# Burt Lake Shoreline Survey 2022

Tip of the Mitt Watershed Council

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# SUMMARY

The Burt Lake Watershed lies in the very center of Northern Michigan and sprawls over nearly 375,000 acres. The watershed includes some of the State's greatest natural resources. Thousands of residents live and recreate on the watershed's lakes and streams, and thousands more come as tourists to enjoy the opportunities these high-quality water resources have to offer. Northern Michigan depends on these resources and their protection is critical. In 2013, Tip of the Mitt Watershed Council acquired funding from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) to develop a nonpoint source pollution watershed management plan for the Burt Lake-Sturgeon River watershed. The Plan was approved in 2018 and identified the following sources of nonpoint source pollution: poor shoreline management and weak water resource protection ordinances, along with stormwater road/stream crossings, streambank erosion, and septic systems. In 2021, the Watershed Council acquired funding from EGLE's Nonpoint Source Program by the United States Environmental Protection Agency (EPA) to address poor shoreline management and weak water resource protection ordinances. In addition to outreach and education, trainings, and ordinance work, the Watershed Council assessed shoreline conditions on Burt Lake in 2022, to create a plan for riparian buffer installations. Shoreline conditions were assessed in a survey based on the Quality Assurance Project Plan (QAPP) created for the project.

# INTRODUCTION

## Background

During the summer of 2022, a shoreline survey was conducted on Burt 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 NPS Pollution Control project has been funded wholly or in part through the Michigan Department of Environment, Great Lakes, and Energy's Nonpoint Source Program by the United States Environmental Protection Agency under assistance agreement 2020-0025 to Tip of the Mitt Watershed Council for the project titled "Protecting High-Quality Water Resources in the Burt Lake Watershed. The contents of the document do not necessarily reflect the views and policies of the United States Environmental Protection Agency or the Department of Environment, Great Lakes, and Energy, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

This project is an implementation step from the Burt Lake Watershed Management Plan: SP.1 "Repeat shoreline surveys on Burt, Larks, and Pickerel-Crooked Lakes (completed on or before 2012)." Previous shoreline surveys were conducted on Burt Lake in 2001 (*Cladophora* only) and 2009. This report will compare the 2022 survey results to previous surveys to assess changes in lake-wide riparian management, determine priorities for riparian buffer installations, and identify successes and failures along critical and priority areas.

The 2022 survey provides a comprehensive data set documenting shoreline conditions on Burt 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, problems in shoreline areas that threaten the lake's water quality can be identified and corrected. 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 publicity and education associated with the survey. This specific shoreline survey will be used to determine areas of concern which will be identified as priority parcels for the green belt cost share program section of the EPA grant. Periodic repetition of shoreline surveys is important for identifying new and chronic problem sites, determining long-term trends of near-shore nutrient inputs and shoreline alterations associated with land-use changes, and assessing the success of remedial actions.

## Shoreline Development Impacts

Lake shorelines are 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 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 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 in 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 Burt 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. Burt Lake is one of the largest inland lakes in the State of Michigan (17,400 acres, maximum depth = 72 feet) and thus, relatively resilient to nutrient pollution.

Additionally, Burt Lake is a drainage lake with inflows and an outflow, which provides a mechanism to flush excess nutrients out of the system. Despite Burt 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 algal 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 both near-shore aquatic and terrestrial organisms. 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 the means to remove contaminants that have accumulated in the lake ecosystem. With regard 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

Burt Lake is located in the northern tip of the Lower Peninsula of Michigan; in Burt and Tuscarora Townships of east-central Cheboygan County. Based on digitization of aerial orthophotography provided by Cheboygan County Equalization (2008), the shoreline of Burt Lake measures 35.07 miles and lake surface area totals 17,436 acres. Burt Lake is approximately 9.5 miles long and nearly 5 miles across at its widest point. Bathymetry maps from the State of Michigan show the deepest area, east of Colonial Point with a maximum depth of 73 feet (Figure 1). Tip of the Mitt Watershed Council water quality monitoring data confirmed this maximum depth.

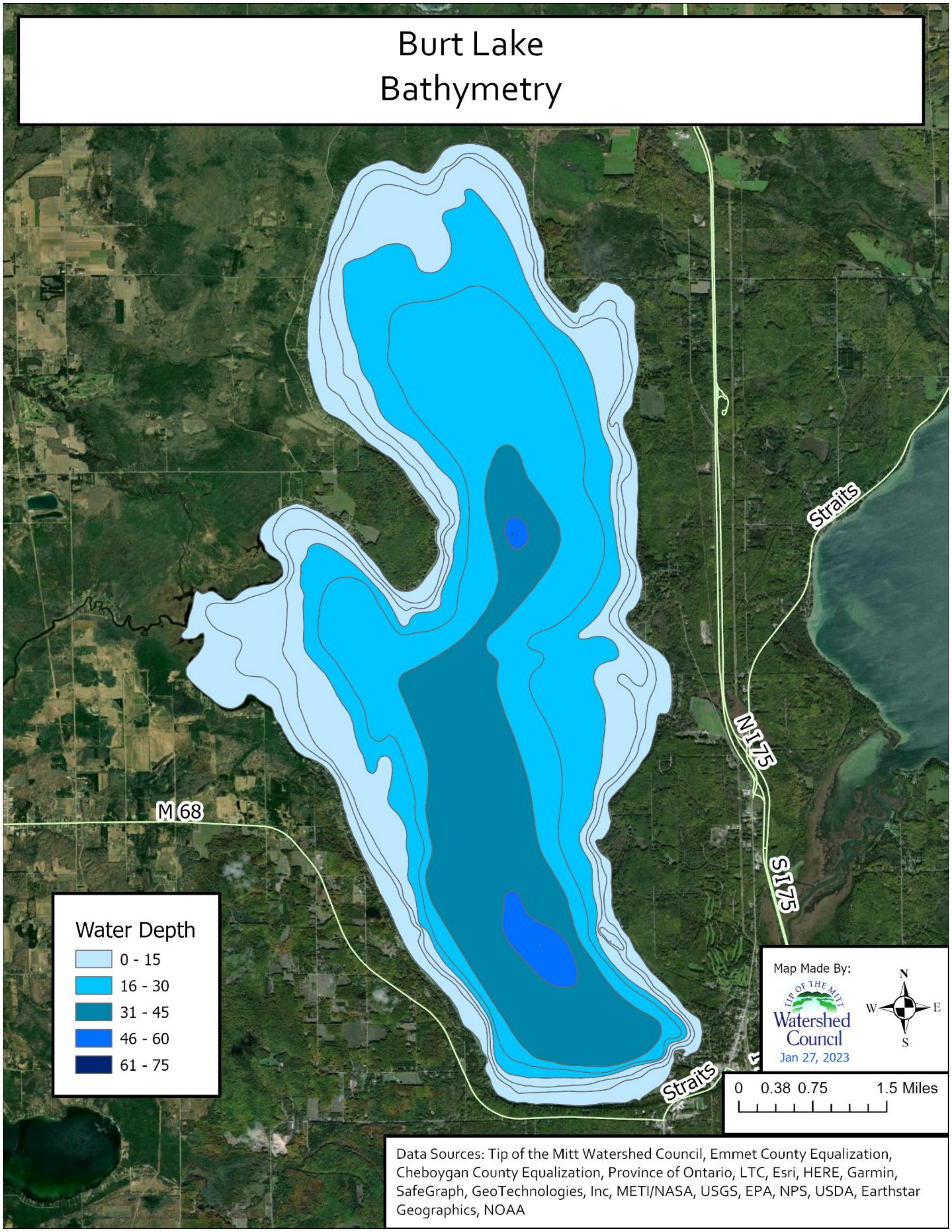



*Figure 1. Burt Lake Features and Depths.*

Burt Lake's primary inflows include the Maple River, the Sturgeon River, the Crooked River, and the Little Carp River. Its primary outflow is the Indian River, which drains to Mullett Lake and eventually Lake Huron through the Cheboygan River.

Of the 18 miles of Burt Lake's 35-mile shoreline that are developed, 45% have wetland characteristics. Extensive wetland areas are located adjacent to the lake between Maple and Poverty Bays on the west-central shoreline and at the northern end of the lake. The shoreline topography ranges from low, flat, wetlands to extremely steep (45%+) banks that rise more than 100 feet above the lake. However, most of the shoreline is fairly level to rolling. The soils of the Burt Lake shoreline are extremely variable. They range from very poorly drained (muck) to excessively drained (sand). All of the soil series contiguous to the shoreline have severe limitations for on-site septic systems.

Land cover in the Burt Lake Watershed has changed little over 30 years (1985-2016). The watershed lost 3% of its forested areas and 1% of grasslands. Agriculture and urban land uses increased by 1%. Wetland areas have been continuously protected, as the percentage has remained the same (Table 1).

*Table 1. Land cover in the Burt Lake Watershed.*

| Land Cover Type | 1985 | % | 2016 | % | Change |
|---|---|---|---|---|---|
| **Agriculture** | 30746 | 8 | 33612 | 9 | 1 |
| **Barren** | 401 | 0 | 651 | 0 | 0 |
| **Forested** | 195515 | 53 | 186493 | 50 | -2 |
| **Grassland** | 38321 | 10 | 33834 | 9 | -1 |
| **Scrub/Shrub** | 13198 | 4 | 20423 | 5 | 2 |
| **Urban** | 10479 | 3 | 13859 | 4 | 1 |
| **Water** | 28003 | 8 | 28025 | 8 | 0 |
| **Wetland** | 54510 | 15 | 54473 | 15 | 0 |
| **Total** | 371173 | 100.00% | 371371 | 100% | |

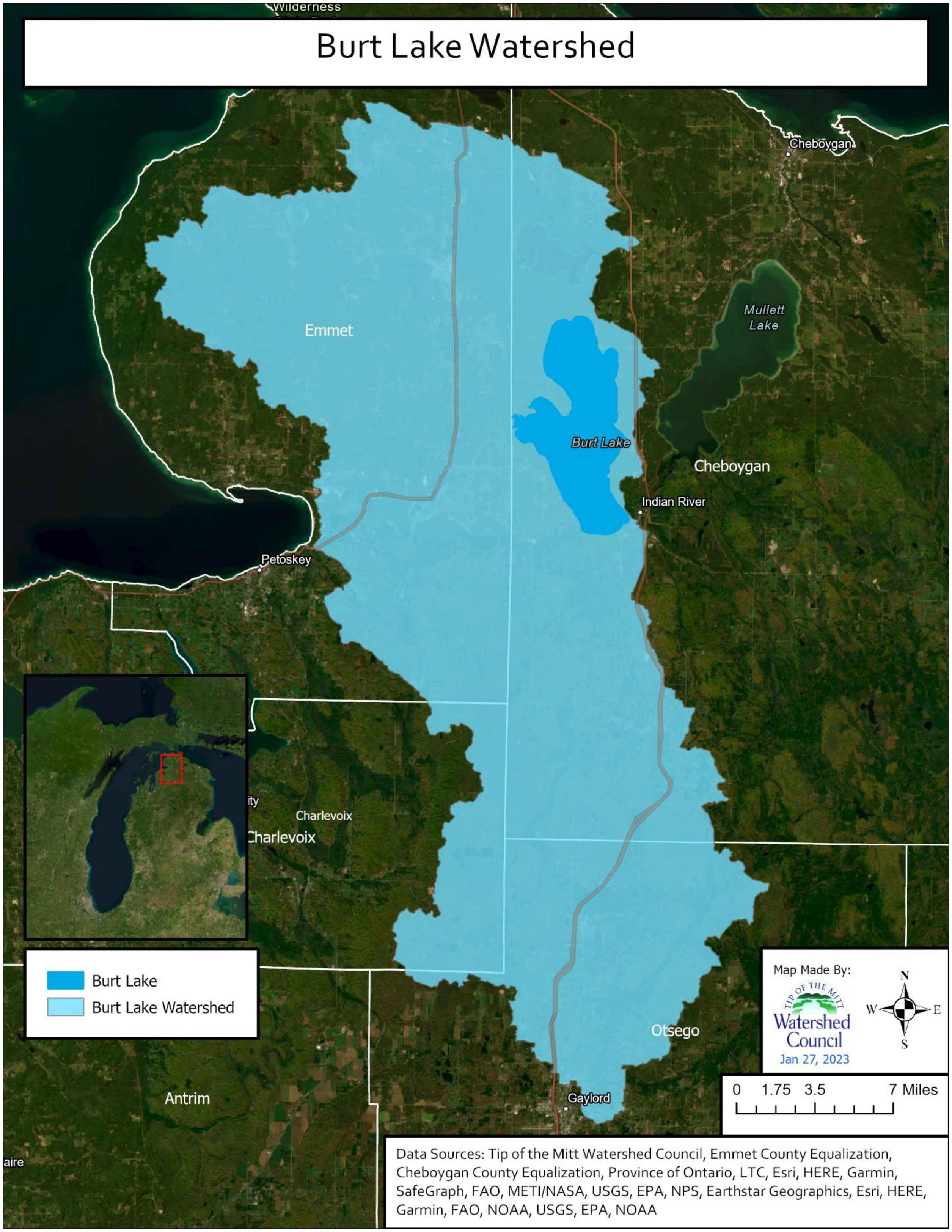
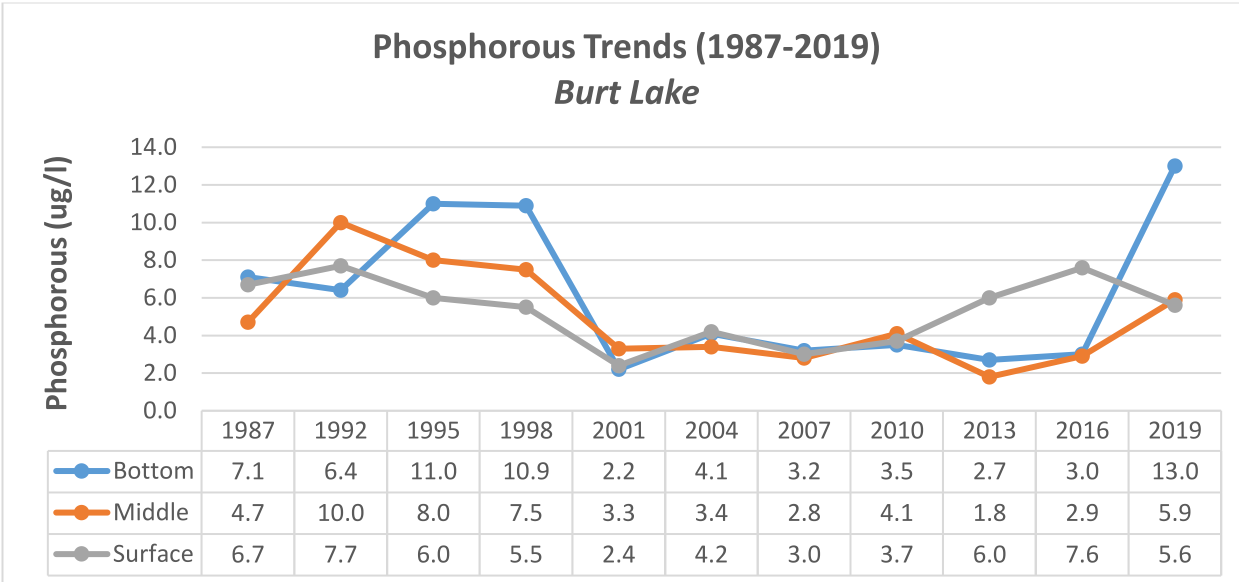



*Figure 2. Map of the Burt Lake Watershed.*

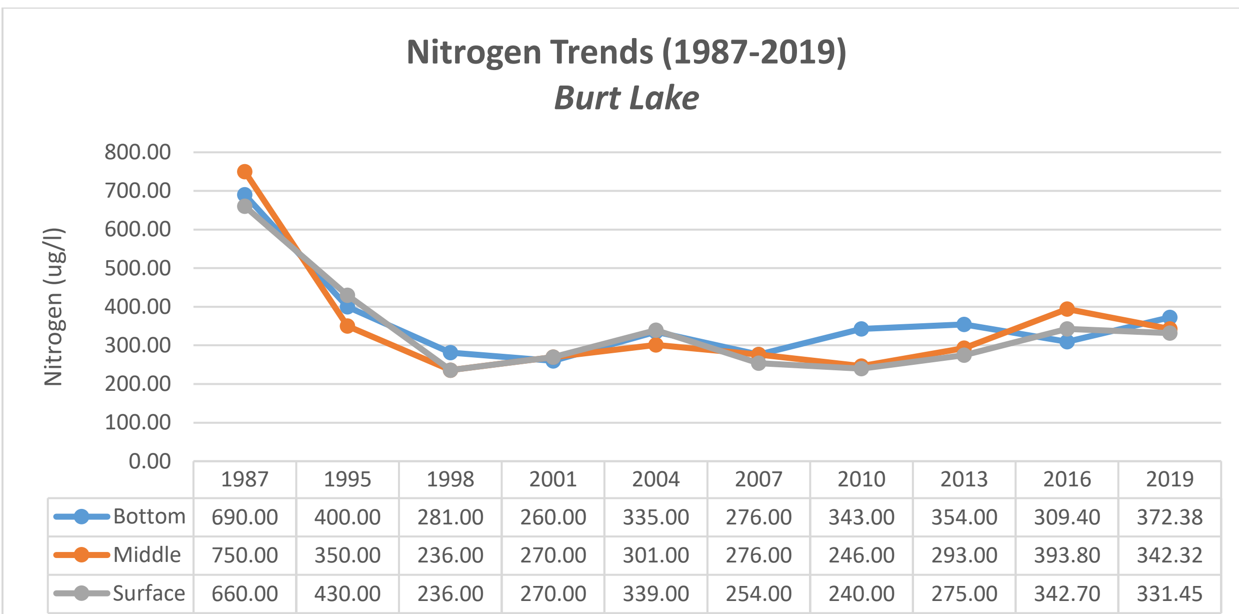
The water quality of Burt Lake has been monitored consistently for more than three decades. The Burt Lake Preservation Association (BLPA) has actively supported water quality monitoring programs on Burt Lake, providing volunteers for monitoring programs coordinated by the Watershed Council. In addition, Burt Lake is monitored by Watershed Council staff as part of the Comprehensive Water Quality Monitoring program (CWQM). Watershed Council databases contain Volunteer Lake Monitoring and CWQM data that date back to 1989 and 1987 respectively.

Burt Lake has been monitored every three years since 1987 at the deepest point by Watershed Council staff as part of our CWQM program. Monitoring is conducted in the spring within two weeks after ice-out. Water samples are collected at the top, middle, and bottom of Burt Lake and analyzed for total nitrogen, nitrate-nitrogen, total phosphorus, and chloride. A multi-parameter probe is used to measure temperature, depth, dissolved oxygen, conductivity, and pH. Monitoring found that nitrogen and phosphorus values were lowest between 2001 and 2016 (**Error! Reference source not found.**, **Error! Reference source not found.**). Nitrogen levels have remained consistent overall, following the significant decrease in the 1990s. However, phosphorus levels have spiked again recently. With phosphorus levels on the bottom of the lake reaching a record high. According to U.S. Environmental Protection Agency recommendations for lakes in ecoregion 50, natural conditions in lakes have less than 9.69 micrograms per liter (µg/l) of total phosphorus and 400 µg/l of total nitrogen. Water near the bottom of Burt Lake exceeded the values for total phosphorus in 1995, 1998, and 2019. The middle and bottom of Burt Lake last exceeded the values for total nitrogen in 1995. Chloride has also been increasing since 1992 (**Error! Reference source not found.**).



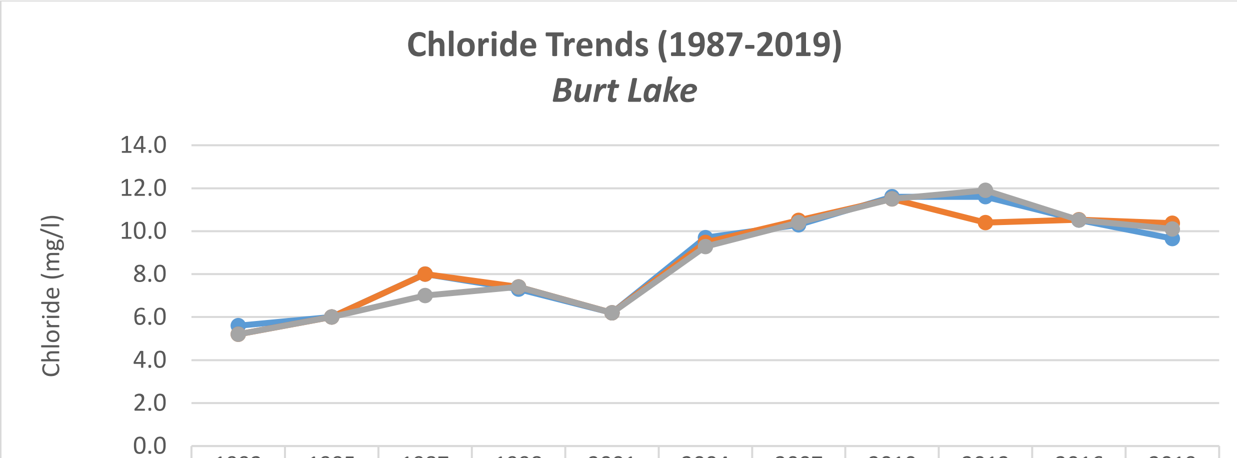

| | 1987 | 1992 | 1995 | 1998 | 2001 | 2004 | 2007 | 2010 | 2013 | 2016 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bottom | 7.1 | 6.4 | 11.0 | 10.9 | 2.2 | 4.1 | 3.2 | 3.5 | 2.7 | 3.0 | 13.0 |
| Middle | 4.7 | 10.0 | 8.0 | 7.5 | 3.3 | 3.4 | 2.8 | 4.1 | 1.8 | 2.9 | 5.9 |
| Surface | 6.7 | 7.7 | 6.0 | 5.5 | 2.4 | 4.2 | 3.0 | 3.7 | 6.0 | 7.6 | 5.6 |

*Figure 3. Phosphorus trends on Burt Lake.*




| | 1987 | 1995 | 1998 | 2001 | 2004 | 2007 | 2010 | 2013 | 2016 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Bottom | 690.00 | 400.00 | 281.00 | 260.00 | 335.00 | 276.00 | 343.00 | 354.00 | 309.40 | 372.38 |
| Middle | 750.00 | 350.00 | 236.00 | 270.00 | 301.00 | 276.00 | 246.00 | 293.00 | 393.80 | 342.32 |
| Surface | 660.00 | 430.00 | 236.00 | 270.00 | 339.00 | 254.00 | 240.00 | 275.00 | 342.70 | 331.45 |

*Figure 4. Nitrogen trends on Burt Lake*




| | 1992 | 1995 | 1987 | 1998 | 2001 | 2004 | 2007 | 2010 | 2013 | 2016 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bottom | 5.60 | 6.00 | 8.00 | 7.30 | 6.20 | 9.70 | 10.30 | 11.60 | 11.60 | 10.52 | 9.66 |
| Middle | 5.20 | 6.00 | 8.00 | 7.40 | 6.20 | 9.48 | 10.50 | 11.50 | 10.40 | 10.54 | 10.37 |
| Surface | 5.20 | 6.00 | 7.00 | 7.40 | 6.20 | 9.29 | 10.40 | 11.50 | 11.90 | 10.52 | 10.10 |

*Figure 5. Chloride trends on Burt Lake.*

Volunteer Lake Monitoring has been conducted at two sites on Burt Lake since 1986 (North and South basins) and one site since 1989 (main). Volunteer Lake Monitoring follows Cooperative Lakes Monitoring Program protocols (adapted slightly for Watershed Council volunteers) and includes weekly Secchi disk readings and bi-weekly chlorophyll-a samples May through August each year  (Tip of the Mitt Watershed Council, 2021). Secchi disk readings and chlorophyll-a samples can be used to assign a Trophic State Index value, which characterizes the lake's productivity. Based on volunteer lake monitoring data, Burt Lake falls into the oligotrophic category, which indicates low biological productivity (Figure 10). Oligotrophic lakes are characteristically large, deep, and nutrient poor, but have ample stores of dissolved oxygen and, in general, high water quality.

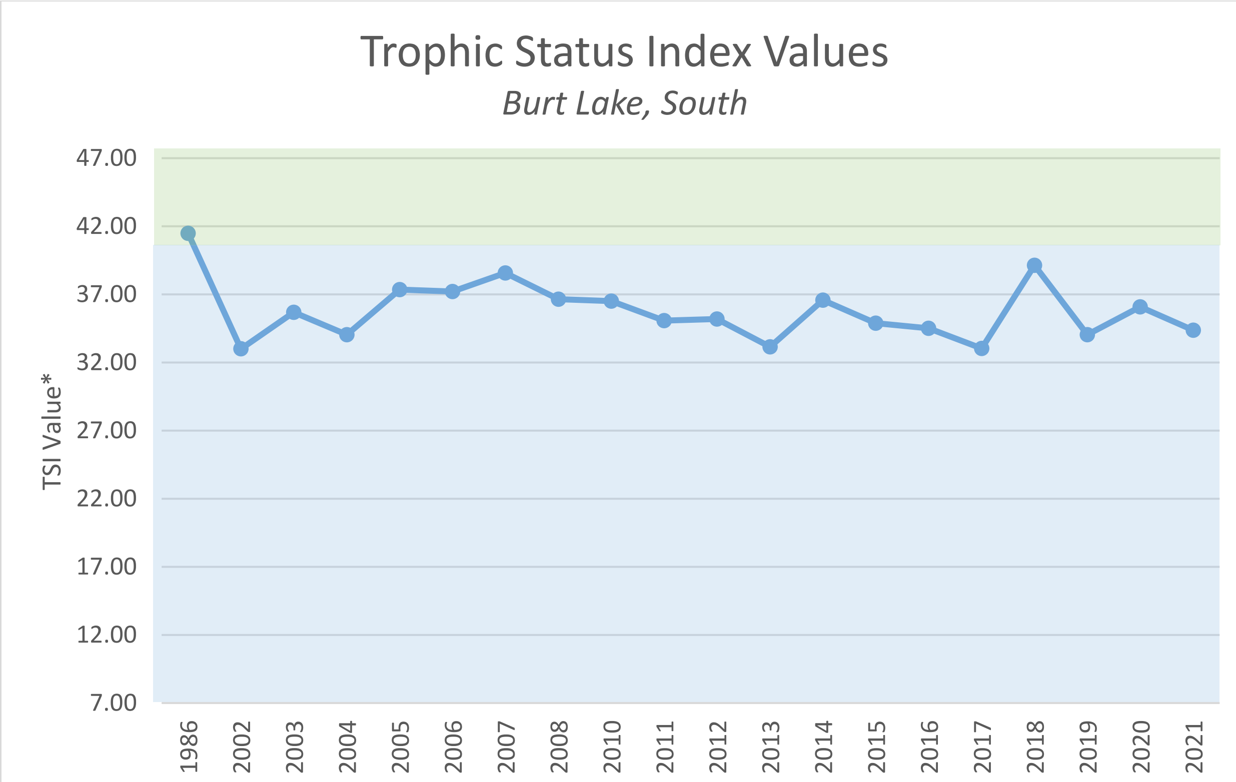



*Figure 6. Historical trophic status index values for Burt Lake (South).*

A shoreline survey performed on Burt Lake was carried out in 2001 and used for the development of the Burt Lake Watershed Management Plan (TOMWC, 2002). Based on the 2001 shoreline survey report, indicators of nutrient pollution were found at 20% of the 972 properties surveyed and poor greenbelts were documented at 56% of properties (TOWMC, 2001). The last shoreline survey conducted on Burt Lake occurred in 2009. The results of this survey indicated that human activity along the Burt Lake shoreline was likely impacting the lake ecosystem and water quality. A sign of nutrient pollution was noted at over half of the shoreline properties, 36% had greenbelts in poor condition, 46% had altered shorelines, and erosion was present at 6% of sites in this survey. In comparison to 32 other lakes surveyed in Northern Michigan, Burt Lake had above average *Cladophora* density (heavy algae levels), and a moderate number of poor greenbelts and altered shorelines. Recommendations were made as a result of this survey, including education to homeowners, encouragement to participate in identifying and rectifying issues at their properties, and repeating the shoreline survey every 3-5 years.

In 2013, the Watershed Council acquired funding from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) to develop a nonpoint source pollution watershed management plan for the Burt Lake Watershed. The Plan was approved in 2018 and identified the following sources of nonpoint source pollution: poor shoreline management and weak water resource protection ordinances, along with stormwater road/stream crossings, streambank erosion, and septic systems. In 2021, the Watershed Council acquired funding from EGLE to address poor shoreline management and weak water resource protection ordinances. In addition to outreach and education, trainings, and ordinance work, the Watershed council assessed shoreline conditions on Burt Lake in this survey and will install riparian buffers based on the results. Shoreline conditions were assessed based on methods described in the Quality Assurance Project Plan (QAPP) for the project.

The 2022 survey provides another comprehensive data set documenting shoreline conditions on Burt Lake; a valuable data set that can be used as a lake management tool. Combined with follow-up activities, including on-site visits, problems in shoreline areas that threaten the lake's water quality can be identified and solved. 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 and shoreline alterations associated with land-use changes, and for assessing the success of remedial actions.

# METHODS

From June to July, the entire Burt Lake shoreline was surveyed to comprehensively document shoreline conditions. 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, and tributaries. Information for each property was recorded on iPads using the app ArcGIS FieldMaps, which immediately linked it with property owner data from county equalization records.

## Field Survey Parameters

A feature class with shoreline property outlines and ownership information were collected from Emmet and Charlevoix County Equalization in February 2022, and imported into the software program ArcGIS Pro. The parcels from each county were merged into a single feature layer. Only shoreline parcels were selected using a 200-meter buffer around a shapefile of Burt Lake. Fields for each survey parameter were set up in an attribute table with owner, property identification numbers, and address information. Domains were described in each field according to options available under each parameter. The feature layer was uploaded to ArcGIS online and options were set for editing offline in the app ArcGIS FieldMaps. The lake was split into five zones, and each zone was downloaded separately on the FieldMaps app in an iPad for data collection.

Shoreline property features were documented by photographing and noting physical features in the FieldMaps app on iPads. Physical features include building descriptions, public access sites, and county road endings. Building descriptions were recorded in an abbreviated style such as, “*Red 2 sty, brn rf, wht trm, fldstn chim, lg pine.”* This 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.

### Development

Parcels were noted in FieldMaps as developed, non-developed, or partially developed, in 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. Partially developed parcels included those with a non-livable structure or addition to the land, including a shed, driveway, gazebo, etc. The length and area of developed versus undeveloped shoreline was not calculated.

### *Cladophora*

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, such as unidentified Golden Brown Algae, 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 feet 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) | A green shimmer |
| Light | (L) | Up to 25% coverage |
| Light to Moderate | (LM) | 25-49% coverage |
| Moderate | (M) | 50-59% coverage |
| Moderate to Heavy | (MH) | 60-74% coverage |
| Heavy | (H) | 75-99% coverage |
| Very Heavy | (VH) | 90-100% coverage |

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 considered 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), W = woody debris (logs, sticks), and MTL = steel bulkhead, barrels, etc. Suitable habitat for *Cladophora* growth, which is based on the substrate types present and includes the categories: G, R, B, W and MTL. Either Yes (Y), Partial (P), or No (N), was noted to record if habitat for *Cladophora* was present throughout most of the shoreline.

## Greenbelts

Greenbelts, i.e. shoreline vegetation, 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:

*Table 3. Greenbelt scoring chart.*

| **Score** | **Length (%)** | **Depth (feet)** |
|---|---|---|
| 0 | Absent | Absent |
| 1 | <10% | <10 |
| 2 | 10-25% | 10-40 |
| 3 | 25-75% | >40 |
| 4 | >75% | NA |

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

Shoreline alterations were surveyed and noted with the following abbreviated descriptions. Bulkheads refer to an erect manmade structure parallel to shoreline, which hardens the shoreline. Rip-rap can be described as a range of individual rocks that harden the shoreline.

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

## Erosion

Erosion was noted based on shoreline areas that exhibited areas of bare soil, leaning or downed trees, exposed tree roots, scalloped shoreline shape, rapid rate of recession, vegetation removal for beach sand, slumping hunks of sod, undercut bans and gullies from runoff.  Similar to *Cladophora*, shoreline erosion was recorded on field data sheets with estimates of its extent and relative severity (light (L), moderate (M), or heavy (H)).  For example, “Mx20’ at E. End” indicated 20 feet of shoreline with moderate erosion on the east end.  Additional information about the nature of the erosion, such as obvious causes, were also noted.

## Tributaries

Tributaries (i.e., rivers and streams) were noted (Y = yes, N = no) on the field data sheets and included in a separate column in the database. Tributary information is important because effluent may contain higher levels of nutrients, which can contribute to *Cladophora* growth and cause algal blooms.

### Aquatic Plants

Aquatic plants along the shoreline were recorded because they provide habitat and their root systems assist in stabilizing the shoreline. Aquatic plants within 20' of the water's edge were noted using the following categories:

E = emergent plants (bulrushes, cattails, arrowhead, or pickerelweed)

F= floating leaved plants (white water lily or yellow pond lily)

S = submergent aquatic plants (pondweeds, watermilfoils, chara)

### Comments

Additional information regarding shoreline property features or shoreline conditions recorded on field data sheets was included in the database in a "comments" column.

## Data Processing

Data was collected using the app ArcGIS FieldMaps on offline maps. Offline maps were synced daily to a web map on ArcGIS online. Data was downloaded from the ArcGIS shapefile.

Discrepancies were altered when processing the data in order to best represent the data collected. All "Null" values were changed to "None" or "0" depending on the parameter for the specific data. The counting of discharge pipes was inconsistent in the field. Each discharge pipe was counted as one alteration, meaning if one parcel had multiple, each was counted individually, when they should have only been recorded as one. This was fixed, so if one or more discharge pipes existed on the parcel it was counted as one alteration per parcel. A section of parcels on the east side of the lake had a shared lawn, so data was only collected for one parcel in the field. In the office, the other parcels were scored the same for each parameter based off the one all-encompassing parcel. Not all parcels were recorded as developed or non-developed in the field. The parcel layer and property descriptions captured in the field were coupled with high resolution imagery to determine if a parcel as developed in the office.

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 departments and a Burt Lake shoreline layer. The new map layer consists of a 200-meter band following the shoreline, split into polygons that contain field and equalization data. This had to be increased from the original proposed, 100-meter band, because a band of that size was not visible on the maps produced. Parcels were generalized and squared off so the public data layer does not match actual parcel size and shape.

Final products include a comprehensive database with attached photos, GIS data layers of shoreline parcels that include both county equalization and shore survey data, and a story map displaying results. 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 hard-copy maps.

# RESULTS

This survey documented shoreline conditions at 1,139 parcels on Burt Lake.

## Development

Approximately 92% (1,045) of shoreline properties on Burt Lake were considered to be developed or partially developed, with the vast majority of these being developed (Figure 7).

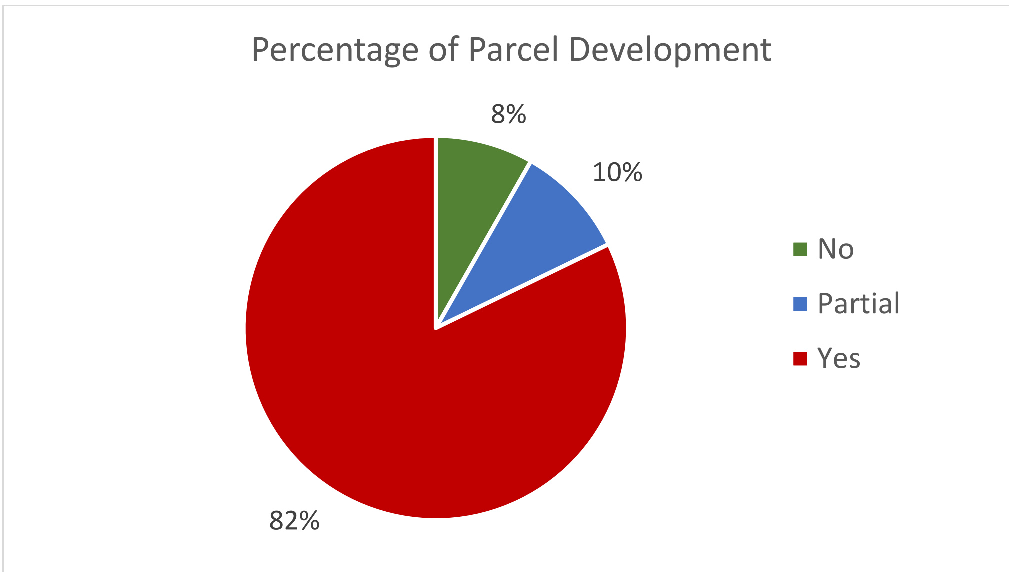



*Figure 7. Percentage of parcel development on Burt Lake 2022.*

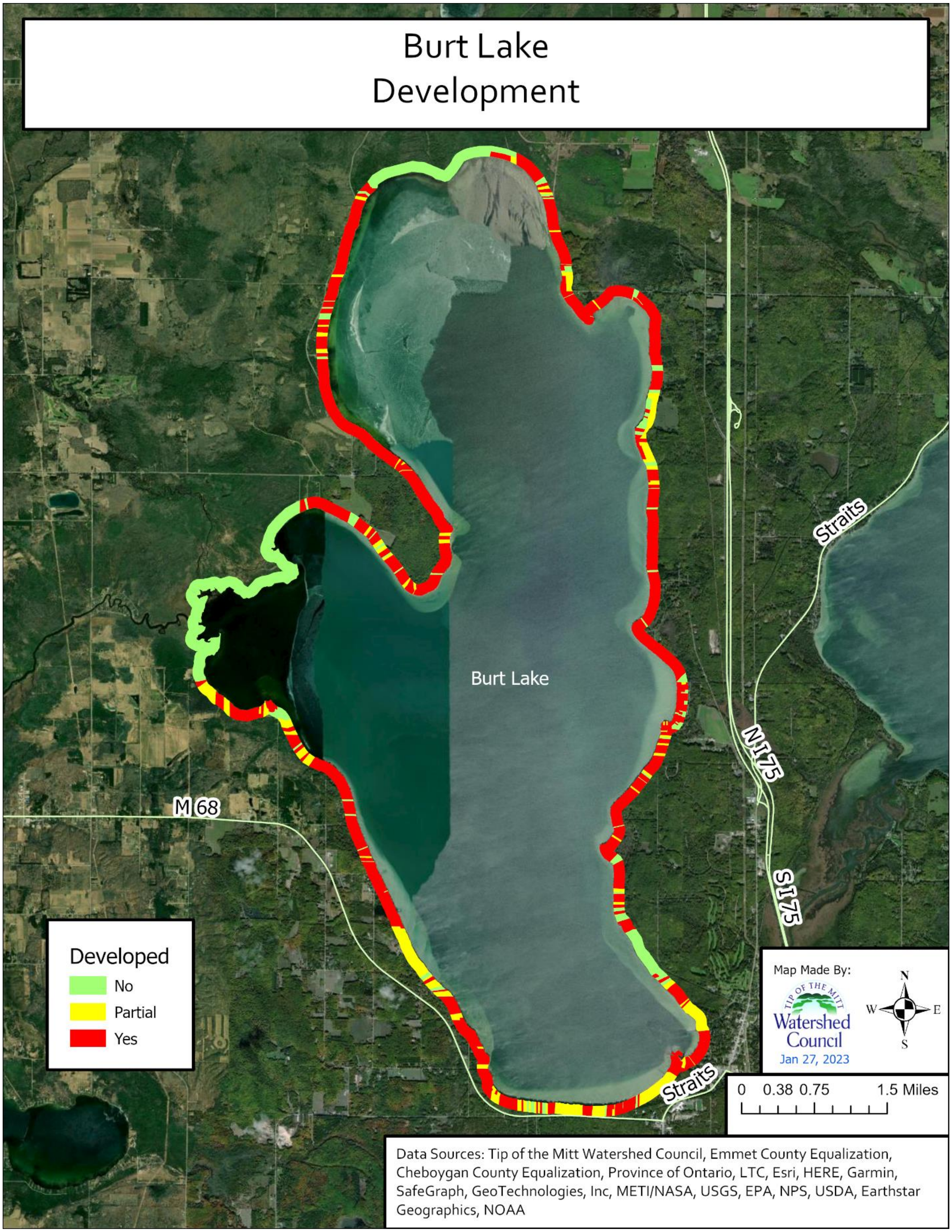



*Figure 8. Parcel development for Burt Lake 2022.*

### *Cladophora*

The majority (77%) of parcels had no visible *Cladophora* growth. However, habitat suitable for *Cladophora* growth was present along only 23% of shoreline properties (261). About half (47%) of parcels where *Cladophora* growth was observed in 2022 consisted of light to very light growth (Table 4). Results show there are fewer parcels with a very heavy amount of *Cladophora* overall, but a few more with moderate-heavy, heavy, and even more with moderate amounts.

*Table 4. Cladophora density 2022.*

| ***Cladophora* Density** | **Number of Parcels** | **Percent** |
|---|---:|---:|
| Very light | 44 | 16.9 |
| Light | 78 | 29.9 |
| Light to Moderate | 38 | 14.6 |
| Moderate | 53 | 20.3 |
| Moderate to Heavy | 22 | 8.4 |
| Heavy | 20 | 7.7 |
| Very Heavy | 6 | 2.3 |
| TOTAL | 261 | 100.0 |

Notably, the majority of *Cladophora* were associated with sites near tributaries or discharge pipes (refer to Discussion section). Most were artesian wells.

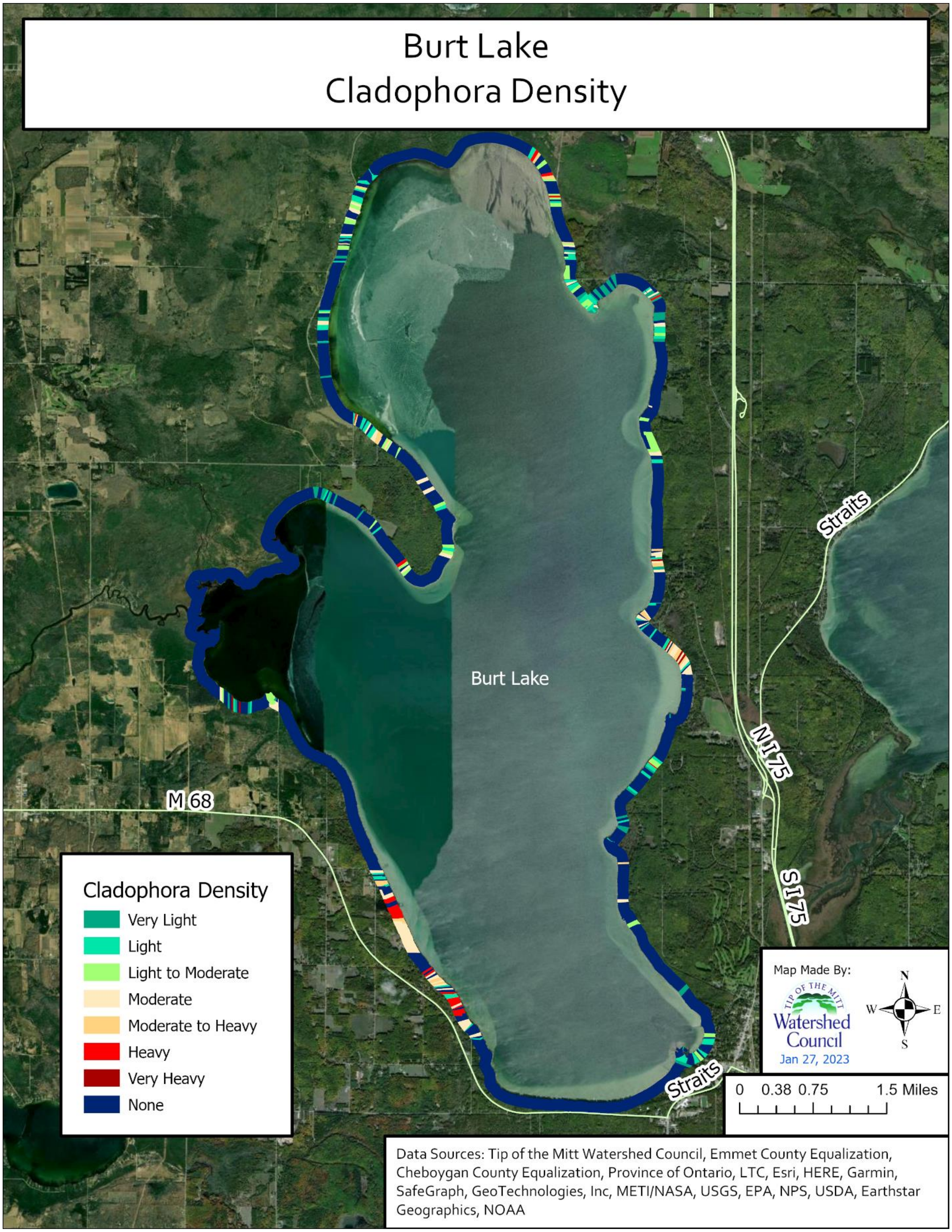



*Figure 9. Cladophora density for Burt Lake 2022.*

Recording the substrate present at parcels is important because 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 considered when interpreting the occurrence of individual growths, and assessing the overall distribution of *Cladophora* along a particular stretch of shoreline. *Cladophora* requires a hard surface to grow on. Suitable habitat for *Cladophora* growth in this project, based on the substrate types present, includes the categories: gravel, rock, boulder, woody debris and steel bulkhead/barrels etc.

Survey results show that 345 parcel shorelines (30.3%) were suitable habitat for *Cladophora* growth. This number was comprised of rock and gravel substrates, as no boulder, steel bulkhead/barrels, or woody debris was found (Table 5).

*Table 5. Substrate types found showing parcels suitable for Cladophora habitat.*

| **Substrate Type** | **Frequency** | **Percent** |
|---|---|---|
| Boulders (>10") | 0 | 0 |
| Rocks (2.5"-10") | 337 | 29.6 |
| Gravel (0.1"-2.5") | 8 | 0.7 |
| Steel bulkhead, barrels, etc. | 0 | 0.0 |
| Woody debris (logs, sticks, bulkhead) | 0 | 0.0 |
| Muck-soft or marl bottom | 16 | 1.4 |
| Sand | 560 | 49.2 |
| None | 218 | 19.1 |
| Total | 1139 | 100.0 |

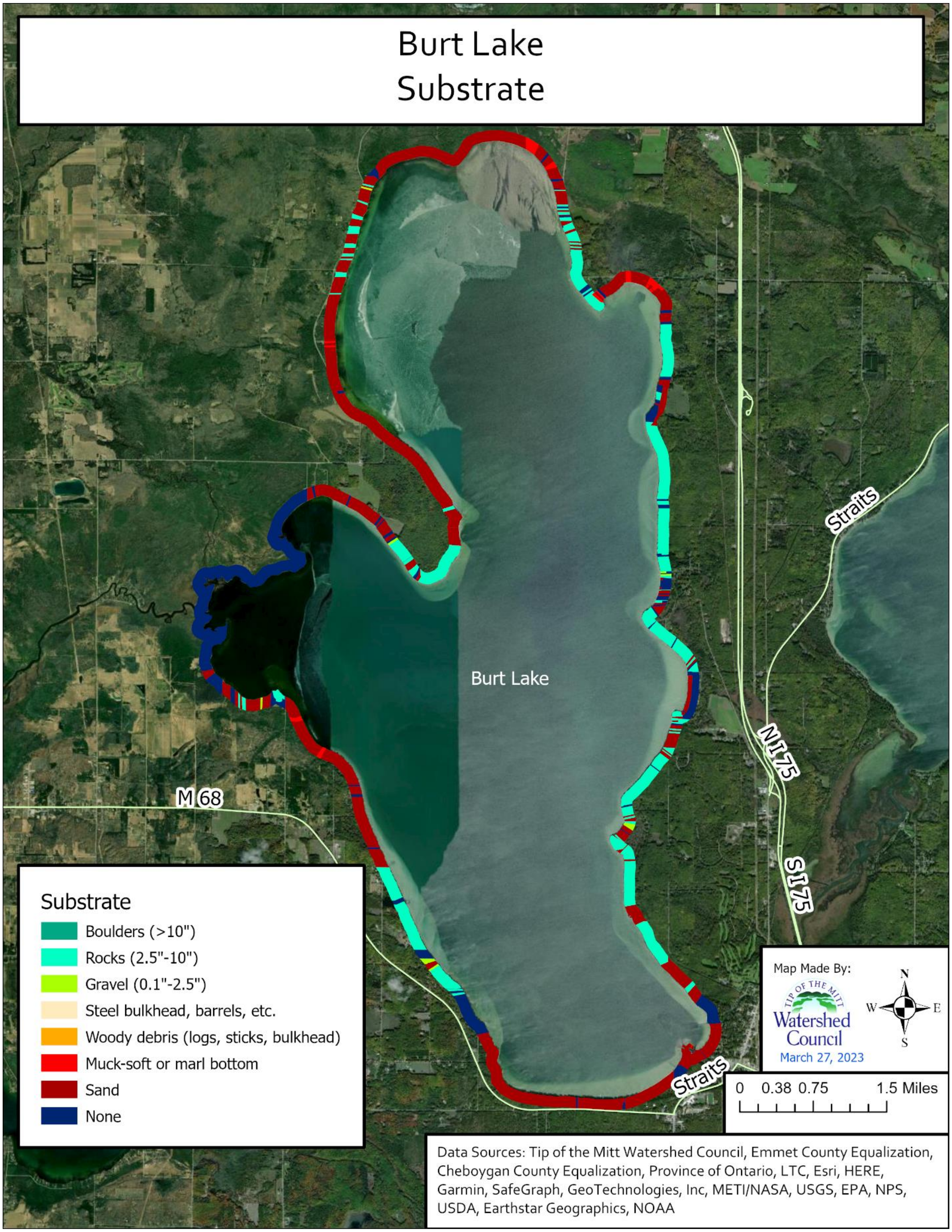



*Figure 10. Map of substrate types for parcels.*

### Greenbelts

Greenbelt scores ranged from 0 (Very Poor) to 7 (Excellent). The highest percentage (39.6%) of Burt Lake parcels had a very poor greenbelt score, meaning that the greenbelt was absent. Just under half (49.2%) of Burt Lake's parcels fell into the two lowest categories, labeled very poor or poor, while 38.2% of parcels were rated good or excellent (Table 6). The parcel greenbelt scores chart and map (Figures 11 and 12) are great visuals for understanding the large number of parcels where greenbelts were absent.

*Table 6. Greenbelt scores 2022.*

| Greenbelt Score | Frequency | Percent |
|---|---|---|
| Very Poor (0/Absent) | 451 | 39.6 |
| Poor (1-2) | 110 | 9.6 |
| Moderate (3-4) | 143 | 12.6 |
| Good (5-6) | 299 | 26.3 |
| Excellent (7) | 136 | 11.9 |
| **Total** | **1139** | **100.0** |

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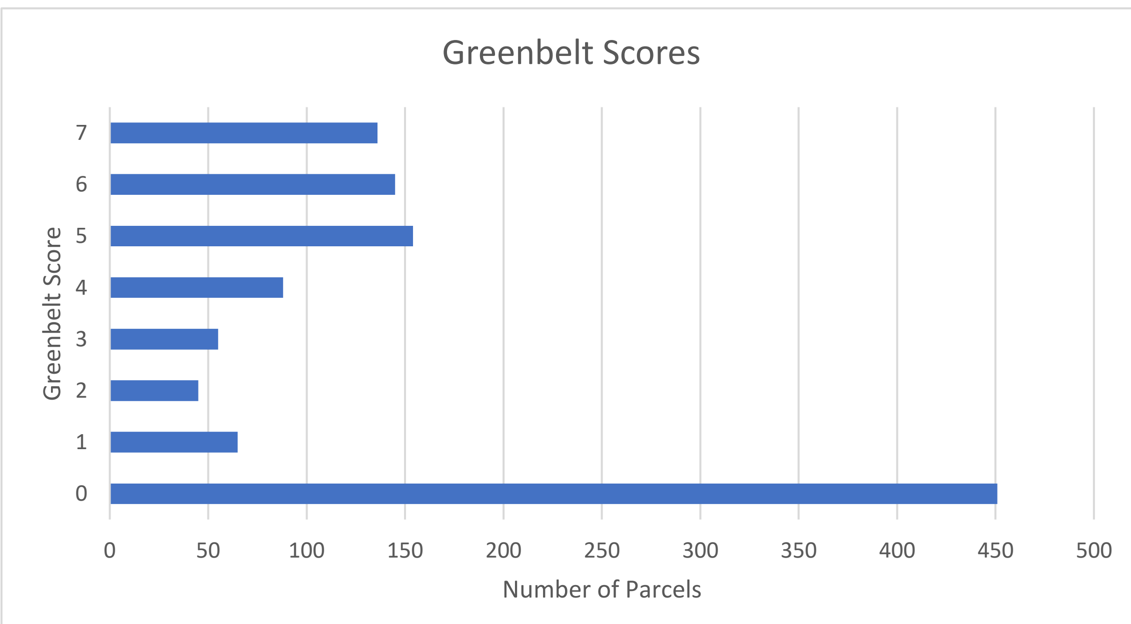


*Figure 11. Greenbelt scores for Burt Lake 2022.*

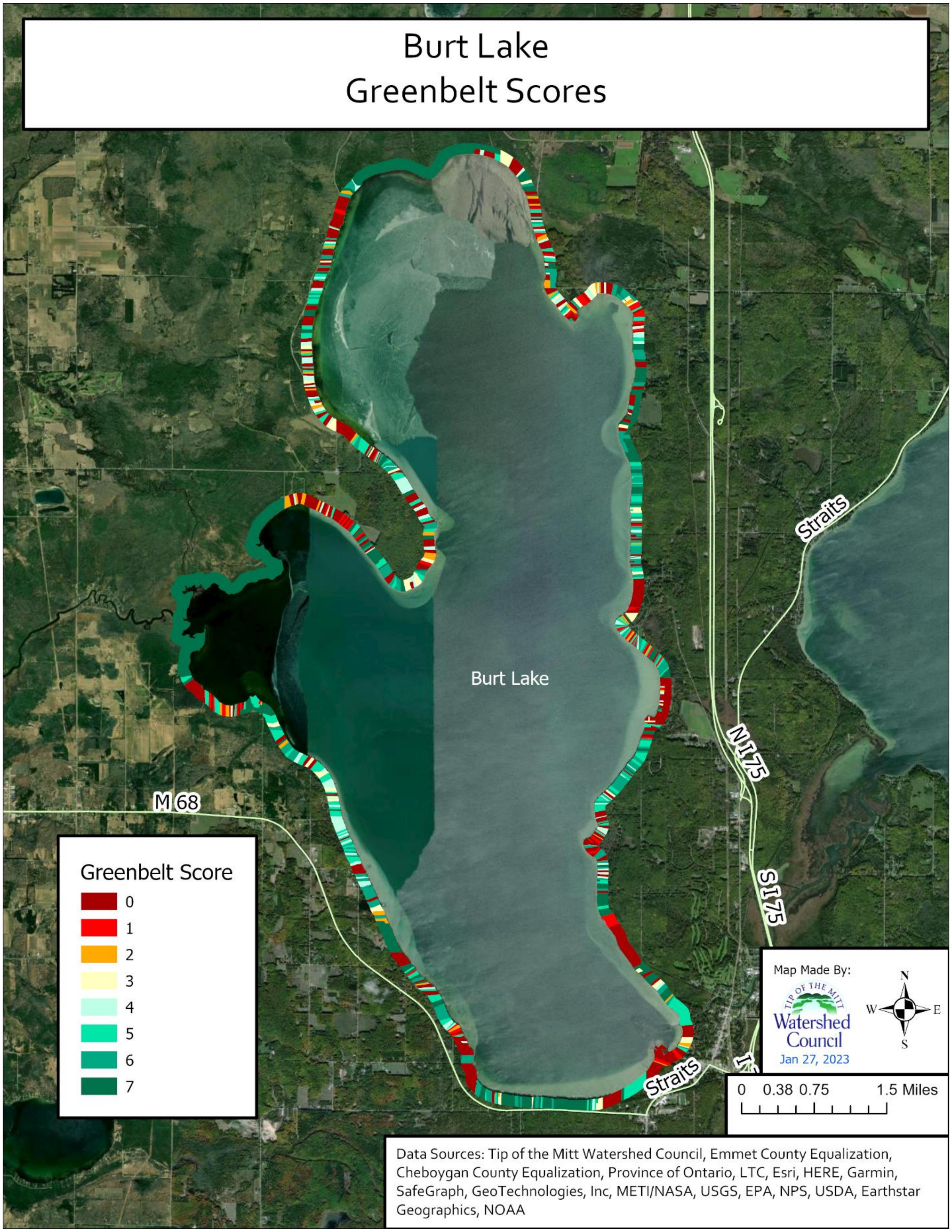


*Figure 12. Map of Burt Lake greenbelt scores 2022.*

## Shoreline Alterations

A total of 743 parcels (65%) had at least one alteration to the shoreline, while over one-third (35%) of properties had no alterations to their shorelines. The most shoreline alterations found on one parcel was 4 alterations, but the most common number of alterations was just 1, which was present at 519 properties (45.6%) (Table 7). The most common alteration seen (40%), was some form of rip-rap including rock rip-rap, mixed boulder and rock rip-rap, and big boulder rip-rap/bulkhead (Table 8 & Figure 13).

Note that the percentages for the following two tables depend on the total frequency numbers, which are different in the two tables. The first table refers to the total number of parcels, while the second refers to the total number of alterations found.

*Table 7. Number of alterations per parcel 2022.*

| Number of Alterations per Parcel | Frequency | Percent |
|---|---|---|
| 0 | 396 | 34.8 |
| 1 | 519 | 45.6 |
| 2 | 174 | 15.3 |
| 3 | 36 | 3.2 |
| 4 | 14 | 1.2 |
| **Total** | **1139** | **100.0** |

*Table 8. Alteration types for shorelines 2022.*

| Alterations (Aggregated) | Frequency | Percent |
|---|---|---|
| Rip-rap (all types) | 565 | 40.0 |
| Seawall/Bulkhead (all types) | 109 | 7.7 |
| Beach Sand | 87 | 6.2 |
| Other | 256 | 18.1 |
| None | 396 | 28.0 |
| **Total** | **1413** | **100.0** |

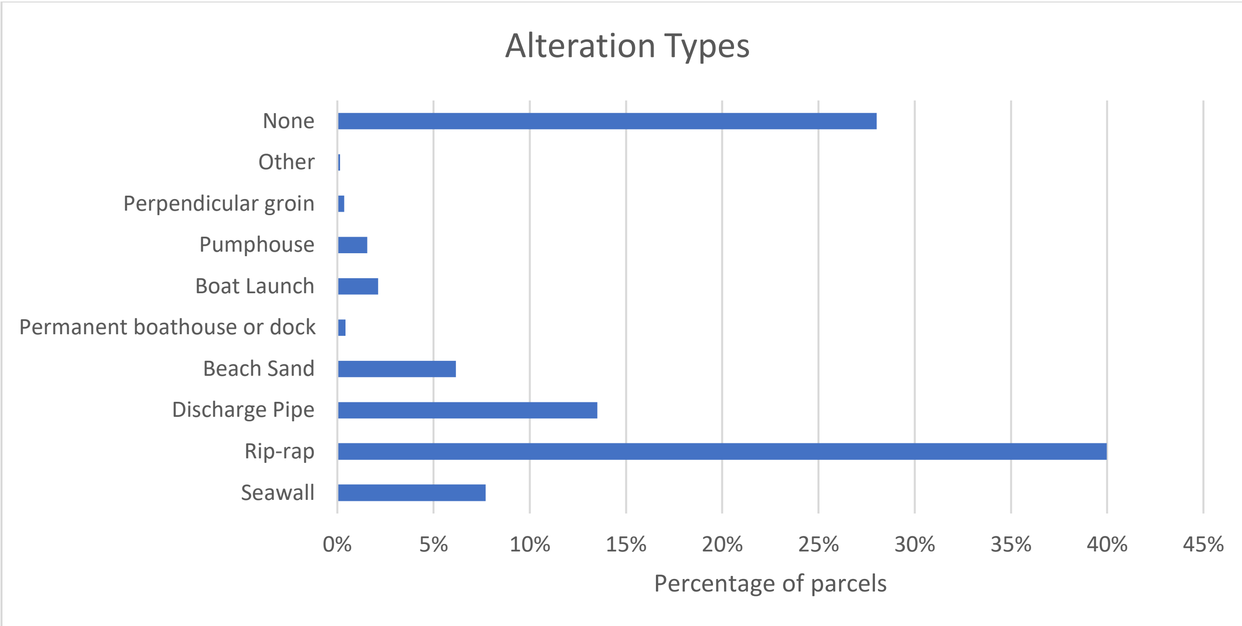


*Figure 13. Alterations on Burt Lake shorelines 2022.*

### Erosion

Erosion was noted at 116 parcels on Burt Lake in 2022. Only erosion that was observed to be caused by human activities was recorded. The majority (89.8%) of shoreline properties did not show signs of erosion (Table 9). Locations for erosion were scattered along the Burt Lake shoreline, but one concentrated location for erosion was on the west shore of White Goose Bay (Figure 14).

*Table 9. Erosion severity 2022.*

| Erosion Severity | Frequency | Percent |
|---|---|---|
| Low | 44 | 3.9 |
| Medium | 46 | 4 |
| High | 23 | 2 |
| Severe | 3 | 0.3 |
| None | 1023 | 89.8 |
| **Total** | **1139** | **100.0** |

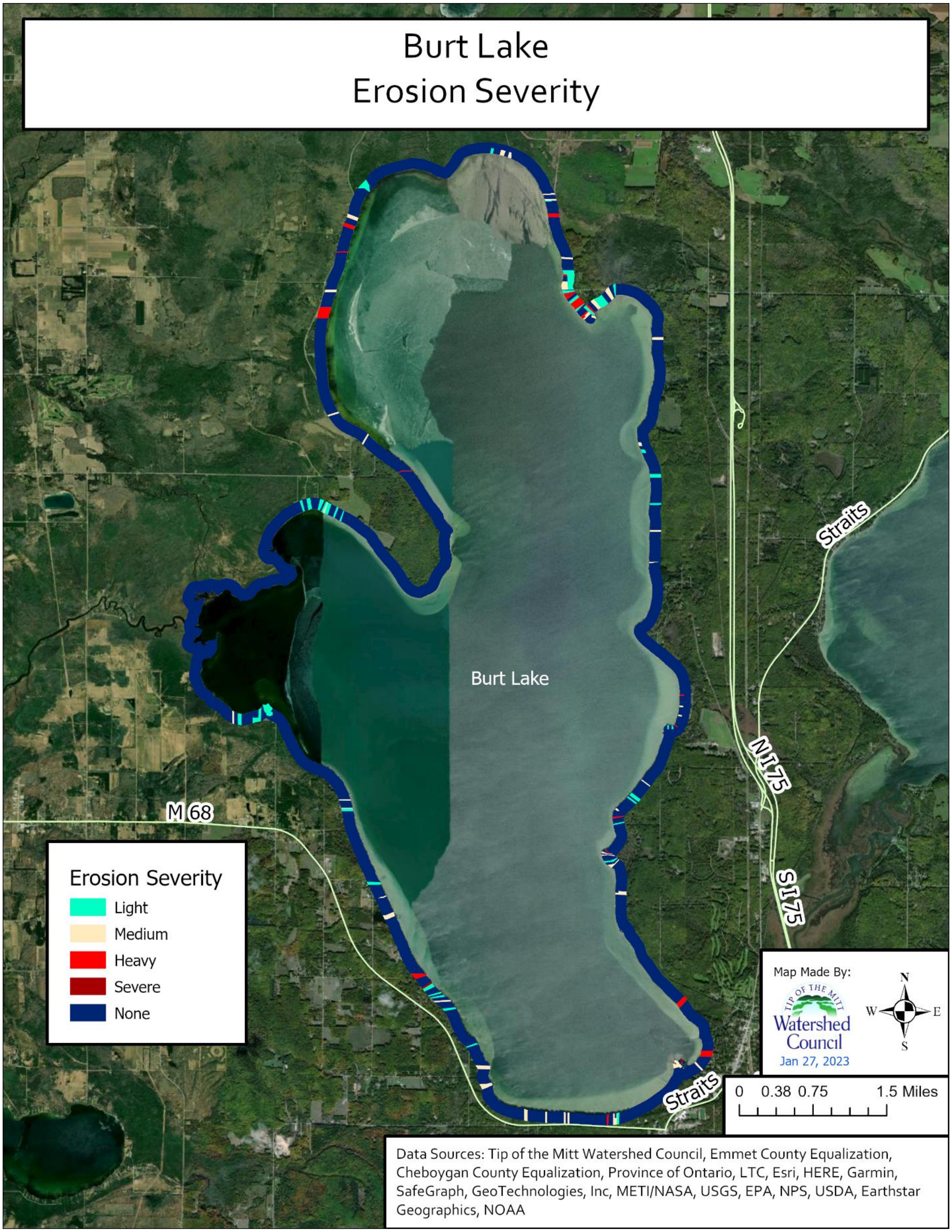


*Figure 14. Map of Burt Lake shoreline erosion 2022.*

# 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 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 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. Residents who live on the lake were also concerned about the impact of fluctuating water levels and how water level fluctuations could exacerbate the impacts of development. There are many problems associated with development, but there are also many solutions for reducing or even entirely eliminating impacts.

## Development

Approximately 18 miles (57%) of Burt Lake's 35-mile shoreline was recorded as at least partially developed in the 2009 survey. This number has dramatically increased since 2009. In 2022, 92% of the shoreline was documented as being at least partially developed.

## *Cladophora*

Comparisons with prior shoreline surveys show that there are fewer properties with *Cladophora* growth in 2022 compared to 2009; furthermore, the 2022 numbers show improvement from 2009. The 2022 numbers were lower than 2009 numbers in all categories besides the "very light" category (Table 10). *Cladophora* density percentages in 2022, were slightly higher, but comparable to 2001 *Cladophora* percentages (Figure 15). In 2009, 53% of shorelines were recorded as having no signs of *Cladophora*, and in 2022, this percentage improved to 77% of properties showing no signs.

*Table 10. Cladophora density comparison; 2009 and 2022. The green boxes in the "% change" category show improvement from the past survey, and this table only represents the properties where some level of* Cladophora *density was noted.*

| ***Cladophora* Density** | **Frequency 2009** | **Percentage 2009** | **Frequency 2022** | **Percentage 2022** | **% Change** |
|---|---|---|---|---|---|
| Very light | 14 | 2.7 | 44 | 16.9 | 14.2 |
| Light | 113 | 21.4 | 78 | 29.9 | 8.5 |
| Light to Moderate | 76 | 14.4 | 38 | 14.6 | 0.2 |
| Moderate | 117 | 22.2 | 53 | 20.3 | 1.9 |
| Moderate to Heavy | 56 | 10.6 | 22 | 8.4 | 2.2 |
| Heavy | 78 | 14.8 | 20 | 7.7 | 7.1 |
| Very Heavy | 73 | 13.9 | 6 | 2.3 | 11.6 |
| **Total** | 527 | 100.0 | 261 | 100.0 | 100.0 |

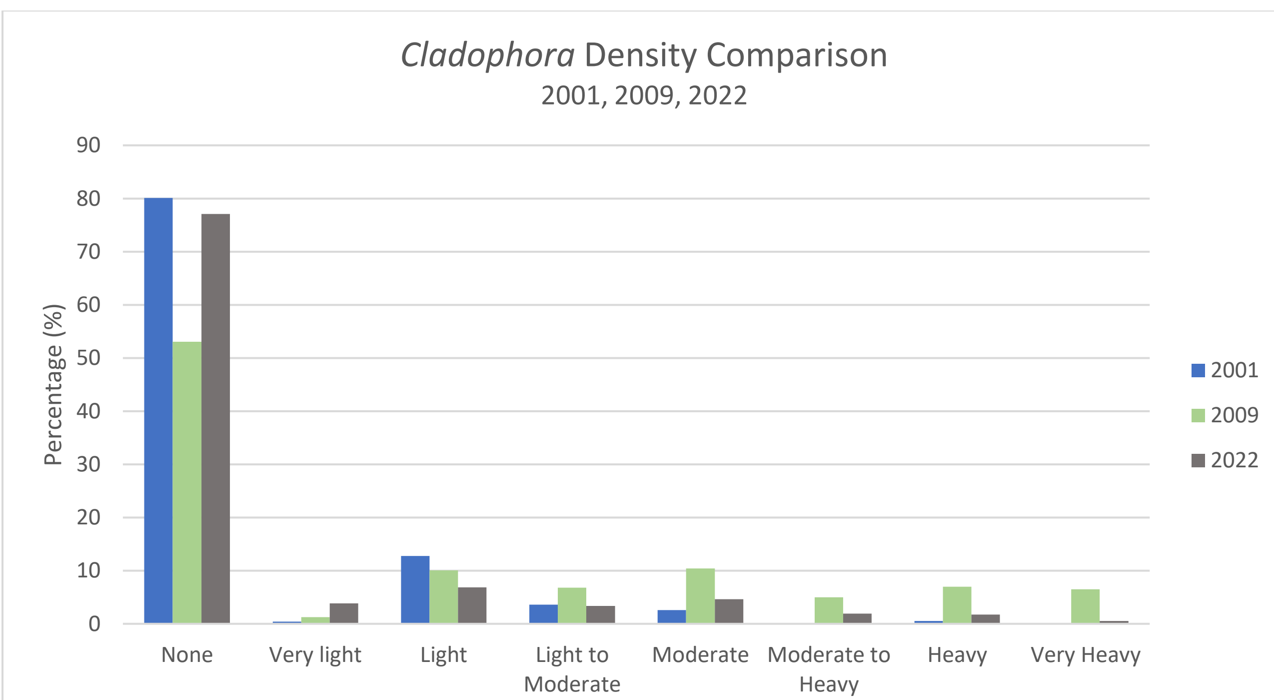


*Figure 15. Burt Lake Cladophora density comparison for years 2001, 2009, and 2022.*

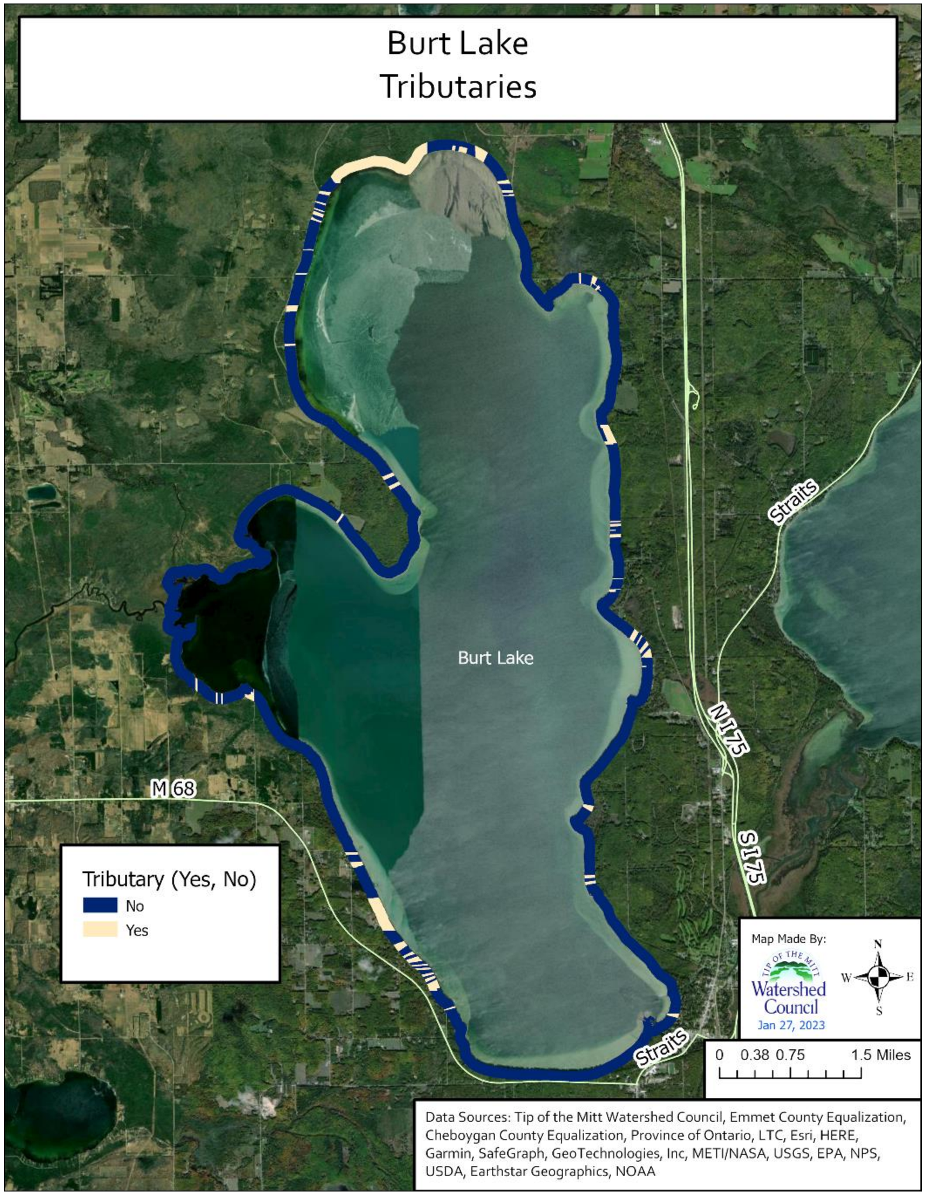


*Figure 16. Map of parcels with tributaries that enter the lake 2022.*

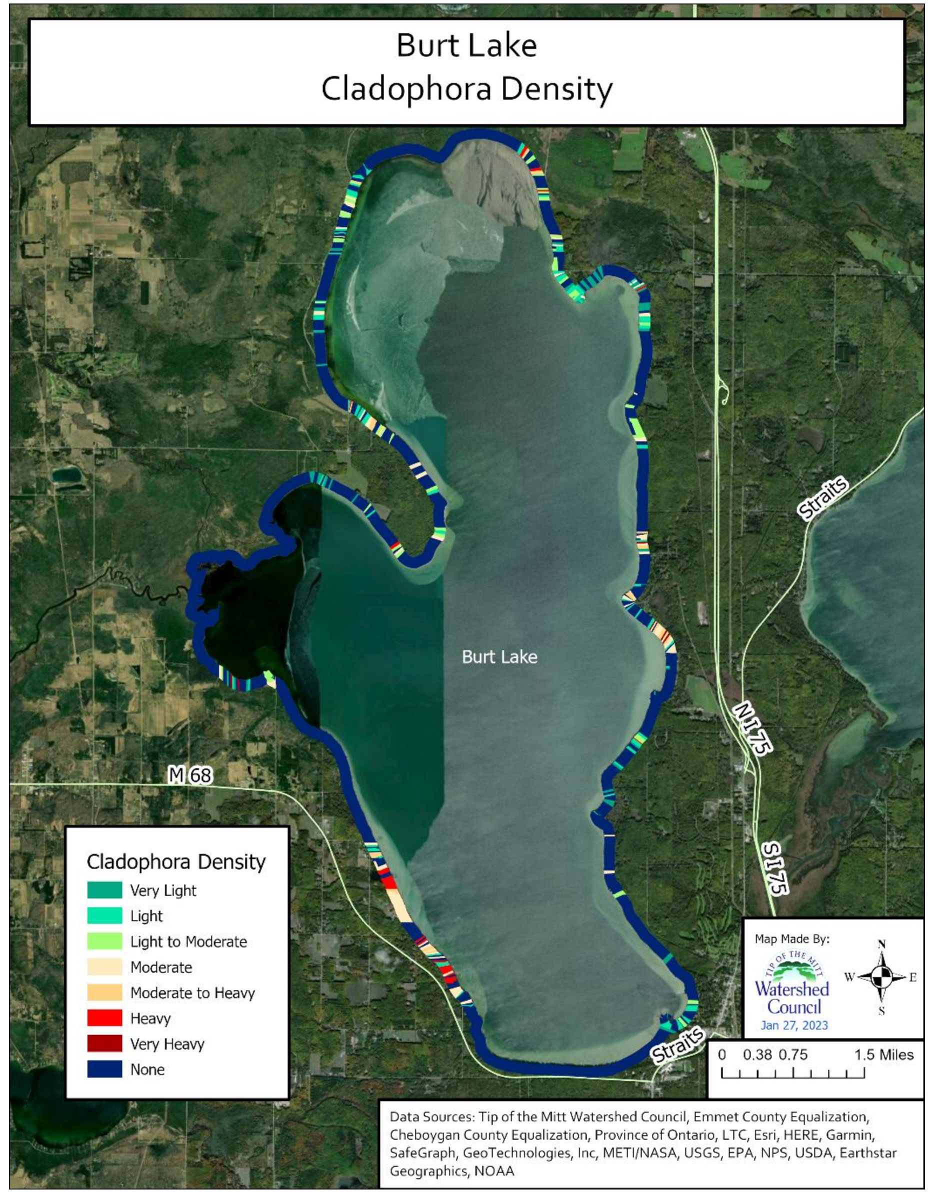


*Figure 17. Map of Cladophora density 2022.*

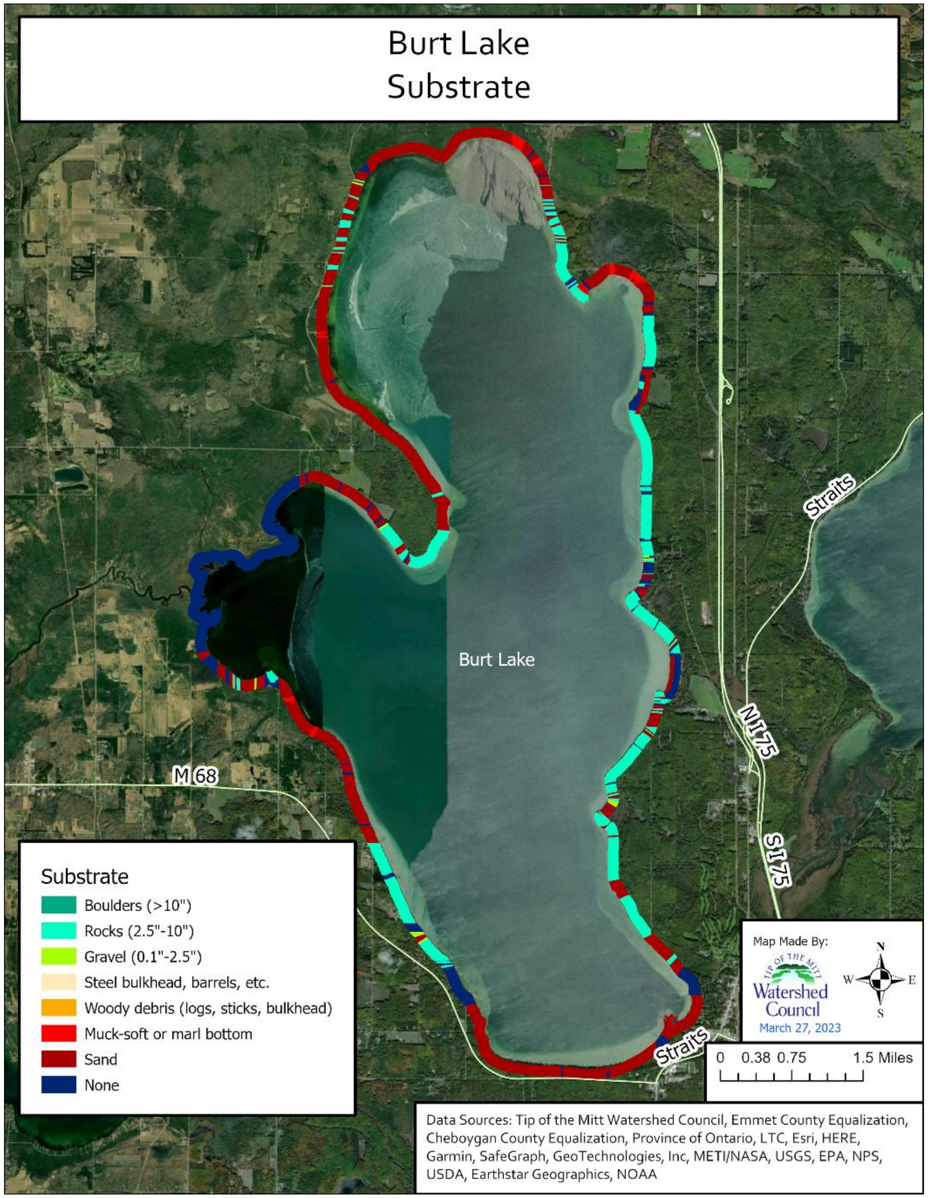


*Figure 18. Map of substrate types to determine Cladophora habitat 2022.*

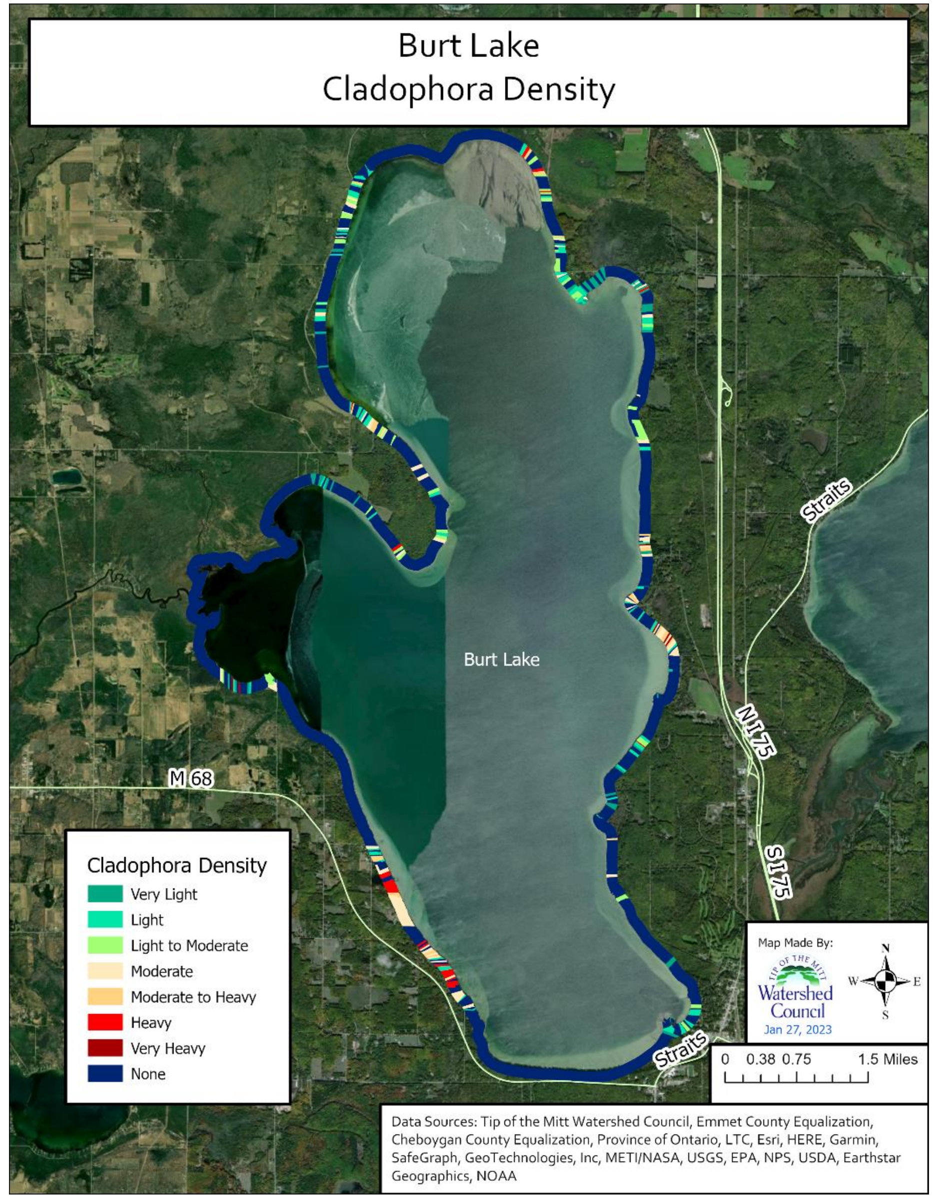


*Figure 19. Map of Cladophora density 2022.*

Of the shoreline areas showing evidence of potential nutrient pollution, some of the heavier algae growth could likely be associated with septic system leachate, fertilizers, or other factors associated with development and human activities. There are also numerous tributaries, springs, and seeps flowing into Burt Lake at different points along the shoreline that may be delivering nutrients that naturally promote algal growth. As shown in figures 16 and 17 above, many of the shorelines where algae growth was present, also had a tributary.

The substrate map created to show where suitable *Cladophora* habitat exists around Burt lake correlates to many parcels where *Cladophora* growth was present. This is recognizable on the Southwest side of the lake where rock substrate was present along a larger section of the shoreline, and Cladophora growth ranged from very light to very heavy (Figures 18 and 19).

Where human-caused nutrient pollution is occurring, the source needs 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.

## Greenbelts

Results from the greenbelt assessment portion of the survey show a worsening trend on Burt Lake. Between 2009 and 2022, the number of properties with very poor greenbelts increased by 26%, while properties with excellent greenbelts decreased by 7% (Table 11).

*Table 11. Greenbelt score comparison; 2009 and 2022. Red indicates negative change (more poor scores and fewer good/excellent scores) and green indicates improvements (fewer poor scores and more good/excellent scores) in the percent change column.*

| Greenbelt Score | Frequency 2009 | Percent 2009 | Frequency 2022 | Percent 2022 | % Change |
|---|---|---|---|---|---|
| Very Poor (0/Absent) | 151 | 13.5 | 451 | 39.6 | **26.1** |
| Poor (1-2) | 253 | 22.5 | 110 | 9.6 | **12.9** |
| Moderate (3-4) | 226 | 20.1 | 143 | 12.6 | **7.5** |
| Good (5-6) | 285 | 25.4 | 299 | 26.3 | **0.9** |
| Excellent (7) | 208 | 18.5 | 136 | 11.9 | **6.6** |
| **Total** | 1123 | 100.00 | 1139 | 100.0 | 100.0 |

While greenbelt scores have worsened since 2009, 2009 and 2022 greenbelt scores show improvement from 2001 scores. This is likely, at least in part, an effect of the initiative of the Burt Lake Preservation Association and subsequent collaborative effort with Tip of the Mitt Watershed Council to address the greenbelt problem documented in the 2001 survey. However, the trend of improvement from 2001 to 2009, did not last. From 2001 to 2009 the number of poor/absent greenbelts improved by 20%, and from 2009 to 2022 the number of poor/absent greenbelts worsened by 13% (Figure 20). It is important to note that methods changed between 2001 and 2022, this is why the comparison chart (Figure 20) categories are condensed.

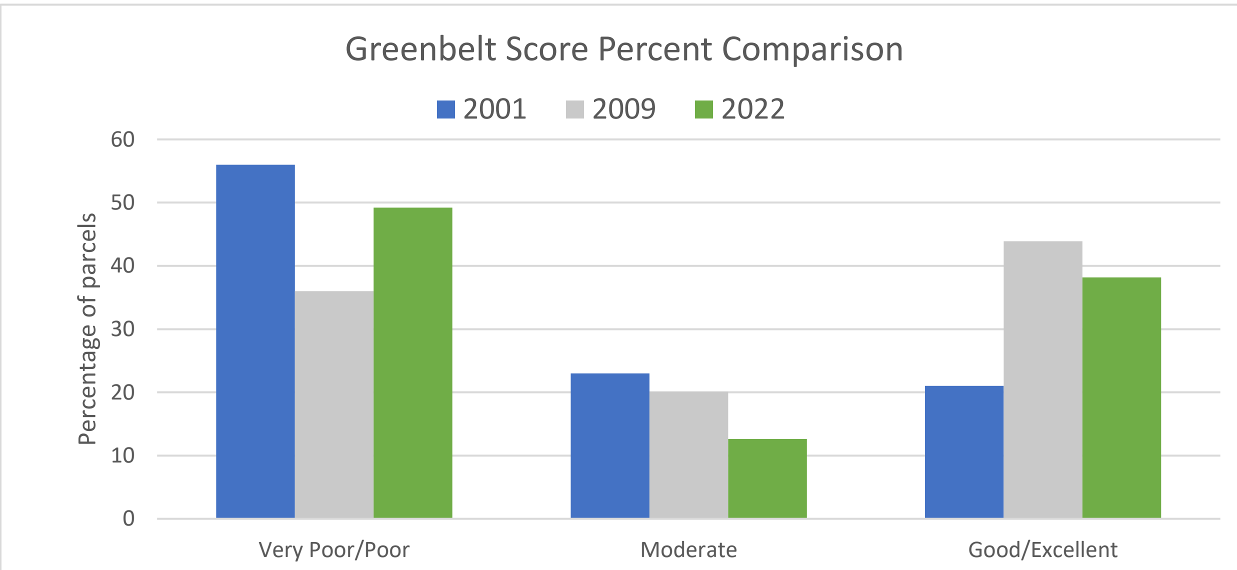


*Figure 20. Greenbelt score comparison for Burt Lake; 2001, 2009 and 2022.*

### Shoreline Alterations

It is important to note that shoreline alterations were categorized differently in 2009 and 2022, which is why NA is marked in the table below. This impacts comparability of the two surveys in regard to shoreline alterations. However, the alteration type is a minor component of each survey, and many categories did stay the same between the two survey years.

The percentage of lakeshore properties with alterations has increased from 45.9% in 2009, to 72% in 2022 (Table 12). The seawall percentage has decreased since 2009. This statistical change is abnormal and could be due to survey parameters changing since 2009, human error, or parcels defined in the surveys changing, such as being grouped together. While seawalls/bulkhead percentages have decreased, shorelines with rip-rap have increased. Overall, the Burt Lake shoreline has hardened since

2009. It is recognizable in Table 12 that more negative change has happened since 2009, than positive change.

*Table 12. Alteration comparison for Burt Lake; 2009 and 2022. In the "% change" column of Table 8, the red boxes indicate negative change, and green indicates positive change. It is important to note that some alterations were categorized differently in 2009 and 2022, which is why NA is marked in the table.*

| Alteration | Frequency 2009 | Percent 2009 | Frequency 2022 | Percent 2022 | % Change |
|---|---|---|---|---|---|
| Rip-rap | 250 | 22.3 | 565 | 40.0 | **17.7** |
| Seawall | 151 | 13.4 | 109 | 7.7 | **5.7** |
| Beach Sand | NA | NA | 87 | 6.2 | **NA** |
| Mixed | 73 | 6.5 | NA | NA | **NA** |
| Other | 42 | 3.7 | 256 | 18.1 | **14.4** |
| None | 607 | 54.1 | 396 | 28.0 | **26.1** |
| **Total** | **1123** | **100.0** | **1413** | **100.0** | **NA** |

With regards to altered shorelines rip-rap, including large rocks or boulders, was the most common type of alteration, found at 40% of all parcels (Table 12). In general, rocks of this size are not endemic to Burt Lake. Oversized boulders can have negative impacts, including lakebed scour, shoreline erosion, and reduced habitat value. Seawalls are the most damaging type of shoreline alteration due to negative impacts that include loss of near-shore habitat, lakebed scour, and wave flanking.

### Erosion

Because erosion was not recorded in the 2001 shoreline survey and methods for documenting erosion severity differed somewhat between the 2009 and 2022 surveys, we cannot make precise comparisons between years. It is important to note that 68 parcels (6%) were recorded as having at least light erosion in 2009, while 116 (10%) of parcels were documented with erosion in 2022. This shows a slight increase in erosion on the Burt Lake shoreline since 2009. Of the parcels exhibiting some level of erosion, light erosion was noted at 32% of parcels in 2009, and in 2022 low amounts of erosion were recorded at 37.9% of parcels. While there was a slightly higher number of parcels with erosion in 2022, a higher percentage of parcels with "heavy" erosion was noted in 2009 (Tables 13 and 14).

*Table 13. Erosion severity percentages 2009.*

| Erosion Severity | Percent of Total Parcels 2009 | Percent of Eroded Parcels 2009 |
|---|---|---|
| None | 93.9 | NA |
| Light | 1.9 | 32 |
| Moderate | 2.4 | 40 |
| Heavy | 1.7 | 28 |
| **Total** | 100 | 100 |

*Table 14. Erosion severity percentages 2022.*

| Erosion Severity | Percent of Total Parcels 2022 | Percent of Eroded Parcels 2022 |
|---|---|---|
| None | 89.8 | NA |
| Low | 3.9 | 37.9 |
| Medium | 4.0 | 39.7 |
| High | 2.0 | 19.8 |
| Severe | 0.3 | 2.6 |
| **Total** | 100.0 | 100.0 |

## Lake Comparison

Like Burt Lake, Mullett Lake is a large inland lake in Cheboygan county. A shoreline survey was conducted on Mullett Lake in 2016 using the same methods and parameters as the Burt Lake 2022 shoreline survey.

In 2016, 44% of parcels on Mullett Lake were recorded as having noticeable growths of *Cladophora* or other filamentous green algae. In 2022, 33% of Burt Lake parcels were recorded as having the same noticeable growths of algae. In comparison, Mullett Lake had a higher percentage of parcels with algae growth and the two lakes had a very similar percentage of parcels showing heavy *Cladophora* density. Burt Lake had a higher percentage of parcels with moderate algae growth, and Mullett had a higher percentage of parcels with light and very light algae growth (Figure 21).

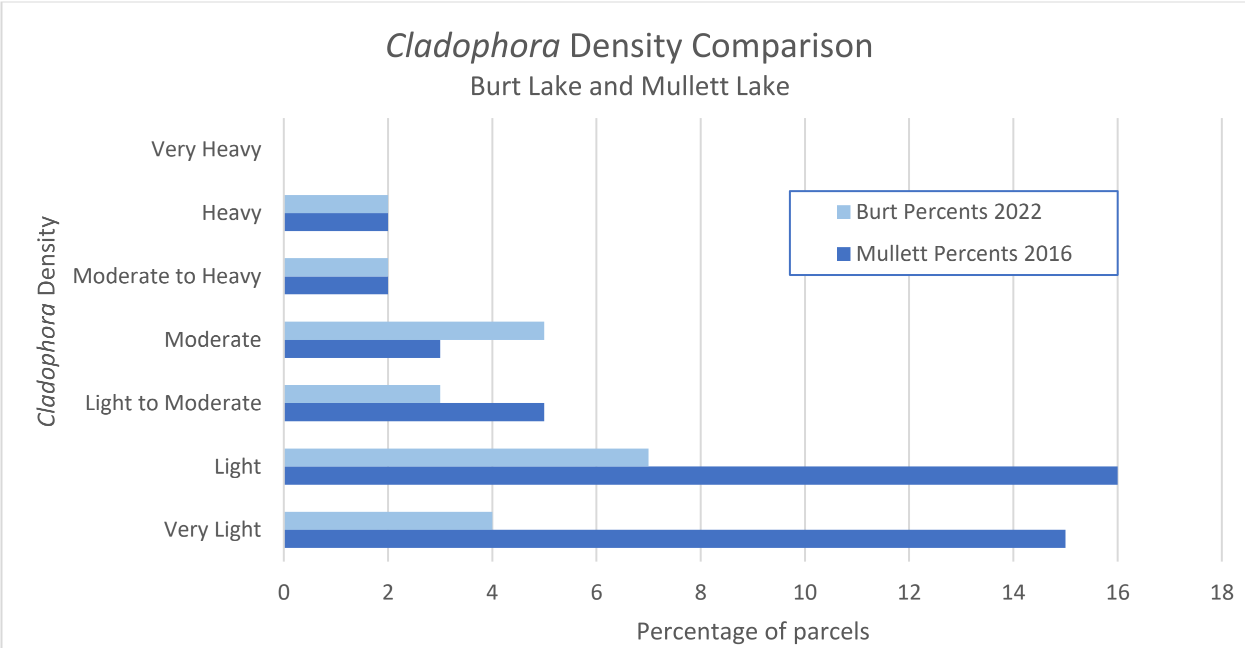


*Figure 21. Cladophora density comparison between Burt and Mullett Lakes.*

Mullett Lake greenbelt scores were also recorded as a part of the 2016 shoreline survey. Burt Lake had a higher percentage of parcels with good and excellent greenbelt scores in 2022, but also had a higher percentage of parcels with absent greenbelts. Mullett Lake had a higher percentage of parcels with poor and moderate greenbelt scores in 2016 (Figure 22).

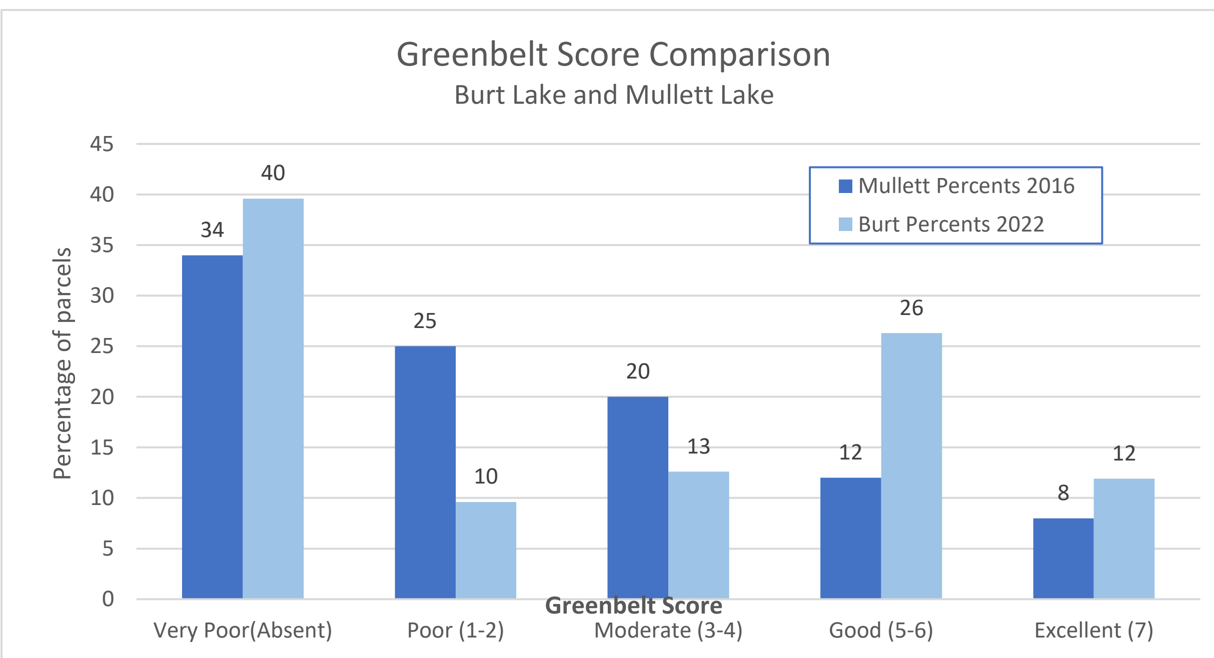


*Figure 22. Greenbelt score comparison for Burt and Mullett Lakes*

Numerous best management practices have been developed that help minimize negative impacts to water quality and can be utilized during, or retroactively after, the development of shoreline parcels. 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. These best management practices will be discussed in more detail in the recommendations section.

# 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. Make specific results available online through an ESRI StoryMap or WebApp. Keep the specific results of the survey confidential (e.g., 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. Share results by:
    a. Sending a general summary of the survey results to all shoreline residents.
    b. Sharing general results and a summary in the Burt Lake Preservation Association (BLPA) and Watershed Council newsletters.
    c. Posting results on the Watershed Council website.
    d. Presenting findings to the Burt Lake Watershed Advisory Committee.
3. Promote and encourage landscape contractors and designers to attend bioengineering workshops and Certified Natural Shoreline Professional certification classes.
4. Hold greenbelt workshops to educate shoreline homeowners about the importance of greenbelts for protecting water quality. Share a summary of the survey results at the workshops.
5. Complete greenbelt restoration projects on through a cost-share program, using survey results to prioritize where grant cost-share funds will be used.
6. Encourage land owners to sign up and take a self-assessment for MI Shoreland Stewards.
7. Use shoreline survey data to advocate for stronger greenbelt ordinances in Cheboygan County.
8. Repeat some version of the survey periodically (ideally every 5-10 years).
9. 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. BLPA 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.