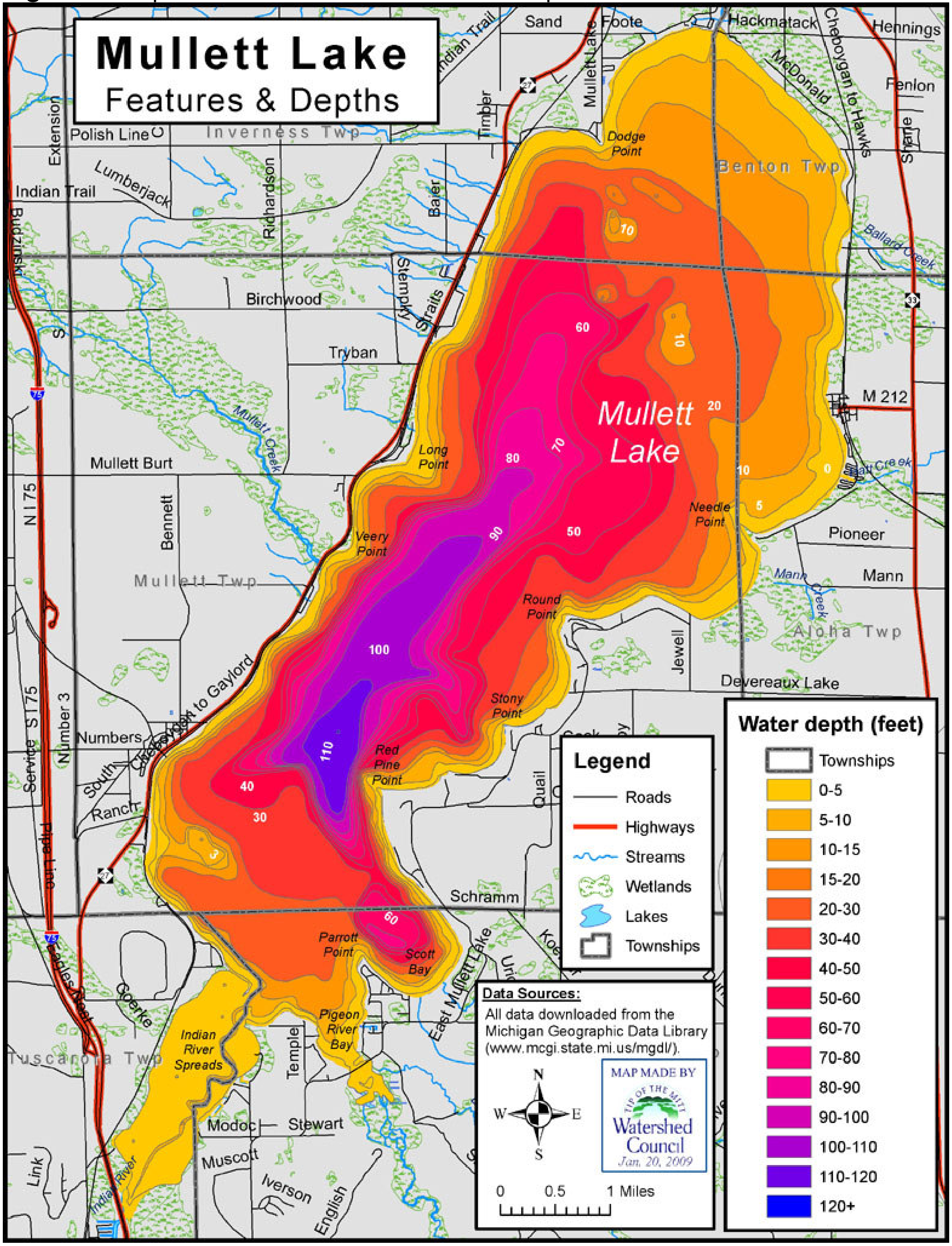
Responsible, low-impact, lake shoreline property management is paramount for protecting water quality. Maintaining a healthy greenbelt, regular septic tank pumping, treating stormwater with rain gardens, addressing erosion sites, and eliminating fertilizer, herbicide, and pesticide application are among many low-cost best management practices that minimize the impact of shoreline properties 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:

Mullett Lake is located in the northeast tip of the Lower Peninsula of Michigan; in Aloha, Benton, Inverness, Koehler, Mullett, and Tuscarora Townships of north-central Cheboygan County. Based upon digitization of aerial orthophotography provided by Cheboygan County Equalization (2004), the shoreline of Mullett Lake proper measures 30.48 miles and lake surface area totals 16,512 acres, while the Indian River Spreads connecting at the south of Mullett Lake includes an additional 692 acres. Mullett Lake is approximately 9 miles long, gradually widening from the southwest to northeast. Pigeon River and Scott Bays are located in the southern part of the lake and prominent points are interspersed along the shoreline including Dodge, Long, Needle, Parrott, Red Pine, Round, Stony, and Veery Points (Figure 1).

Bathymetry maps from the State of Michigan as well as the Sportsman's

Figure 1. Map of Mullett Lake: Features and Depths



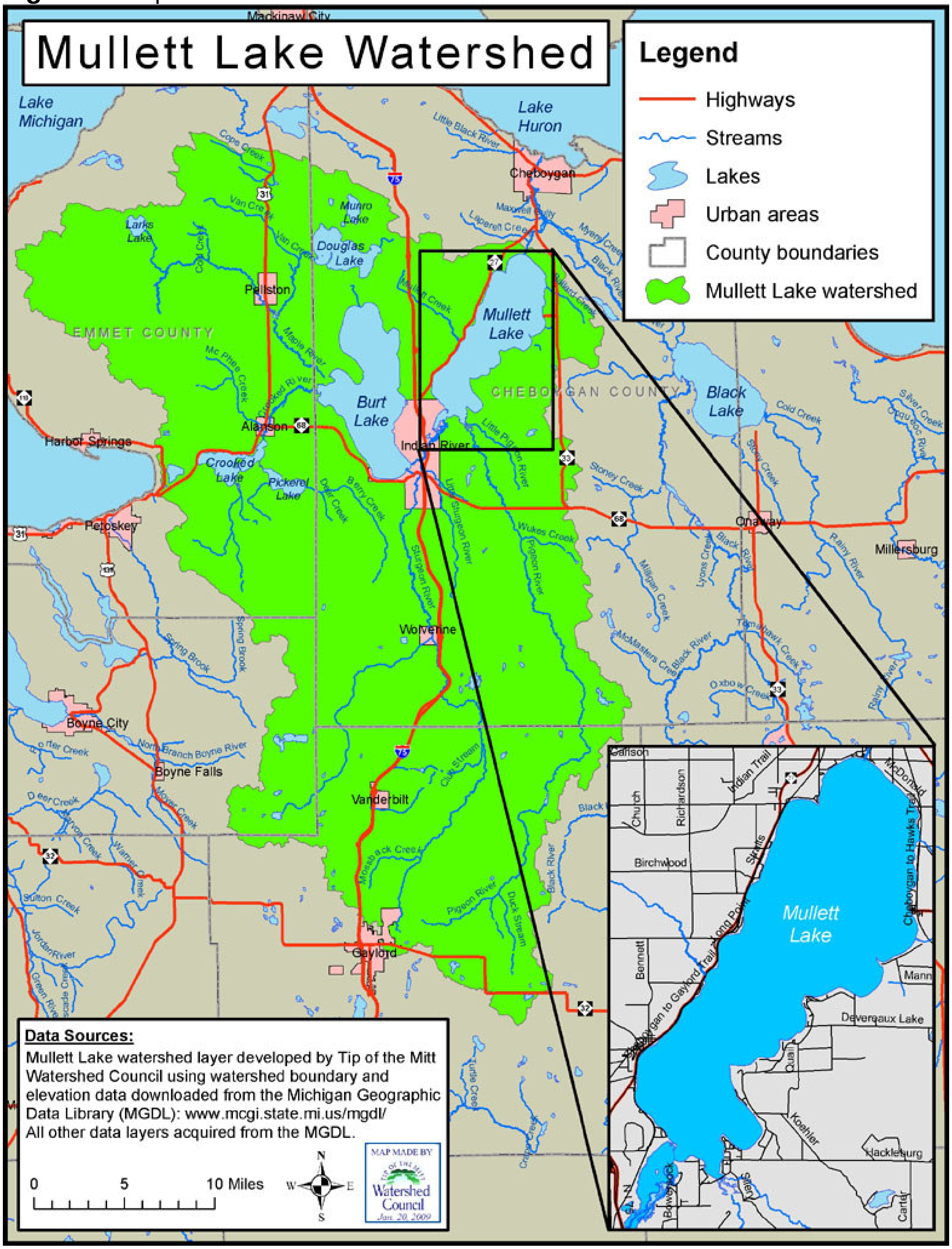
Connection Fishing Map Guide show the deepest area located directly out from Red Pine Point with a maximum depth of 120 feet. However, a deeper hole not appearing on these maps is known to exist in front of Long Point where sampling by Tip of the Mitt Watershed Council staff has documented a depth in excess of 140 feet. According to digitized bathymetry maps acquired from the Michigan Geographic Data Library, approximately 62% of the lake (including Indian River Spreads) exceeds 20 feet of depth. Relatively shallow areas are found in the southwest in the Indian River Spreads and Pigeon River Bay and in the northeast where there is a broad shallow plateau.

Mullett Lake is a drainage lake with water flowing into and out of the lake. The primary inlets include the Indian and Pigeon Rivers in the southwest end of the lake and the only outlet is the Cheboygan River in the northeast end. A number of smaller tributaries enter into the lake throughout its length, including Ballard, Hatt, Mullett, Mullett Lake, and Scott Creeks (USGS, 1990).

According to GIS (Geographical Information System) files developed by the Watershed Council using watershed boundary and elevation data acquired from the State of Michigan, the Mullett Lake watershed encompasses approximately 560,000 acres of land and water. The watershed stretches from the City of Gaylord in the south to the Cheboygan River to the north and contains a number of other regionally important water bodies including Burt Lake, Douglas Lake, Crooked Lake, the Maple River, the Sturgeon River and the Pigeon River (Figure 2). A watershed ratio of 32.55 was calculated by dividing the lake surface area into the watershed area (not including the lake), indicating that there are over 32 acres of watershed area for each acre of Mullett Lake water surface. This ratio provides a statistic for gauging susceptibility of lake water quality to changes in watershed land cover. Relative to other lakes in Northern Michigan, Mullett Lake has a high watershed ratio.

Land cover statistics were generated for the watershed using remotely sensed data from the Coastal Great Lakes Land Cover project (Table 1). Based on 2006 data, the majority of the watershed's landcover is natural; consisting

Figure 2. Map of the Mullett Lake Watershed.



primarily of forest, wetlands, and grassland. There is little agricultural landcover within the watershed (~9%) and even less urban (~3.5%), though both of these land-cover types increased by roughly one percent between 2000 and 2006.

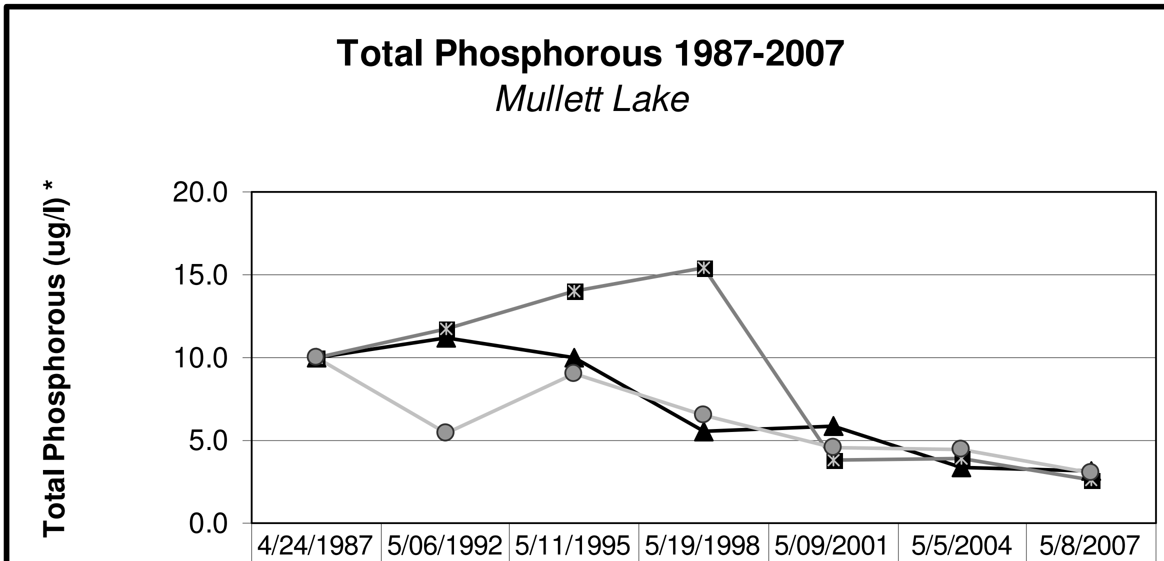
Table 1. Mullett Lake watershed land-cover statistics.

Land Cover Type	2000 Acreage	2000 Percent	2006 Acreage	2006 Percent	Change (%)
Agriculture	45102.32	8.06	49002.21	8.76	0.70
Barren	1222.54	0.22	896.88	0.16	-0.06
Forested	276088.28	49.36	286233.56	51.18	1.81
Grassland	82856.45	14.81	51928.92	9.28	-5.53
Scrub/shrub	18273.30	3.27	22401.78	4.01	0.74
Urban	13153.20	2.35	18755.03	3.35	1.00
Water	46543.63	8.32	45928.76	8.21	-0.11
Wetland	76005.09	13.59	84138.39	15.04	1.45
TOTAL	559244.81	100.00	559285.54	100.00	NA

The water quality of Mullett Lake has been monitored consistently for many years. The Mullett Lake Area Preservation Society has actively supported water quality monitoring programs on Mullett Lake, providing volunteers for volunteer water quality monitoring programs coordinated by the Watershed Council and the Michigan Lakes and Streams Association. In addition, Watershed Council staff monitor Mullett Lake water quality as part of the Comprehensive Water Quality Monitoring program (CWQM). Watershed Council databases contain Volunteer Lake Monitoring and CWQM data that date back to 1986 and 1987 respectively.

Data collected through these programs indicate that water quality remains high. Total phosphorus data collected as part of the CWQM program show that levels have dropped throughout the last 20 years and are now consistently below 10 parts per billion (PPB), which is typical for high quality lakes of Northern Michigan (Figure 3). Based on trophic status index values generated from volunteer lake monitoring data, Mullett Lake falls in the oligotrophic category, which is typical for pristine, large, deep lakes (Figure 4).

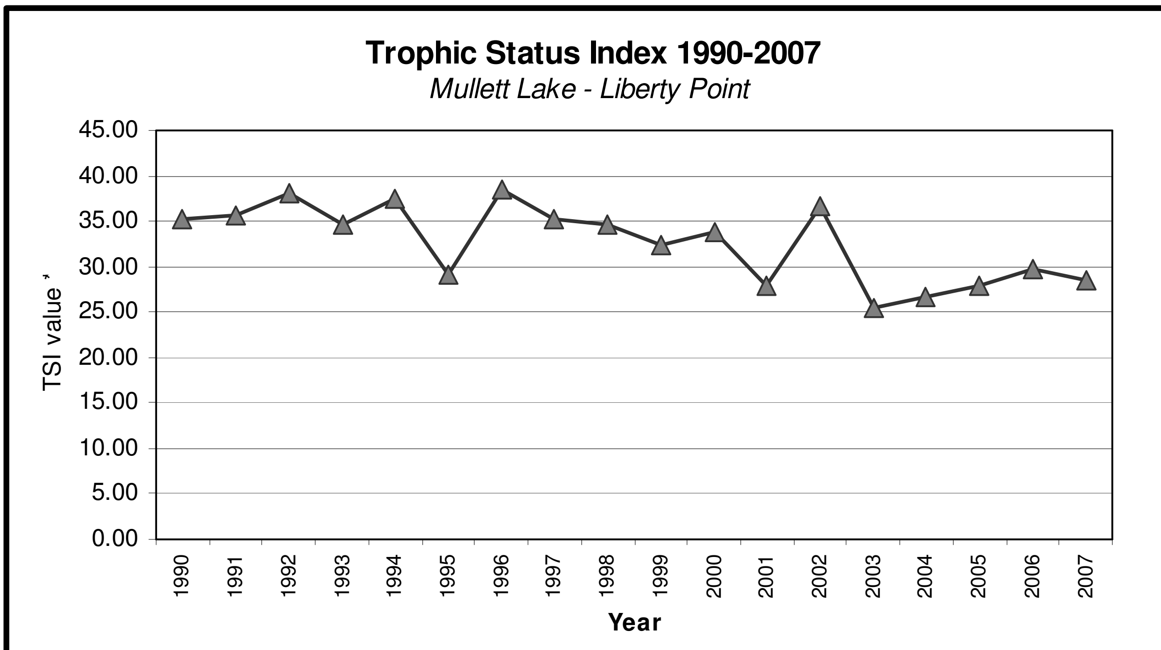
Figure 3. Chart of phosphorus data from Mullett Lake



	4/24/1987	5/06/1992	5/11/1995	5/19/1998	5/09/2001	5/5/2004	5/8/2007
Surface	10.0	11.2	10.0	5.5	5.9	3.4	3.1
Middle	10.0	11.7	14.0	15.4	3.8	3.9	2.6
Bottom	10.0	5.4	9.0	6.5	4.6	4.5	3

**Total phosphorus measured in ug/l, which is milligrams per liter or parts per billion.*

Figure 4. Chart of trophic status index data from Mullett Lake.



**TSI determines trophic status of lake: 0-38 = oligotrophic (low productive system), 39-49 = mesotrophic (moderately productive system), and 50+ = eutrophic (highly productive system).*

METHODS

Mullett Lake was surveyed in kayak during June and July of 2008 to document shoreline conditions. Watershed Council staff coordinator and two interns performed the survey, noting and photographing property features on all shoreline parcels. Shoreline conditions were surveyed by traveling as close to the shoreline as possible (usually within 20 feet) and noting *Cladophora* growth, substrate type, erosion, greenbelt length, greenbelt depth, shoreline alterations, and tributaries. All information was recorded on field data sheets, subsequently inputted into a database, and used in conjunction with GPS data to link field data and photographs with property owner (equalization) data.

Field Survey Parameters

Shoreline property features were documented by photographing and noting physical features on a data sheet, such as building descriptions, public access sites, and county road endings. Due to data sheet space limits, building descriptions were recorded in an abbreviated cryptic style. For example, *Red 2 sty, brn rf, wht trm, fldstn chim, lg pine* means 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 data sheets 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.

Many species of filamentous green algae are commonly found growing in the nearshore regions of lakes. Positive identification of these species usually requires the aid of a microscope. However, *Cladophora* usually has an appearance and texture that is quite distinct to a trained surveyor, and these 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 data sheets 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 relative growth density, and any observed shoreline features potentially contributing to the growth. For example, "MHx30 – seeps" denotes a moderate to heavy growth that covered 30' of the shoreline and with groundwater seeps in the area that may have been contributing to the growth. Both shoreline length and growth density are subjective estimates. Growth density is determined by estimating the percentage of substrate covered with *Cladophora* using the following categorization system:

Table 2. 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.*

Among other things, the distribution and size of each *Cladophora* growth is dependent on the amount of suitable substrate present. The extent of suitable substrate should therefore 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 suitable for *Cladophora* growth include the g, r, b, and w types. However, the extent of suitable substrate along a shoreline parcel in terms of distance 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, excessive deposits of sediments, or muddy water. Similar to *Cladophora*, shoreline erosion was recorded on field data sheets with estimates of its extent and relative severity (light, moderate, or heavy/severe). For example "Mx20" indicated 20 feet of shoreline with moderate erosion. Additional information about the nature of the erosion, such as potential causes, were also noted.

Greenbelts were rated based on the length of shoreline with a greenbelt and the average depth of the greenbelt from the shoreline into the property. Ratings ranged from zero to four and were based on the following.

Length	0: None, 1: <25%, 2: 25-75%, 3: >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.

Tributaries were noted on the field data sheets and included in a separate column in the database. Additional information regarding shoreline property features or shoreline conditions written on field data sheets was included in the database in a “comments” column. The comments column also included notes about shoreline alterations. Shoreline alterations (structures) were noted with the following abbreviated descriptions:

SB = steel bulkhead (i.e., seawall)
CB = concrete bulkhead
WB = wood bulkhead
BB = boulder bulkhead
RR = rock rip-rap
BH = permanent boathouse
DP = discharge pipe

Sometimes abbreviations were mixed or vary from what is listed above.

Data Processing

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

Linking field and equalization data allows shoreline conditions documented during the survey to be referenced by parcel identification number or parcel owner name. Field data were linked to Cheboygan County parcel data in a GIS with the aid of GPS and photographs. Errors can 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 Mullett Lake shoreline layer. The new map layer consists of a narrow band following the shoreline, split into polygons that are contain field and equalization data. This data layer was overlaid with other GIS data from the State of Michigan to produce the maps contained in this report.

Final products include a comprehensive database, a complete set of digital photographs, and a GIS data layer representing shoreline parcels and including both county equalization and shore survey data. The shoreline survey database contains a sequential listing of properties beginning at the Mullett Township boat launch in Topinabee on the southeast side of the lake 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 the GIS data layer and on the hard-copy map. Digital photographs were named using the same identification numbers and are linked to the GIS data layer.

RESULTS

This survey documented shoreline conditions at 1292 parcels on Mullett Lake. The length of shoreline per parcel varied from less than 20 feet to more than 2000 feet. Some portion of the shoreline was developed at 1109 of these parcels (86%).

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline of 1081 properties (84%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline of 758 parcels (59% of the total or 70% of properties with suitable habitat). At properties where *Cladophora* growth was observed, nearly 50% consisted of heavy or very heavy growth (Table 3). Only 12% of parcels had growth in the light or very light categories. Most of the *Cladophora* growths were associated with developed shoreline properties (93%), though growths were also noted at over fifty undeveloped properties.

Table 3. *Cladophora* density statistics.

***Cladophora* Density**	**Parcels**	**Percent**
Very light	32	4.22
Light	58	7.65
Light to Moderate	78	10.29
Moderate	132	17.41
Moderate to Heavy	83	10.95
Heavy	166	21.90
Very Heavy	209	27.57
TOTAL	758	100.00

The majority of greenbelts along the Mullett Lake shoreline were found to be in poor condition. Greenbelt scores ranged from 0 (little to no greenbelt) to 6 (exemplary greenbelt). At 64% of lakeside parcels, greenbelts were in poor condition or absent altogether (Table 6). Only 10% of the parcels received the highest score and an additional 18% were considered to be in good condition. In general, parcels with high greenbelt scores were undeveloped. Over 65% of parcels receiving the highest score were undeveloped compared to 7% undeveloped for parcels with the lowest score.

Table 4. Greenbelt scores and relationship to shoreline development.

Greenbelt Score/Rating	Number of Parcels	Percent of Parcels	Percent Undeveloped
0 = Absent	587	45.43	7.16
1 = Very Poor	49	3.79	6.12
2 = Poor	186	14.40	5.91
3 = Moderate	108	8.36	9.26
4 = Good	157	12.15	10.83
5 = Very Good	81	6.27	23.46
6 = Excellent	124	9.60	65.32

Some form of shoreline alteration was noted at 754 properties (58%). Erosion was noted along the shoreline at 158 parcels (12%). Most erosion areas were categorized as light to moderate with less than 15% in the heavy category. A total of 48 tributary streams were documented during the survey.

Occurrences of *Cladophora*, erosion, poor greenbelts, and shoreline alterations were relatively equally distributed throughout the Mullett Lake shoreline. Maps developed to identify problem areas in the lake, where there were clusters or other patterns, did not reveal any definitive patterns for the parameters surveyed.

DISCUSSION

Survey results have revealed poor riparian land management practices along much of the Mullett Lake shoreline, which are undoubtedly having negative impacts on the lake's ecosystem. Few undeveloped parcels remain, heavy nutrient pollution appears to be occurring throughout much of the lake, and shoreline vegetation is absent or in poor condition along most of the shoreline. Relative to shore surveys conducted on other lakes in the region, Mullett Lake had high percentages of shoreline parcels with *Cladophora*, heavy *Cladophora* growth, and poor greenbelts (Table 5). Mismanagement of shoreline properties can degrade the lake's water quality, diminish fisheries, and even create an environment that poses threats to human health.

Table 5. Shore survey statistics from Northern Michigan lakes.

Lake Name	Survey Date	Cladophora*	Heavy Algae*	Erosion*	Greenbelts*	Alterations*
Black Lake	2005	20%	21%	ND	ND	ND
Huffman Lake	2006	60%	22%	ND	ND	76%
Charlevoix	2007	17%	20%	9%	30%	61%
Larks Lake	2006	4%	0%	ND	12%	29%
Mullett Lake	2008	59%	50%	12%	64%	58%
Sixmile Lake	2008	14%	5%	11%	34%	30%
Thumb Lake	2007	4%	0%	ND	ND	39%
Walloon Lake	2005	36%	15%	1%	ND	68%

**Percentages are in relation to number of parcels on the lake shore, except for "heavy algae", which is the percent of parcels with Cladophora growth. Greenbelt percentage reflects the percentage of parcels with greenbelts in poor condition. ND=no data.*

In spite of the problems exposed by this survey, the water quality of Mullett Lake remains high. Due to its oligotrophic (nutrient poor) nature and the high volume of water flushing through it as a drainage lake, Mullett Lake has a great deal of resiliency against nutrient pollution. However, such resiliency is not without limits. To prevent potentially serious and irreversible changes to the lake ecosystem, changes need to be made in shoreline property management.

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 absorb and filter pollutants in stormwater runoff as well as stabilize shoreline areas and prevent erosion, 2) increased impervious surface area such as roofs, driveways and roads, which leads to greater amounts of stormwater runoff and an increase in pollutants associated with roads, 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. Clearly, there are many problems associated with development, but there are also many solutions for reducing or even entirely eliminating impacts.

Numerous best management practices have been developed that can be utilized during or retroactively after the development of shoreline parcels, which help minimize negative impacts to water quality. A buffer of diverse, native plants can be maintained along the shoreline to filter pollutants and reduce erosion. Impacts from stormwater generated from roofs, roads, and driveways can be reduced using rain barrels, rain gardens, grassy swales, and many other techniques. Leachate reaching the lake from septic systems can be minimized by pumping the septic tank regularly, having all components of the septic system inspected regularly and replacing the septic system when necessary. Mulch can be composted far from the shoreline and fertilizers applied sparingly if at all.

Of the shoreline areas showing evidence of potential nutrient pollution, some of the algae growth is undoubtedly associated with septic system leachate or other factors associated with development and human activities, but others are probably due to natural factors. There are numerous streams, springs and seeps flowing into Mullett Lake at different points along the shoreline that may be delivering nutrients that naturally increase algal growth. Where human-caused nutrient pollution is occurring, the source has to be identified in order to address the problem. Although impeded by factors such as wind, wave action, currents, and groundwater paths, efforts by trained personnel to identify specific nutrient input sources on individual properties are often successful.

Water quality monitoring data from Mullett Lake do not show an increase in nutrient concentrations, though these data may not reflect what is occurring in nearshore areas. Contrary to what one might expect based on shoreline survey results, phosphorus and nitrogen levels have decreased in Mullett Lake during the last few decades. In addition, water clarity has increased and algal biomass has decreased. These data seem to indicate a decrease in nutrient pollution, but there are a few things to consider when interpreting such data. One is that all such data have been collected out in open water, far removed from shoreline areas where the majority of nutrient pollution tends to occur. More importantly, zebra mussels have altered the lake ecosystem, disrupted natural nutrient cycling, and probably caused the decrease in nutrient concentrations and algal biomass while increasing water clarity.

The shoreline vegetation in Mullett Lake is in great need of attention. Greenbelts were in poor condition throughout much of the lake, with nearly half of parcels completely devoid of shoreline vegetation beyond turf grass. The lack of vegetation on the lake shoreline, which provides habitat and food source, impacts aquatic fauna ranging from minute crustaceans to top predator fish. Furthermore, the absence of vegetation leads to greater amounts of shoreline erosion and less filtration of pollutants. Although most shoreline vegetation on lakeside parcels is in poor condition, nearly 30% of parcels have greenbelts in the good to excellent categories. Properties with healthy, intact greenbelts provide a model for improvement for other shoreline properties. Improving the quality of greenbelts throughout the shoreline would invariably have positive impacts on the lake's water quality and ecosystem in general.

Erosion and shoreline alterations were noted on many parcels, but the numbers were not alarming. Only 12% of shoreline parcels showed signs of erosion and few displayed heavy erosion. Approximately 58% of parcels had some type of shoreline alteration, the majority consisting or riprap, which as far as alterations go is one of the least damaging types in regards to lake ecosystem health. Although erosion was limited, correcting eroded areas, preventing further erosion, and reducing the length of altered shoreline will benefit the Mullett Lake ecosystem.

Comparisons with the 1988 shoreline survey were not carried out due to a lack of data and differing methodologies. Different rating systems were used for the variables surveyed in the 2008 survey. Furthermore, the 2008 survey varied from that of 1988 in that GPS and GIS technologies were incorporated to more accurately track field conditions in relation to parcel delineations. However, changes in watershed landcover likely parallel changes in shoreline development, which would indicate a trend of increasing water quality impacts as a result of human activity on the Mullett Lake shoreline.

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 (i.e., do not publish a list of sites where *Cladophora* algae were found) as some property owners may be sensitive to publicizing information regarding their property.

2. Send a general summary of the 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 as well as practical, feasible, and effective actions to protect water quality.

3. Organize and sponsor an informational session 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 the lake's water quality.

4. Inform owners of properties with *Cladophora* growths of the specific results for their property, ask them to fill out a questionnaire in an attempt to interpret causes of the growth, and offer individualized recommendations for water quality protection. Following the questionnaire survey, property owners have the option to contract the Watershed Council to perform site visits and even conduct ground water testing in an effort to gain more insight into the nature of the findings. Again, it should be stressed that all information regarding names, specific locations, and findings be kept confidential to encourage property owner participation in this project.

5. Inform owners of properties with poor greenbelt scores and those with eroded shorelines of specific results for their property. Supply these property owners with information (e.g., brochures) regarding the benefits of greenbelts and/or the problems associated with erosion. Encourage property owners to improve greenbelts using a mix of native plants and to correct erosion problems. Property owners have the option to contract the Watershed Council to perform site assessments and carry out projects to improve greenbelts and/or correct erosion problems.

6. 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. During each subsequent survey, more details about shoreline features are added to the database, which can be utilized for other water resource management applications.

7. 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 the lake association to monitor shoreline activities, recruit new members, and compile and manage other water resource information.

8. Continue to support the Tip of the Mitt Watershed Council Volunteer Lake and Stream Monitoring programs by providing volunteer support. The information collected by volunteers is extremely valuable for evaluating water quality and determining trends. MAPS is encouraged to continue supplying volunteer help and volunteers should attend training sessions held by the Watershed Council to ensure that a complete set of quality data is being collected each year.

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