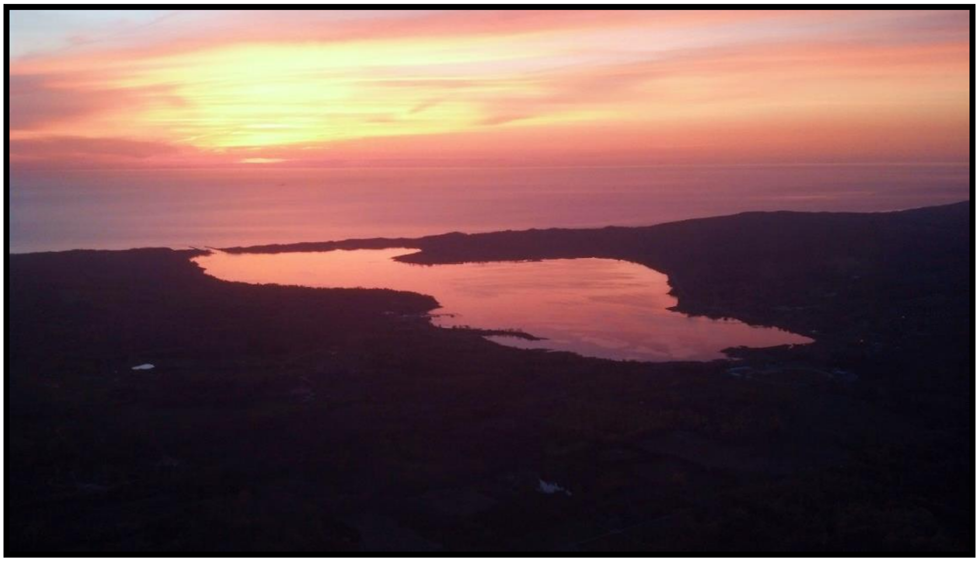
Portage Lake

WATERSHED MANAGEMENT PLAN

SEPTEMBER 2019



PREPARED FOR

Portage Lake Watershed Forever

ONEKAMA, MICHIGAN

portagelakewatershed.com

PREPARED BY

Spicer group

MANISTEE, MICHIGAN

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GLOSSARY

AES – Alliance for Economic Success (formerly Manistee Economic Development Office)

AMV – Aquatic Maximum Value

AVAS – Aquatic Vegetation Assessment Sites

BBC – British Broadcasting Corporation

BCD – Benzie Conservation District

BFE – Base floodplain elevation

BGD – Bacterial gill disease

BKD – Bacterial kidney disease

BMP – Best management practice(s)

BOD – Biological oxygen demand

CFS – Cubic feet per second

CFU – Colony-forming unit

CLMP – MiCorps Cooperative Lake Management Program

COD – Chemical oxygen demand

County – Manistee County

CSI – Cladophora Status Index

DEC – Department of Environmental Conservation

DO – Dissolved oxygen

EGLE – Michigan Department of Environment, Great Lakes, and Energy (formerly Michigan Department of Environmental Quality)

EWM – Eurasian Watermilfoil

FCV – Final Chronic Value

FEMA – Federal Emergency Management Agency

FIRM – Flood Insurance Rate Map

GIS – Geographic Information System

GPS – Global positioning system

GTRLC – Grand Traverse Regional Land Conservancy

Harbor Commission – Portage Lake Harbor Commission

Health Dept. – District Health Department #10

Historical Museum – Manistee County Historical Museum

HUC – Hydrologic Unit Code

LiDAR – Light Detection and Ranging

LRBOI – Little River Band of Ottawa Indians

L-THIA – Long-Term Hydrologic Impact Assessment

LUST – Leaking underground storage tank

M – Million

MAEAP – Michigan Agriculture Environmental Assurance Program

MCCF – Manistee County Community Foundation

MCD – Manistee Conservation District

MCL – Maximum contaminant level

MCL – Michigan Compiled Laws

MCRC – Manistee County Road Commission

MDARD – Michigan Department of Agriculture and Rural Development

MDCH – Michigan Department of Community Health

MDEQ – Michigan Department of Environmental Quality (Now EGLE)

MDHHS – Michigan Department of Health and Human Services

MDIT/CGI – Michigan Department of Information Technology Center for Geographic Information

MDNR – Michigan Department of Natural Resources

MDNRE – Michigan Department of Natural Resources and Environment (Now EGLE)

MDOT – Michigan Department of Transportation

MIRIS – Michigan Resource Inventory System

MISIN – Michigan Invasive Species Information Network

MISIP – Michigan Swimmer's Itch Partnership

MNFI – Michigan Natural Features Inventory

MNFI-MSUE – Michigan Natural Features Inventory MSU Extension

MPN – Most probable number

MRLCC – Multi-Resolution Land Characteristics Consortium

MSU CEVL and LPI – Michigan State University Computational Ecology and Visualization Laboratory and Land Policy Institute

MSU Ext. – Manistee County Michigan State University Extension Office

NLCD – National Land Cover Database

NMRPDC – Northwest Michigan Regional Planning and Development Commission

NOAA – National Oceanic and Atmospheric Administration

NRCS – Natural Resources Conservation Services

NWI –National Wetland Inventory

NWISN – Northwest Invasive Species Network

NWM – Northwest Michigan

Onekama Twp. – Onekama Township

ORP – Oxidation reduction potential

OSDS – On-site disposal systems

OZ– Overlay zone

PCB – Polychlorinated biphenyls

PDR – Purchase of development rights

PFAs – Per- and polyfluoroalkyl substances

PFOs – Perfluorooctanesulfonic acid

PIW – Plant It Wild

PLA – Portage Lake Association

PLGC – Portage Lake Garden Club

PLWF – Portage Lake Watershed Forever

PPB – Parts per billion

PPCP – Pharmaceutical and personal care products

PUD – Planned unit developments

SAD – Special Assessment District

SAW – Stormwater, Asset Management, and Wastewater

School – Onekama Consolidated Schools

SEG – Snell Environmental Group, Inc

STORET – Storage and Retrieval

TDS – Total dissolved solids

TKN – Total Kjeldahl nitrogen

TMDL – Total maximum daily load

TN – Total nitrogen

Townships – Onekama, Bear Lake, Manistee, and Brown Townships

TP – Total phosphorus

TSI – Trophic Status Index

USACE – United States Army Corps of Engineers

USCG – United States Coast Guard

USDA-NRCS – United States Department of Agriculture - Natural Resources Conservation Service

USEPA – U.S. Environmental Protection Agency

USGS – United States Geological Survey

USFS – United States Forestry Service

USFWS – United States Fish and Wildlife Service

UV – Ultraviolet

VHS – Viral hemorrhagic septicemia

Village – Village of Onekama

Watershed – Portage Lake Watershed

WWTP – Wastewater treatment plant

EXECUTIVE SUMMARY

PURPOSE

In 2008, Michigan's Department of Environment, Great Lakes, and Energy approved the watershed plan submitted by Portage Lake Watershed Forever (PLWF). This document is a 10-year update of that plan. While the purpose of the plan remains the same, there has been growth in our understanding of what it takes to protect a watershed and an increase in our community's awareness of its role in this effort. Consequently, our intent is to continue to engage all interests in the community in developing a living document that will ensure the wise use and enjoyment of the Portage Lake Watershed for present and future generations. This updated plan will be used to guide and inform future monitoring, planning, management, and community and economic development efforts within the watershed. It is not regulatory in nature and its associated committees are non-political and do not have regulatory powers. While the Portage Lake Watershed Forever committees will provide coordination, the implementation of the plan largely depends on assistance from and the cooperation of numerous local, state, and federal partners.

VISION

The vision of the Portage Lake Watershed Forever Plan is that the Portage Lake Watershed will be preserved forever by investing in protection and enhancement of natural and related cultural and historical resources in the watershed to provide economic benefit and to improve the quality of life for present and future residents and visitors.

BRIEF DESCRIPTION OF THE PORTAGE LAKE WATERSHED

The Portage Lake Watershed is located in Michigan's northwestern Lower Peninsula in Manistee County, and encompasses portions of Bear Lake, Brown, Manistee, and Onekama Townships, as well as the Village of Onekama, see **Figures 1** and **2**. A sub-watershed of the Betsie Platte, the USGS Hydrology code is HUC# 040601040405. The Portage Lake Watershed is approximately 24.6 square miles, or 15,777 acres, in size (MDIT/CGI, LP Watersheds). 13 percent of the watershed's surface area is comprised of Portage Lake, at 2,051.6 acres (MDIT/CGI, LP Watersheds). Portage Lake was formed naturally by glaciers, has a maximum depth of up to 60 feet in two areas, and a mean depth of 19 feet. Two other named lakes (Gordon Lake and Cooper Lake), seven named tributaries, several small, unnamed creeks and drains, numerous artesian wells, and significant groundwater drain into Portage Lake and eventually to Lake Michigan through a manmade channel (Portage Lake Channel) on the west side of Portage Lake. Portage Lake is very popular for fishing, sailing, cruising, waterskiing, and swimming.

The Portage Lake Watershed has undergone significant change in land use and land cover since the area was first surveyed and platted in 1836. According to pre-European settlement maps of forest communities, the Portage Lake Watershed land cover was dominated by American beech, sugar maple, and eastern hemlock, with smaller inclusions of mixed hardwood swamps, northern white-cedar, mixed conifer, and shrub swamps, and emergent marshes. In 1800 there were approximately 12,960 acres of forest land. Comparatively, 2016 land use data shows that there are now 5,292 acres of forest land, a 48.6% reduction from 1800. The current forest communities include northern hardwood forests, with smaller inclusions of aspen and birch forests, mixed deciduous upland forests, some of which include large sections of oak, upland coniferous forests, which include red pine plantations, lowland hardwood and conifer forests, scrub shrub, emergent wetlands, herbaceous open lands, and beaches.

Unlike many watersheds in the northern Lower Peninsula, there is very little state or federal public land within the watershed. Private land practices associated with forestry, agricultural, recreational, commercial, industrial, and residential uses have been and will continue to be the major influence on the condition of the watershed, the quality of its groundwater, and surface water resources.

PARTNERSHIP AGREEMENT

Portage Lake Watershed Forever Plan

"This . . . serves as a partnership agreement between various individuals, interest groups, nonprofit organizations private businesses, units of government and others that are Interested in the future of the Portage Lake Watershed.

We, the undersigned, concur that the development of the Portage Lake Watershed Forever Plan is in the best long-term interest of property owners, individuals, groups, organizations, businesses, schools, students and other interests concerned with the Portage Lake Watershed -now and in the future."

Michael Acton	Onekama Resident
Paul Adamski	Brown Township
Dan Behring	Portage Lake Landowner
Zach Prause	Little River Band of Ottawa Indians
Dennis Bjorkquist	Manistee Township
Doug & Patty Callaway	Callaway Construction
Jeff Dontz	Manistee County Board of Commissioners
Rob Carson	Manistee County Planner
Frank English	Realtor
Linda English	Appearance Salon
Donna Ervin	Glenwood Restaurant
Kathy Ervin	MacBeth & Co.
Wayne Farber	Little Eden Camp
Ray A. Franz	Onekama Village President
Carolyn & Park Gilmore	Blue Slipper Bistro
Peggy Green	Onekama Guild
Katie Grzesiak	Invasive Species Network Coordinator
Gina Hagen	Onekama Consolidated Schools
Susan Halloran	Portage Lake Garden Club
Kevin P. Hughes	Manistee County Sports Fishing Assn.
Jane M. Johnson	Attorney
Shelli Johnson	Pappa J's Ice Cream Shop
Julie Lapinski	Portage Lake Association
Rich Lapinski	Onekama Parks & Rec Committee
Dennis B. McCarthy	Blarney Castle Oil Company
Bonnie McPhedran	Yellow Dog Coffee Shop
Shirley Milner	Shirley's Restaurant
David Meister	Onekama Township Supervisor
Jim Mrozinski	Harbor Commission, Onekama Marina
Dave Nesberg	Portage Lake Bible Camp
Ted Peacock	Benzie Conservation District
Margaret A. Punches	Riparian Owner
Tom Reichard	District 10 Health Department
Chris Riley	US Forest Service
Suzanne Riley	Century 21 Realtor
Jim Simons	Portage Lake Resort Corporation
Susan Spencer	Manistee Conservation District
Mark Sohlden	Manistee Road Commission
Vicki Strevey	West Shore Bank
Al Taylor	Grand Traverse Reg. Land Conservancy
Jim Trout	Onekama Township Planning Commission
Glen VanBrocklin	VanBrocklin Real Estate

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CHAPTER 1: DESCRIPTION OF PORTAGE LAKE WATERSHED

This section provides a comprehensive description of the Portage Lake Watershed, including its physical, environmental, and political setting, and how it has changed since the 2008 Watershed Management Plan.

PHYSICAL AND NATURAL FEATURES

Location, Size, and Boundaries

The Portage Lake Watershed is located in the northwest portion of Michigan's Lower Peninsula in Manistee County, **Figure 1**, below. The Hydrologic Unit Code (HUC) is 040601040405. As shown in **Figure 2**, below, the boundaries of the Portage Lake Watershed encompass portions of Bear Lake, Brown, Manistee, and Onekama Townships as well as the Village of Onekama. The Watershed covers approximately 24.6 square miles, or 15,777 acres (MDIT/CGI LP Watersheds).

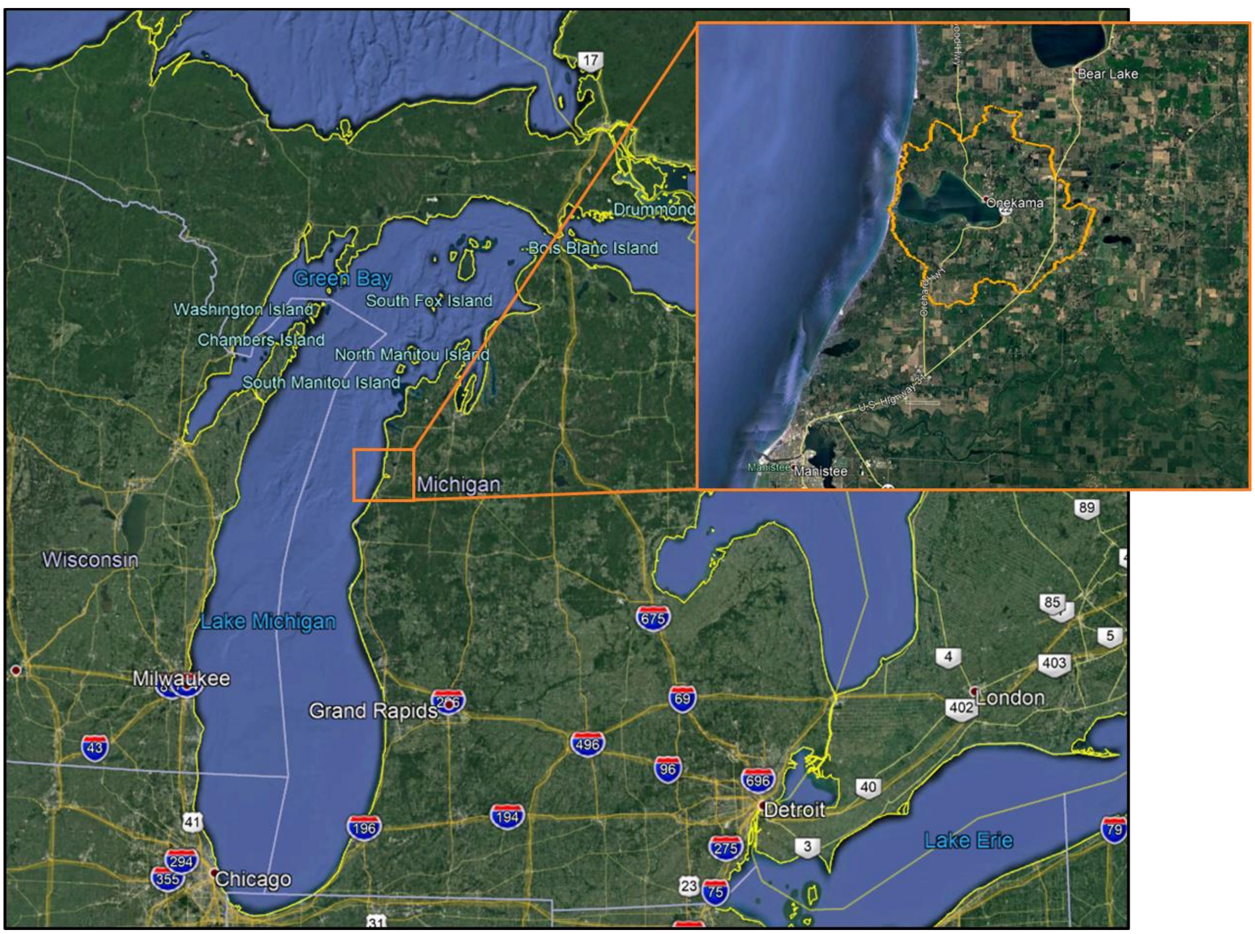


Figure 1. *General location of Portage Lake Watershed (shown by orange outline)*

SOURCE: Spicer Group, Inc., 2019, using Google Earth

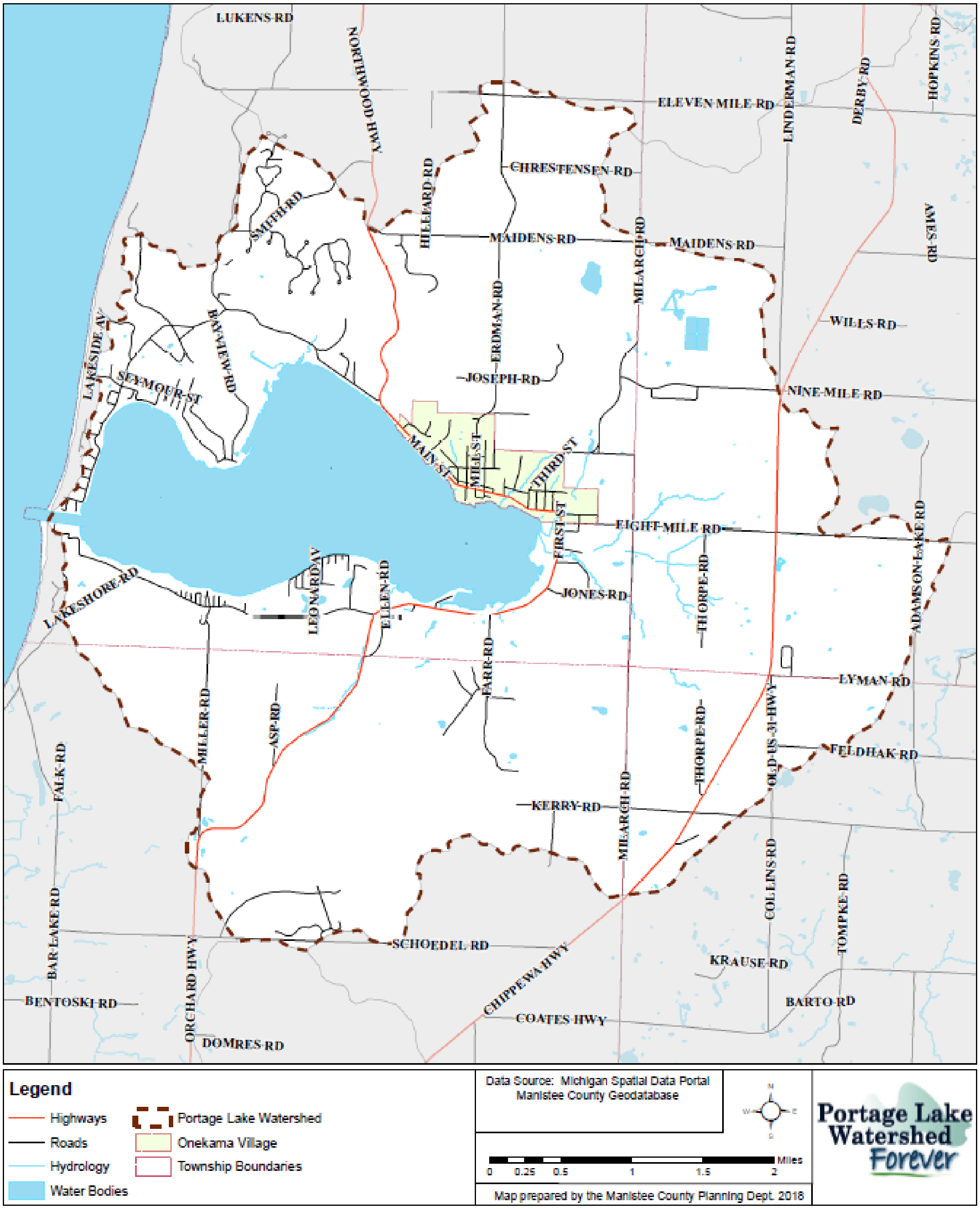
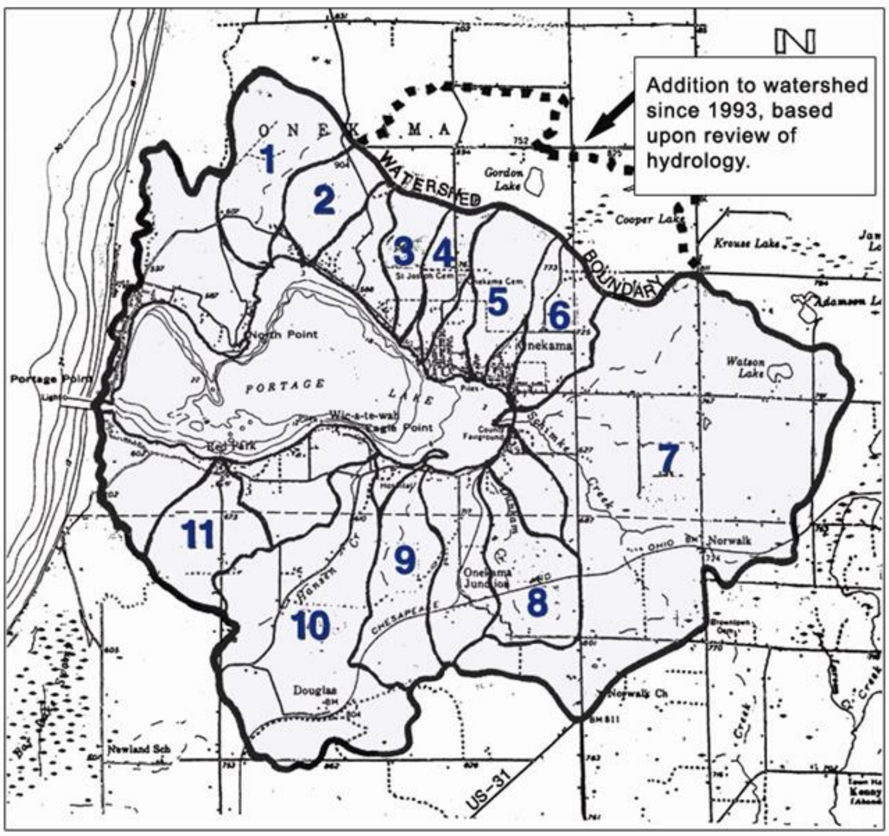


Figure 2. *Portage Lake Watershed boundary*

SOURCE: Michigan Spatial Data Portal, Manistee County Geodatabase. Map prepared by the Manistee County Planning Dept. 2018.

In the *Portage Lake United States Environmental Protection Agency (USEPA) Phase I Diagnostic/Feasibility Study* (Phase I Study), published in 1993 (SEG, 1993), the major sub-watersheds were established to include drainage areas for each of the lake's named tributaries plus three areas that do not contain a named surface tributary (Red Park, East Village, and Sandy Point). Unfortunately, the 1993 study did not include a significant part of the area that now is recognized as within the Watershed's hydrologic boundary, **Figure 3**. However, sub-watershed data has since been updated, and includes the northern reach that was not included in the 1993 map. With the northern addition to the Watershed, many of the sub-watersheds north of Portage Lake were consolidated. Sub-watersheds 1, 2, 3, 4, 5, 6 and the northern addition were consolidated into one large sub-watershed, shown in **Figures 3** and **4** respectively.



Subwatersheds

1. McGowan's Creek
2. Little Eden
3. Glen Creek
4. McCormick Creek
5. Onekama Creek
6. East Village
7. Schimke Creek
8. Dunham Creek
9. Sandy Point
10. Hansen Creek
11. Red Park

Figure 3. *Major sub-watersheds of Portage Lake*

SOURCE: SEG, 1993.

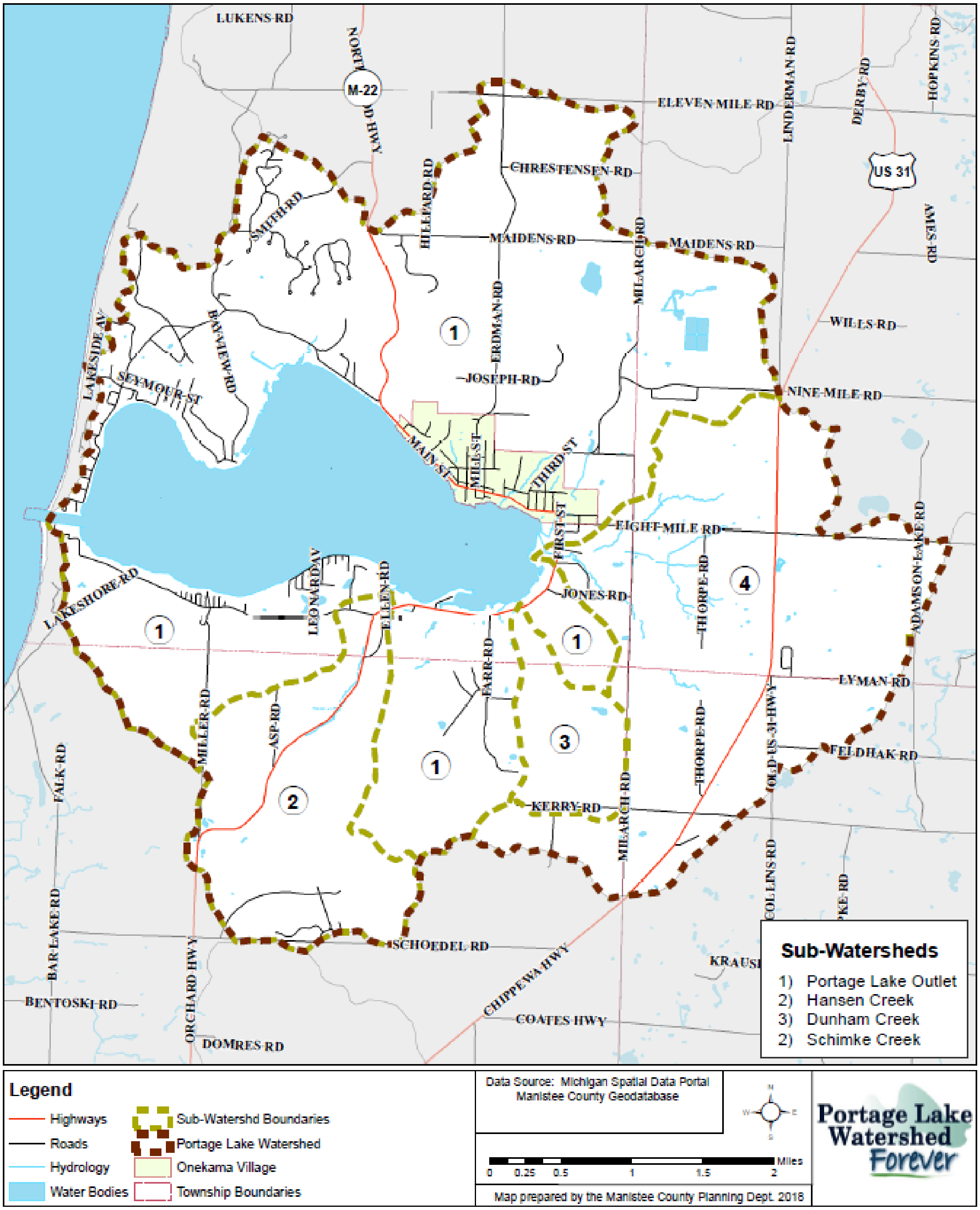


Figure 4. *Portage Lake sub-watershed boundaries*

SOURCE: Michigan Spatial Data Portal, Manistee County Geodatabase. Map prepared by the Manistee County Planning Dept. 2018.

Topography and Elevation

The Portage Lake Watershed is generally bowl shaped with elevations at the outer edges of the Watershed reaching as high as 1,000 feet above sea level (304.8 meters) and sloping toward Portage Lake. The lowest point of land is approximately 580 feet (176.8 meters) above sea level. The eastern side of the Watershed is relatively flat with grades less than 3 percent, while the area north of Portage Lake has steep slopes with grades as much as 20 percent. The northeast portion of the Watershed boundary is a shallow basin surrounded on three sides by relatively high ridges that taper off to the south and west, eventually allowing groundwater to drain toward Portage Lake. The western portion of the Watershed is bounded by coastal dunes that reach heights of over 80 feet (24.4 meters), with grades as great as 40 percent on the Lake Michigan side, depending on the year, **Figure 5**.

Soils

The surface soils of the Watershed reflect the glacial origins of this area of the Lake Michigan shoreline. In general, the soils are well drained sand or sandy loam, with interspersed, smaller areas of slower-to-drain mineral and organic soils, see **Figure 6**. In general, surface runoff is minimized by the permeability of the soils in the Watershed. Both Portage Lake and its tributaries have significant contributions of groundwater inputs due to the nature of the Watershed's soils.

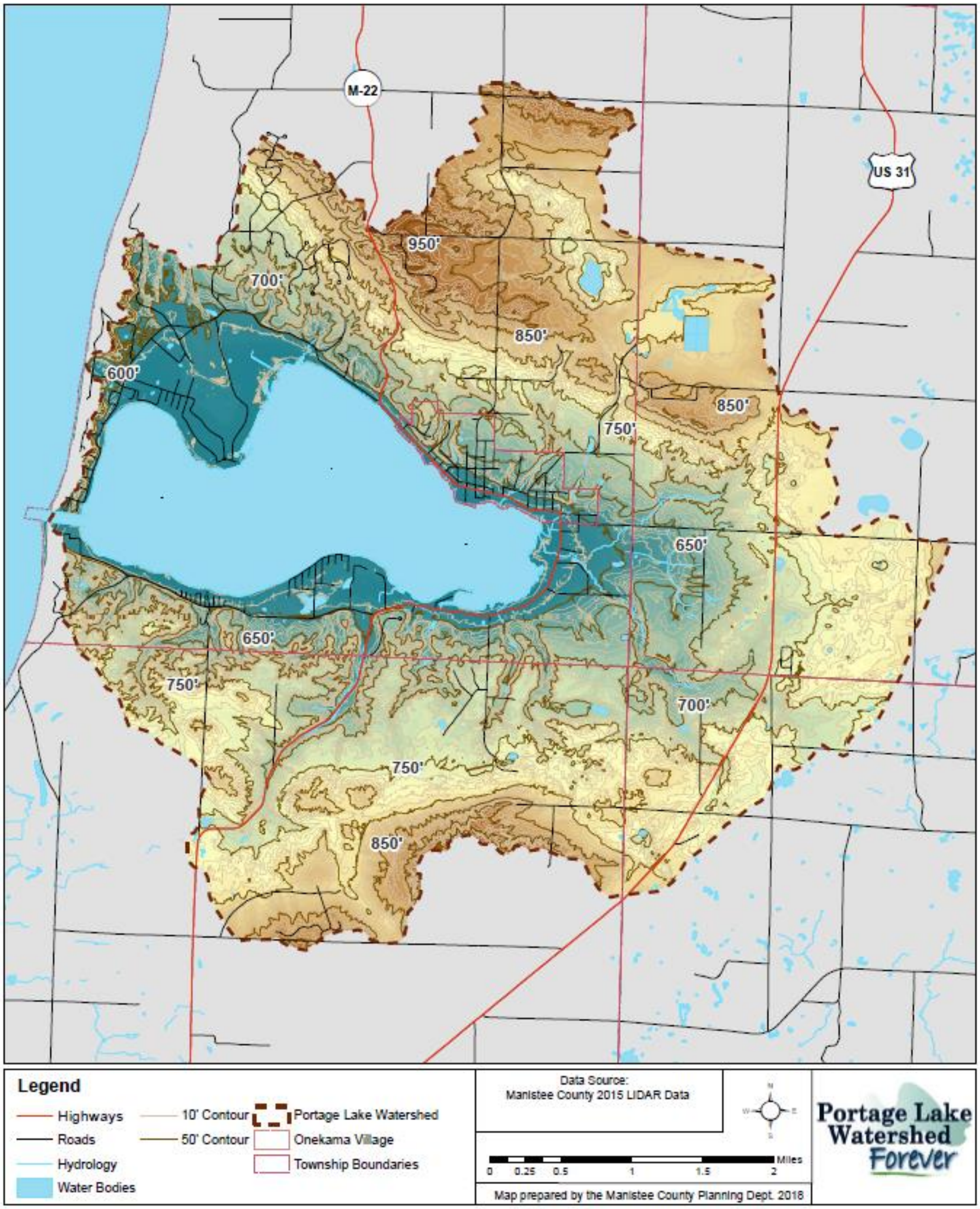


Figure 5. *Portage Lake Watershed topography*

SOURCE: Michigan County 2015 LiDAR Data. Map prepared by the Manistee County Planning Dept. 2018.

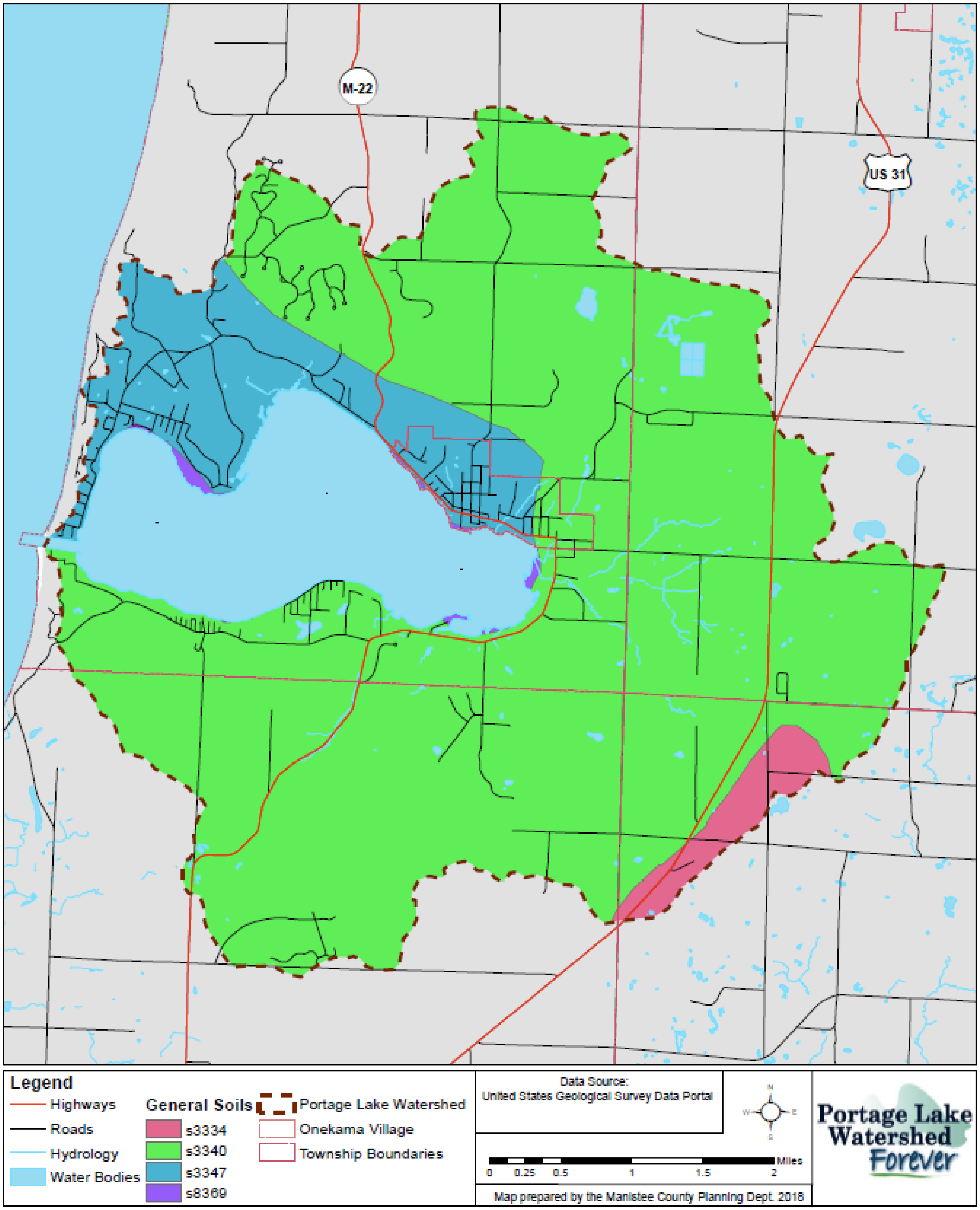


Figure 6. *Portage Lake Watershed general soil classes*

SOURCE: United States Geological Survey Data Portal. Map prepared by the Manistee County Planning Dept. 2018.

Geology

The bedrock beneath the glacial deposits in Manistee County consists predominantly of sandstones (i.e. Marshal Formation) and shale (i.e. Antrim, Coldwater, and Ellsworth formations), **Figure 7**. The Portage Lake Watershed is underlain almost entirely by Ellsworth shale, with only a small portion in the northwest corner underlain by Antrim shale, see **Figure 8**. The Portage Lake Watershed is at the rim of the large geologic sedimentary rock feature covering most of the Lower Peninsula of Michigan (described as the Michigan Basin) that contains significant hydrocarbon deposits.

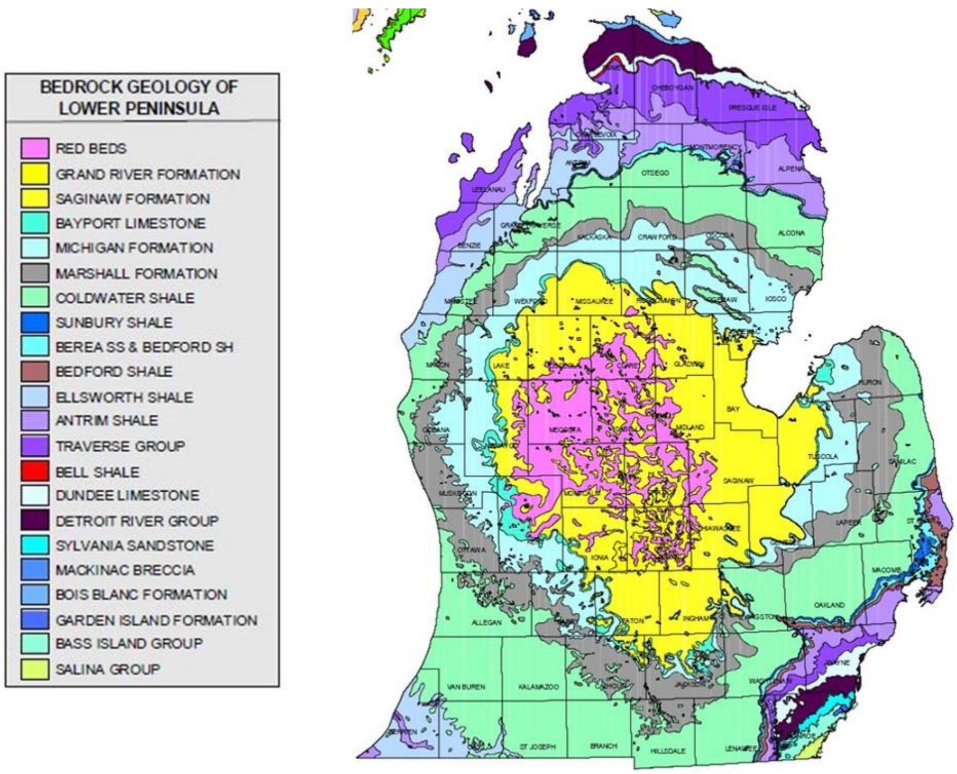


Figure 7. *Lower Michigan bedrock geology*

SOURCE: Michigan Department of Natural Resources Land and Minerals Services Division Resource Mapping and Aerial Photography.

Glacial deposits (drift thickness) vary within the Portage Lake Watershed from coarse-grained stratified sediment, 400-800 feet thick, on the most western portion to coarse-grained stratified sediment, 600-1,000 feet thick, and till 600-800 feet thick on the most eastern portion, **Figure 9**.

A mixture of dune sand, medium and coarse-textured glacial till, end moraines of medium-textured till, glacial outwash sand and gravel and postglacial alluvium characterize the near-surface geologic conditions within the Portage Lake Watershed shown in **Figure 10**.

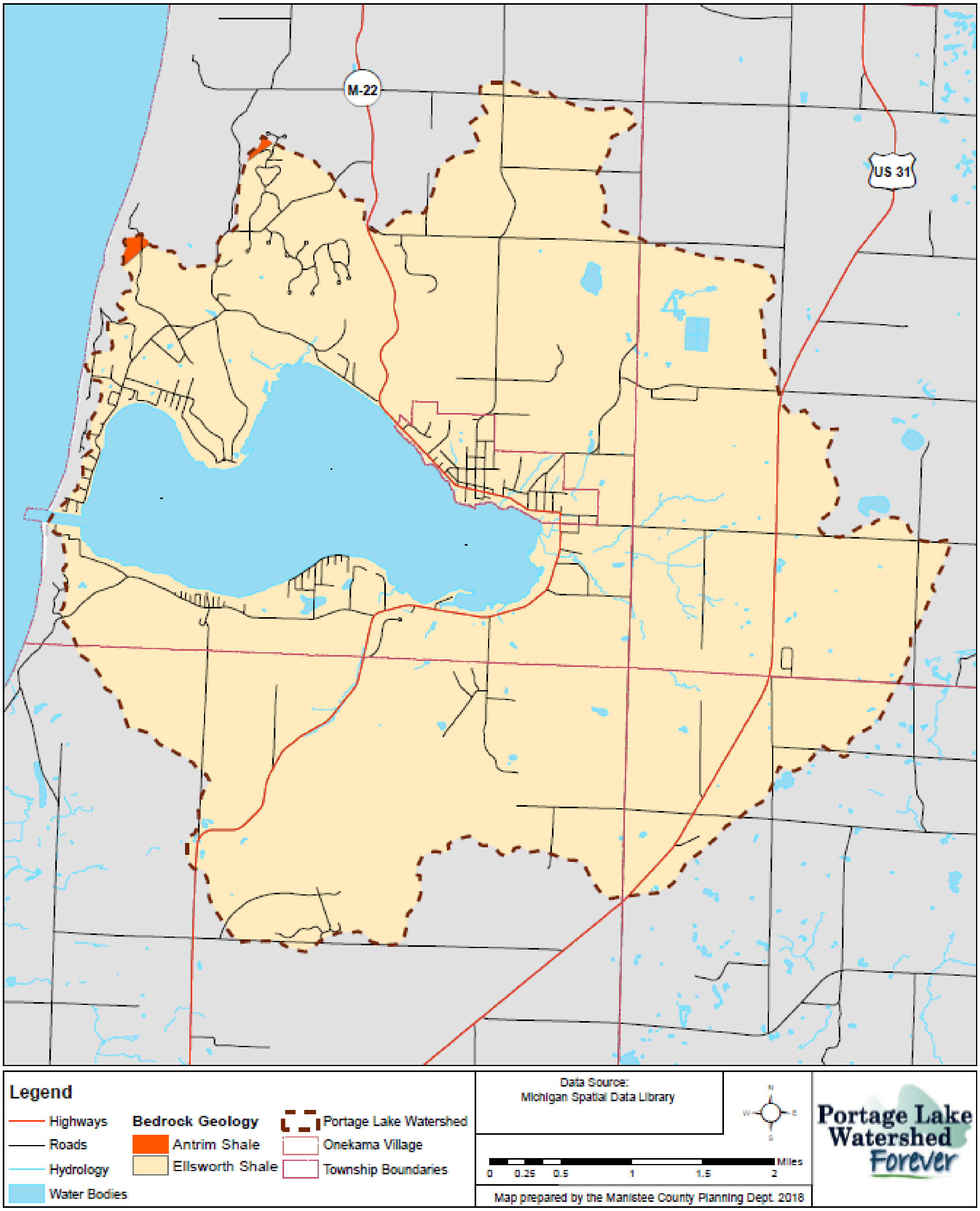


Figure 8. *Bedrock geology of Portage Lake Watershed*

SOURCE: Michigan Spatial Data Library. Map prepared by the Manistee County Planning Dept. 2018.

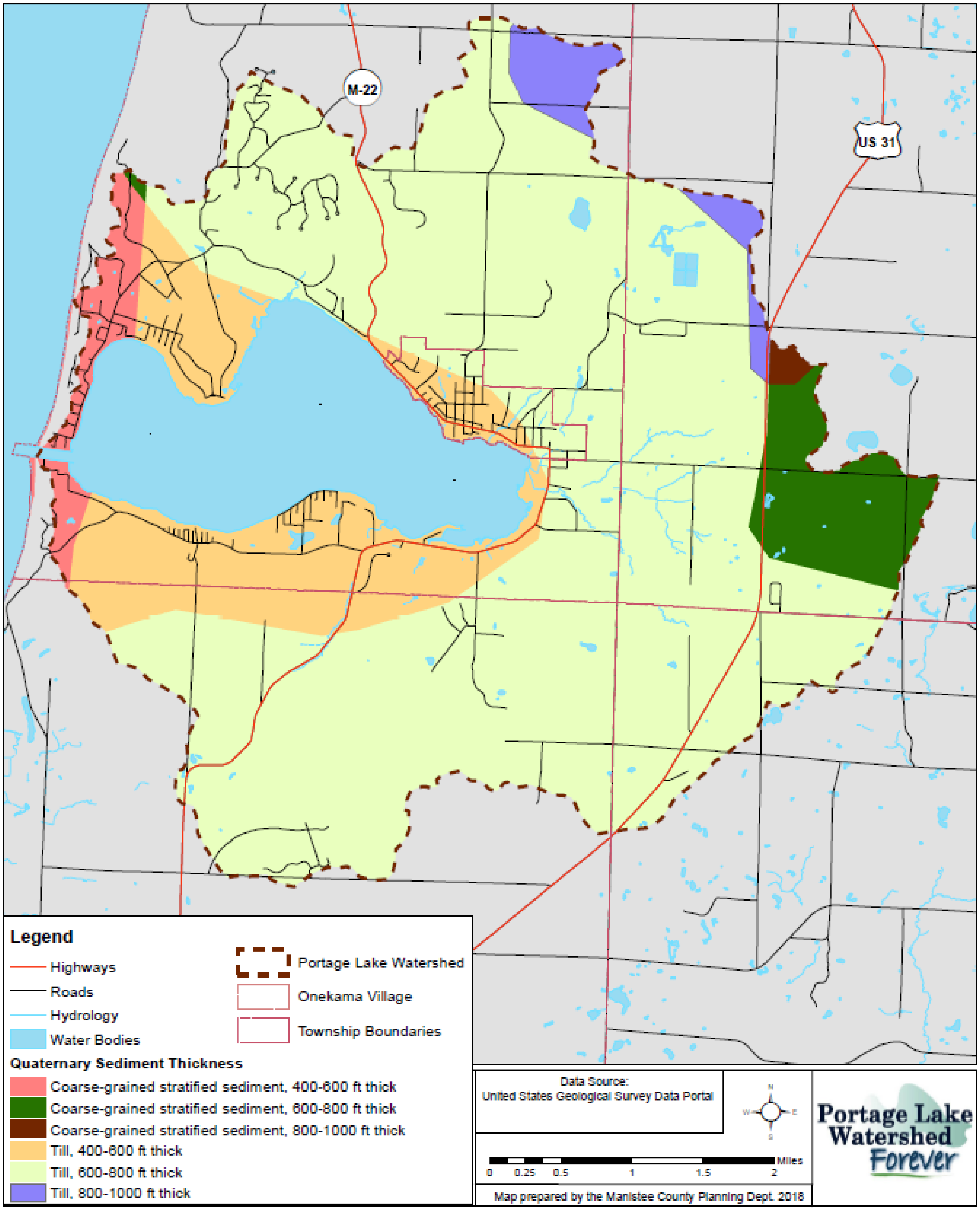


Figure 9. *Portage Lake Watershed thickness of glacial deposits*

SOURCE: United States Geological Survey Data Portal. Map prepared by the Manistee County Planning Dept. 2018.

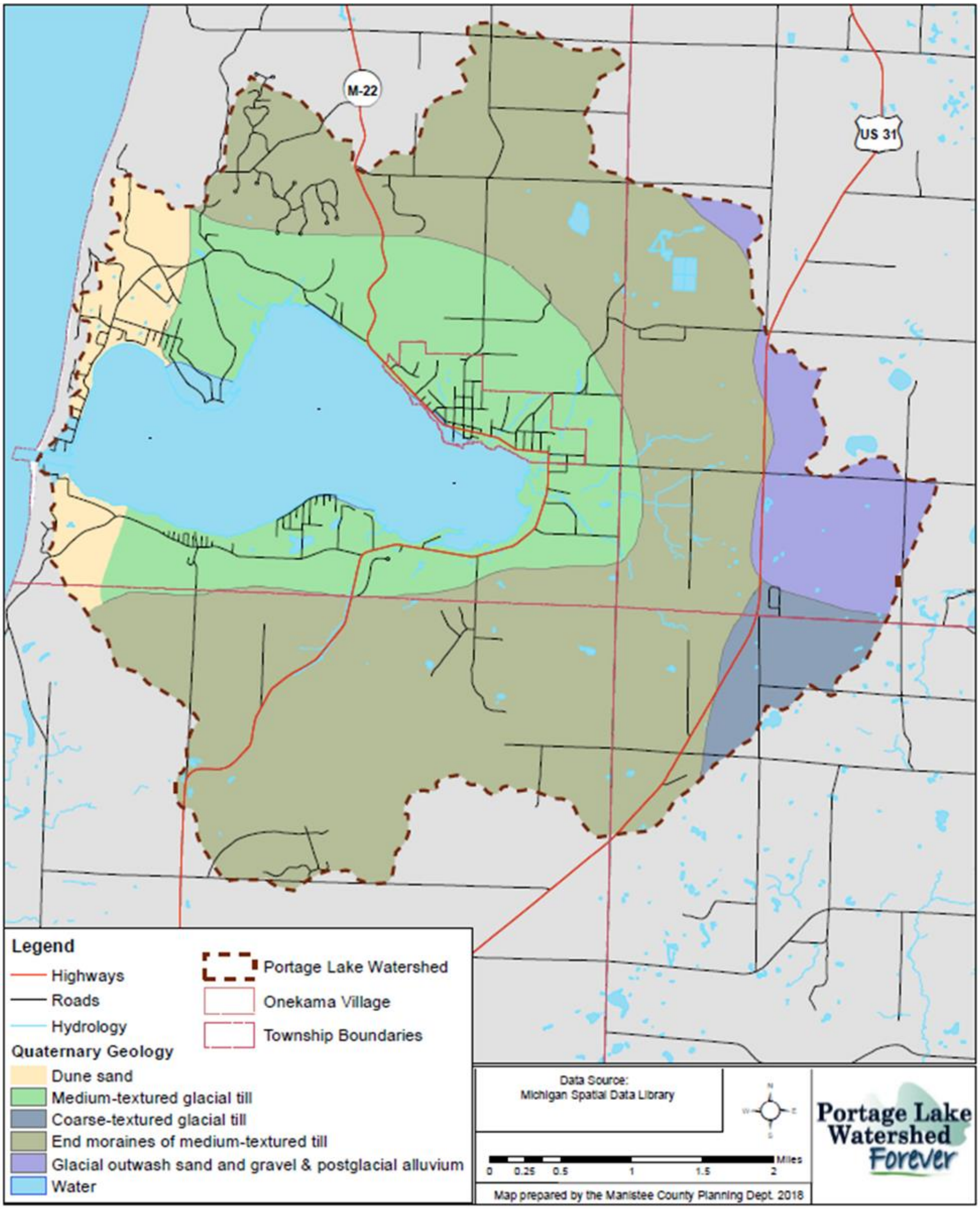


Figure 10. *Portage Lake Watershed area quaternary geology*

SOURCE: Michigan Spatial Data Library. Map prepared by the Manistee County Planning Dept. 2018.

Climate and Precipitation

PRECIPITATION

An average of 33 inches of total precipitation falls annually at the Manistee County Blacker Airport, the nearest weather station to the Portage Lake Watershed (NOAA, 2018). The maximum average precipitation occurs in August (3.6 inches) and the lowest in February (1.5 inches). See **Figure 11** for monthly precipitation averages. **Figure 12** below shows annual inches of precipitation from 1971-2017.

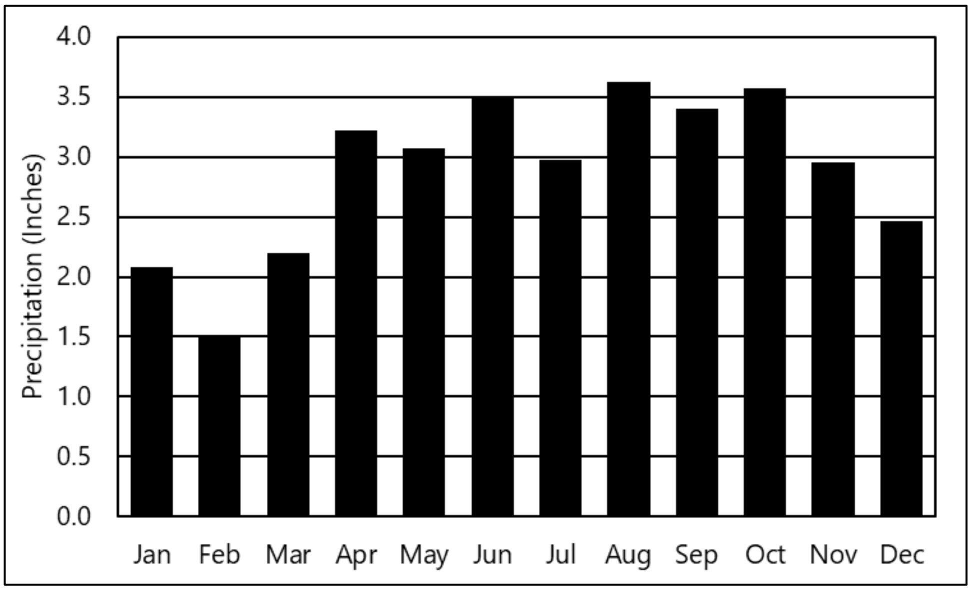


Figure 11. *Average monthly precipitation, 1971 - 2018*

SOURCE: Spicer Group, Inc., 2018, using data from NOAA, 2018.

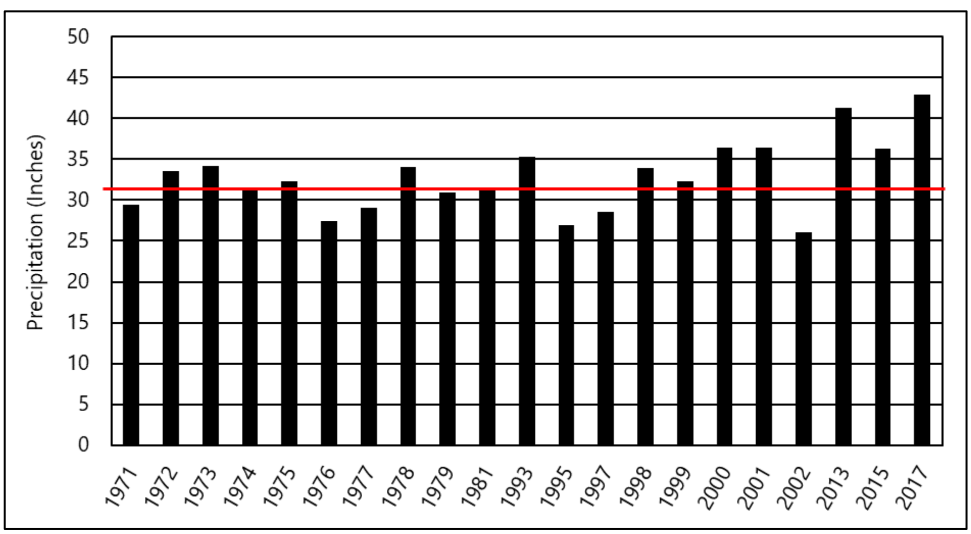


Figure 12. *Annual inches of precipitation, 1971 - 2017*

SOURCE: Spicer Group, Inc., 2018, using data from NOAA, 2018.

TEMPERATURE

During January, typically the coldest month of the year, the temperature averages 33.3 to 13.7 degrees Fahrenheit (°F). During July, typically the warmest month of the year, temperatures average between 74.9 and 57.1 °F (NOAA, 2018). See **Figure 13** for monthly temperature averages and **Figure 14** for the average annual temperatures from 1971-2018.

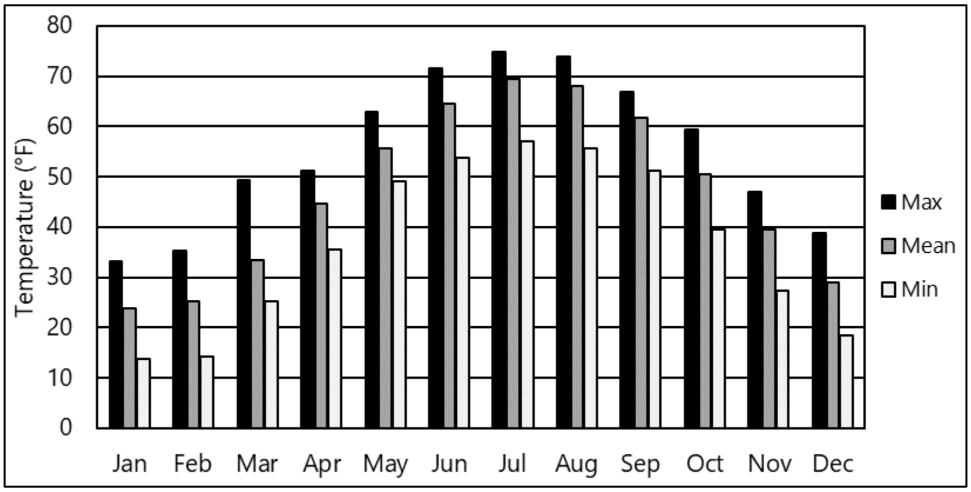


Figure 13. *Monthly temperature average at Manistee County Blacker Airport, 1971 - 2018*

SOURCE: Spicer Group, Inc., 2018, using data from NOAA, 2018.

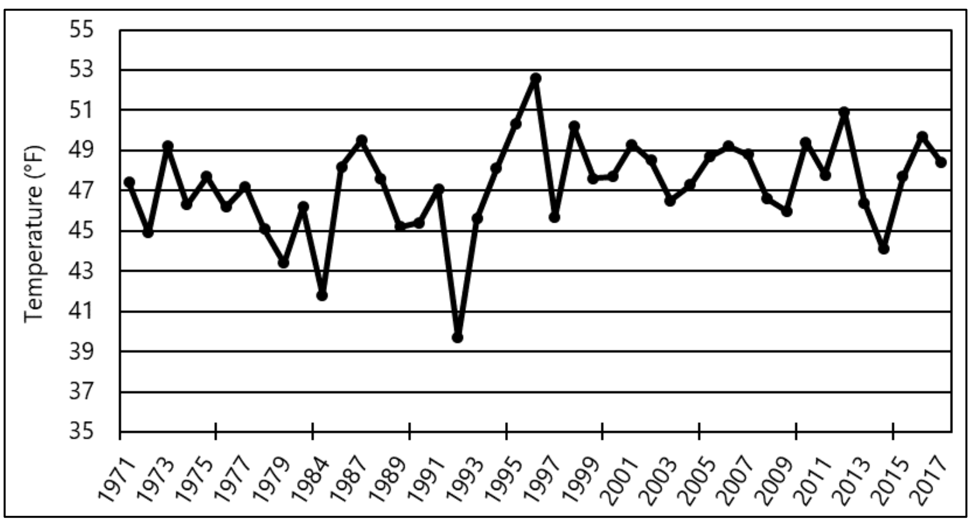


Figure 14. *Average annual temperature, 1971 - 2018*

SOURCE: Spicer Group, Inc., 2018, using data from NOAA, 2018.

Water Resources and Hydrology

The largest surface water feature in the Watershed is Portage Lake, whose area is 2,051.6 acres and comprises 13.0 percent of the total surface area of the Watershed (MDIT/CGI LP Watersheds). It is a natural lake formed by glaciers with maximum depths in two areas of up to 50 feet, see

Figure 16. The littoral zone (areas less than 15 feet in depth) makes up just over half the lake area, and the mean depth is approximately 19 feet. The total volume of the lake is estimated to be 39,449 acre-feet (48,706,500 cubic meters).

Surface water courses drain to Portage Lake and eventually to Lake Michigan through a manmade channel (Portage Lake Channel) on the west side of Portage Lake that, in 1871, replaced the natural outlet. Prior to 1871, Portage Lake was connected to Lake Michigan by Portage Creek, described at the time as a "winding, fast-flowing stream" located approximately one mile north of the current Portage Lake Channel. A water-powered sawmill and associated dam structure was located on Portage Creek, which elevated Portage Lake up to an additional six feet above natural levels. This prompted local property owners faced with flooded shoreline property to dig through the dunes to construct a permanent channel to Lake Michigan in order to lower the lake level. The channel eventually eroded to the point that the existing water level is more than ten feet below where it was prior to 1871 when the sawmill dam on Portage Creek was operating under peak conditions.

Figure 15, below, shows the original location of Portage Creek as depicted on the 1836 General Land Office Plat of Manistee County. The natural elevation of Portage Lake was four to five feet above that of Lake Michigan prior to the opening of the current channel. Now the level of Portage Lake is essentially regulated by the level of Lake Michigan. The former Portage Creek outlet to Lake Michigan no longer exists. Since the early 1900s the Portage Lake Channel has been periodically dredged to maintain navigation between Portage Lake and Lake Michigan. In 2018, a contract was awarded to Portage Lake by the U.S. Army Corps of Engineers for upkeep dredging. The last time the channel was dredged prior to 2018 was 2010.

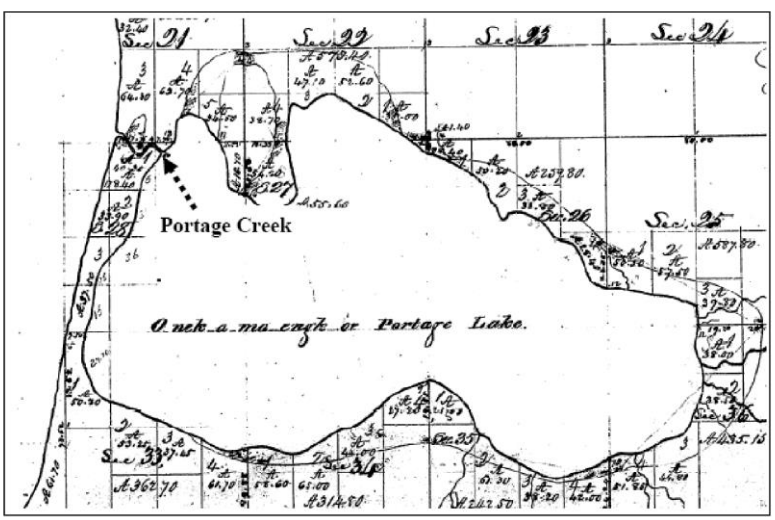


Figure 15. *Portage Lake portion of 1836 general land office plat of Manistee County (adapted)*

SOURCE: Public Sector Consultants Inc., 2007, using Portage Lake portion of MDNR 1836 General Land Office Plat of Manistee County.

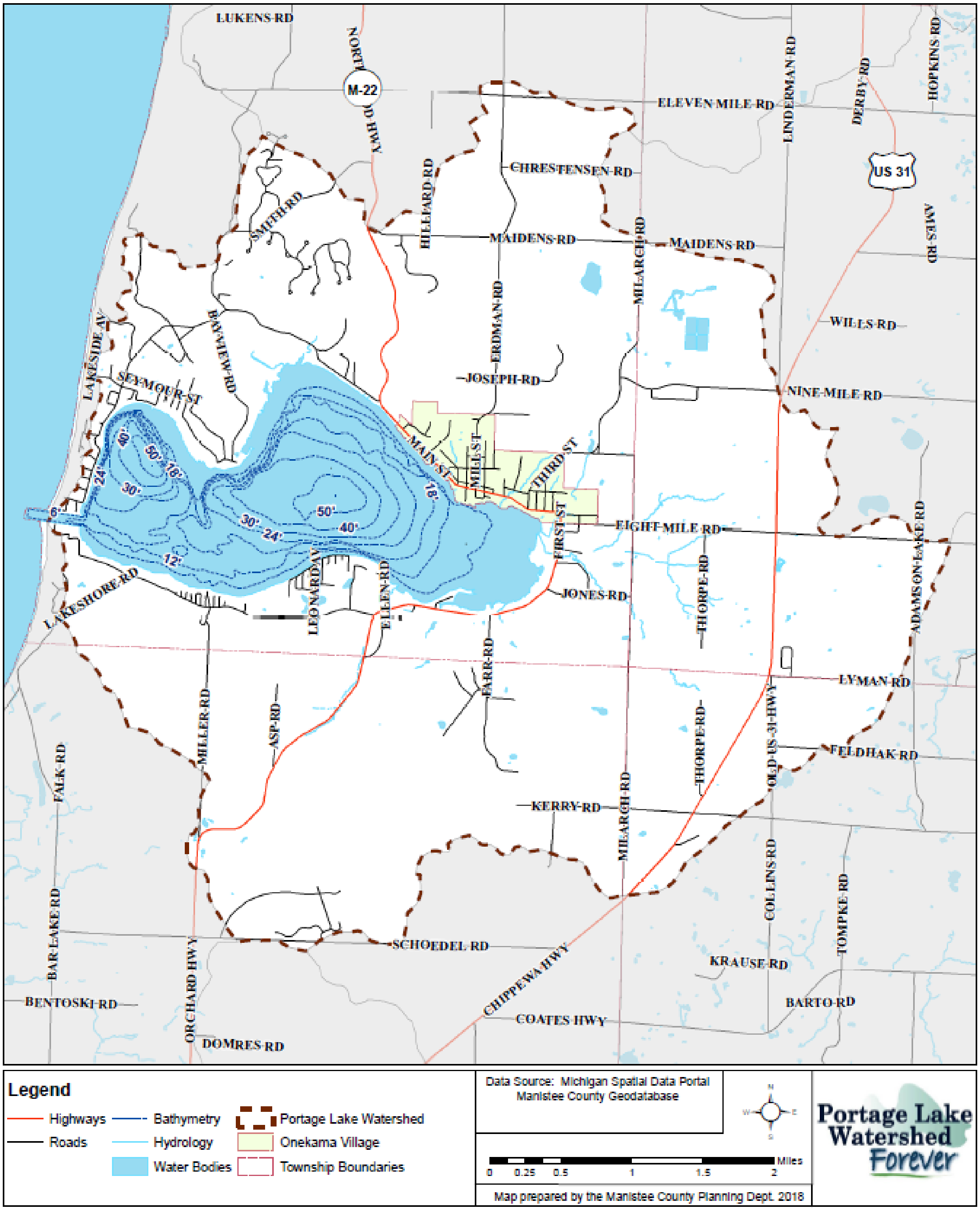


Figure 16. *Portage Lake bathymetry*

SOURCE: Michigan Spatial Data Portal, Manistee County Geodatabase. Map prepared by the Manistee County Planning Dept. 2018.

While Portage Lake is by far the largest lake in the Watershed, there are two other named lakes: Gordon and Cooper Lakes in the northeastern portion of the Watershed. The lakes and their drainages were not included in the Watershed boundary when the boundary was described as part of the 1993 Phase I Study, but these lakes were subsequently added as part of the Watershed based upon a closer examination of the topography and hydrology. Gordon and Cooper Lakes lie in a shallow basin between two ridge lines and their surface water, and presumably the groundwater, moves in a generally southeast direction before moving south and west to enter Portage Lake.

The following tributaries, depicted in **Figure 17** below along with their base flows in cubic feet per second, discharge into Portage Lake: McGowan's Creek, Onekama Creek, Schimke Creek, Dunham Creek, Sandy Point Creek (now Stream #9), and Hansen Creek.

Residence time is an indication of how long it takes for all the water in a lake to be replaced and a measure of how long the lake needs to flush itself out. The shorter the residence time, the faster changes will occur in water quality when controlled sources of nutrient input are reduced. It is estimated that Portage Lake has a relatively fast residence time for a lake its size: 3.5 years (Phase I Study, 1993). However, the unknown influence of Lake Michigan, through the outlet channel, may be a source of variability that has the potential to significantly alter this estimate. A detailed water budget for Portage Lake has not been calculated and relative impacts from various influences, including precipitation, evaporation, surface inflow, outlet outflow, and groundwater input, are not known.

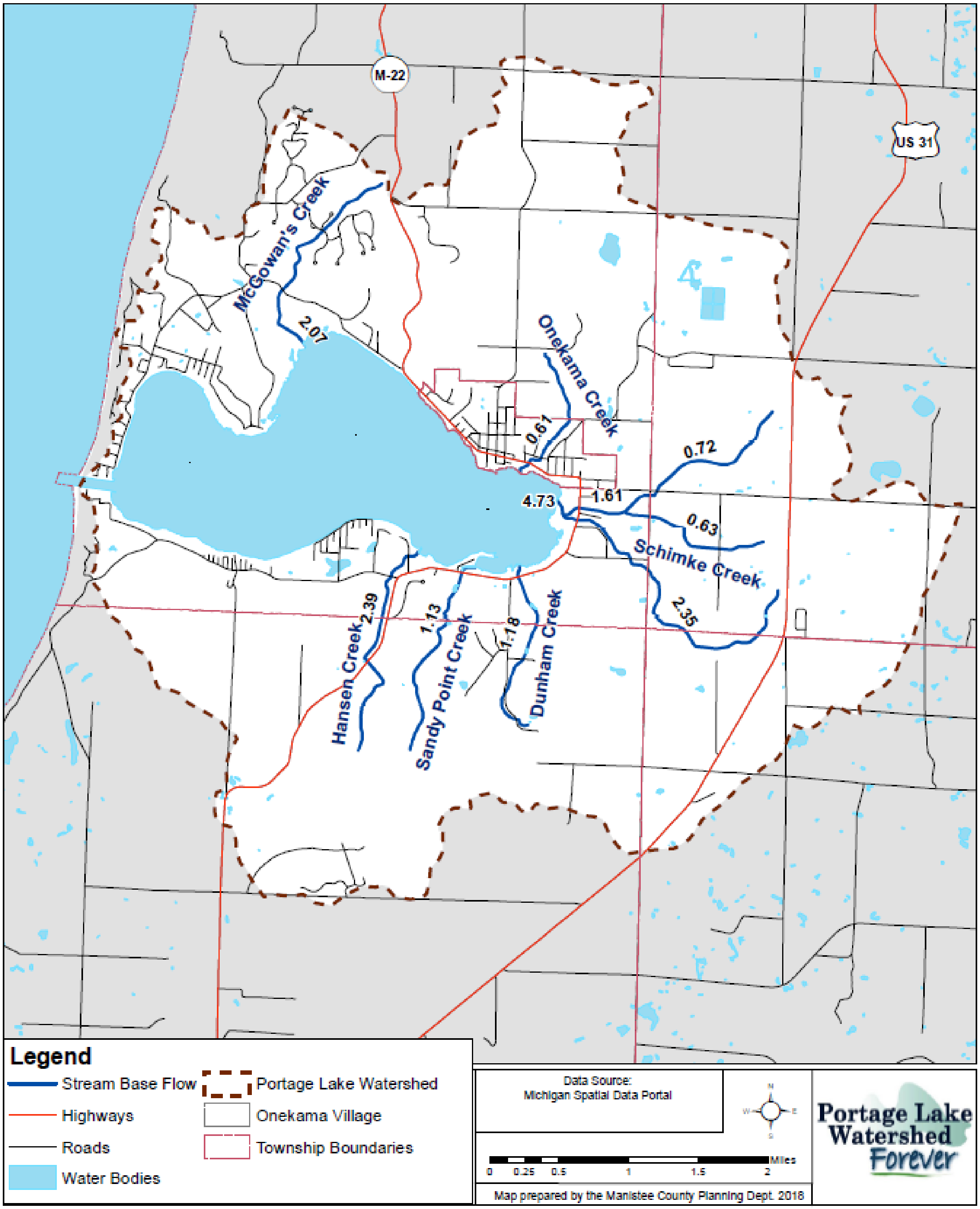


Figure 17. *Portage Lake Watershed base flow of streams (cubic feet/ second)*

SOURCE: Michigan Spatial Data Portal. Map prepared by the Manistee County Planning Dept. 2018.

Groundwater Resources

Groundwater is an important resource in the Portage Lake Watershed. It is a major source of cool water to Portage Lake and most of the tributary streams. Numerous artesian wells are found throughout the Watershed. There is no public water supply in the Portage Lake Watershed and residents and businesses rely on groundwater from wells for drinking water and irrigation. Groundwater quality and quantity are particularly important to safeguard current human uses of surface water and groundwater as well as to protect fish and wildlife habitat in the Watershed. It is estimated that influences from groundwater have a greater impact on water quality of Portage Lake than surface water or runoff. This assumption is due to the low proportion of surface water area and volume (few small lakes, short length and low flow of tributary streams) and primarily well-drained soils in the Watershed, which leads to groundwater recharge.

Unlike many watersheds in the northern Lower Peninsula, there is very little state or federal public land within the Watershed. Private land practices associated with forestry, agricultural, recreational, commercial, industrial, and residential uses have been and will continue to be the primary influence on the quality of its groundwater and surface water resources within the Watershed. Groundwater is highly susceptible to contamination from septic tanks, agricultural runoff, highway de-icing, landfills, underground storage tanks, and pipe leaks.

The Michigan Department of Environment, Great Lakes, and Energy (EGLE), under state law and under federal law delegated to the state by the USEPA, protects groundwater resources from pollution in a number of ways: it establishes and enforces groundwater discharge requirements; regulates the storage, transportation, treatment, and disposal of liquid and solid waste as well as other hazardous substances, offers guidance to owners of domestic wells, regulates underground storage tanks, and responds to accidental spills of hazardous materials or other losses of potential pollutants into or on the ground. The EGLE Wellhead Protection Program, in coordination with local health departments, promotes management practices to protect potable groundwater supplies from contamination as provided under state and federal safe drinking water laws and regulations.

Land Use and Land Cover

Original land surveys in the 1800s show that the entire Portage Lake Watershed was dominated by a beech-sugar maple-hemlock forest with conifers limited to a significant cedar swamp located on the south shore of Portage Lake and a few mixed conifer swamps in other isolated locations, **Figure 18**.

The most recent land use/land cover data available for the Portage Lake Watershed is from 2016, **Figure 19** and **Table 1**. Current land uses include developed land (open space, low, medium, and high intensity), barren land that includes sands, rock, and clay, forested land (deciduous, evergreen, and mixed), scrub/shrub land, grassland, pasture/hay, cultivated crops, and woody and emergent wetlands. The primary land cover in the Watershed is forestland, specifically deciduous forest, followed by agriculture (hay and cultivated crops) and grassland which is similar to 2001 data. There were approximately 12,960 acres of forest in 1800; in 2016, 5,292 acres of forestland were recorded, a decrease of 7,668 acres from 1800. In comparison to 2001 data, shown in **Table 1**, below, wetlands and urbanized areas (low and high density residential and commercial/ industrial/transportation) are limited primarily to shoreline areas adjacent to Portage Lake, particularly in the Village of Onekama on the east end of the lake; along the eastern half of the south shore; in the central portion of the north shore; and along the west shore near the outlet channel to Lake Michigan. The few remaining wetlands are located in these same areas adjacent to Portage Lake and in portions of tributary streams.

Table 1. *Portage Lake Watershed land use/land cover, 2001 and 2016*

	2001 Data		2016 Data	
Land Use Class	**Acres**	**% of Watershed**	**Acres**	**% of Watershed**
Commercial/Industrial	59	0.4	N/A	N/A
High-density residential	672	4.3	89	0.6
Low-density residential	1,043	6.7	618	3.9
Forestland	5,494	35.1	5,292	33.5
Wetland	722	4.6	670	4.2
Grassland	1,946	12.4	1,802	11.4
Agriculture	3,593	22.9	3,310	21.0
Surface Water	2,139	13.7	2,131	13.5

SOURCE: MSU CEVL and LPI, 2007, using data from MRLCC, 2001; Updated by Spicer Group, Inc., 2018, using data from the Natural Resources Conservation Service.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001 and 2016.

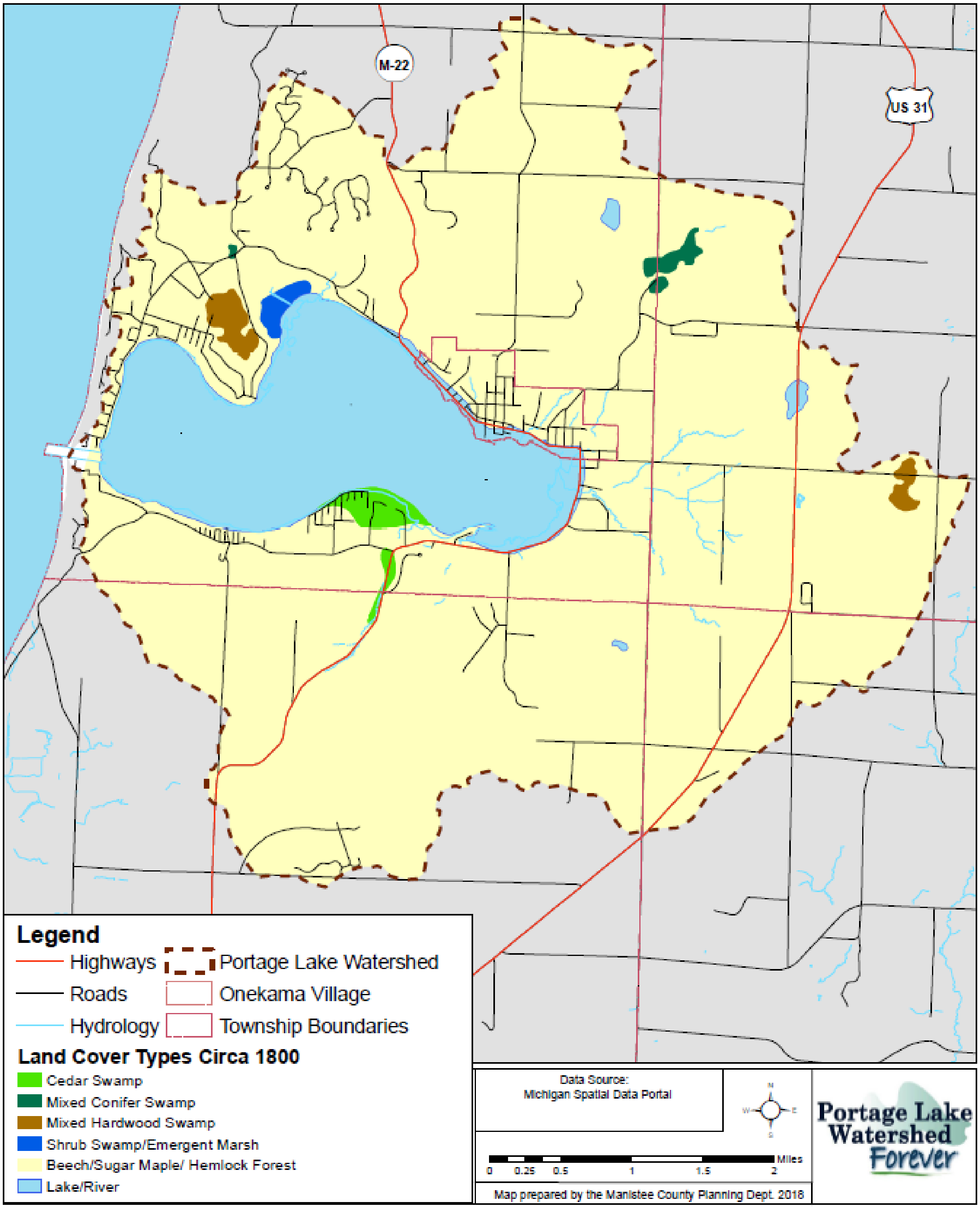


Figure 18. *Portage Lake Watershed 1800 land cover*

SOURCE: Michigan Spatial Data Portal. Map prepared by the Manistee County Planning Dept. 2018.

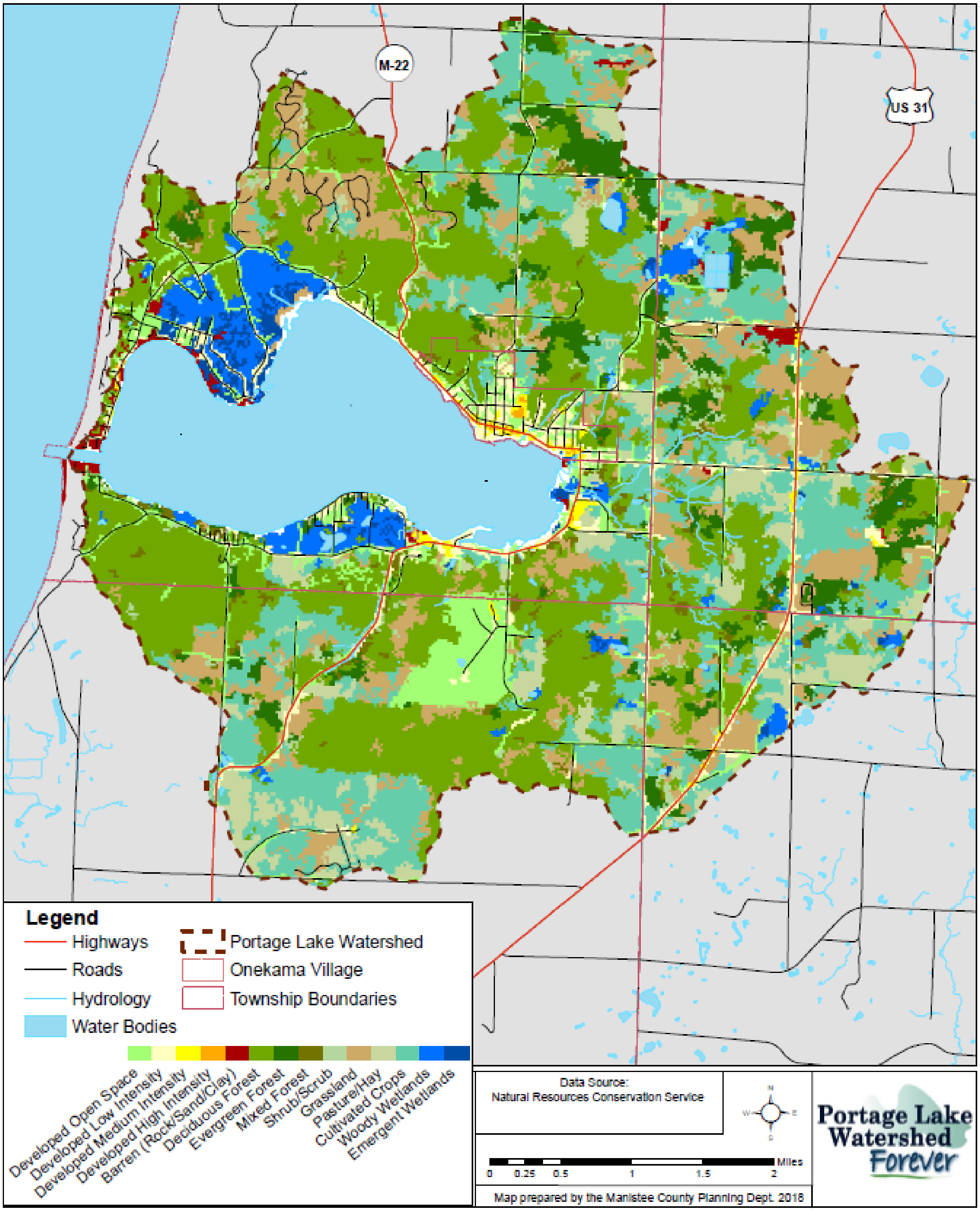


Figure 19. *Portage Lake Watershed 2016 land cover*

SOURCE: Natural Resources Conservation Service. Map prepared by the Manistee County Planning Dept. 2018.

Wetlands

Wetlands provide many important functions such as flood control, groundwater recharge, erosion control, pollution treatment, nutrient sources in aquatic and terrestrial food cycles, and critical habitat for numerous species of wildlife (Richardson 1994). Wetland areas, including those found in the Portage Lake Watershed, are regulated by law according to Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451. These laws define a wetland as "land characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation, or aquatic life, and is commonly referred to as a bog, swamp, or marsh."

HISTORICAL WETLANDS

Based upon wetland maps developed in 1995 by the Michigan Natural Features Inventory, of land cover conditions in the 1800s, **Figure 20** illustrates the areas of wetland loss in the Watershed. Most of the losses have been associated with the shore areas of Portage Lake, where residential and commercial development and related transportation corridors have been most intense over the last 160 years. Nearly 15 percent of the shoreline of the lake has been modified by bulkheads or breakwalls, with less than 25 percent remaining in natural wetland habitat.

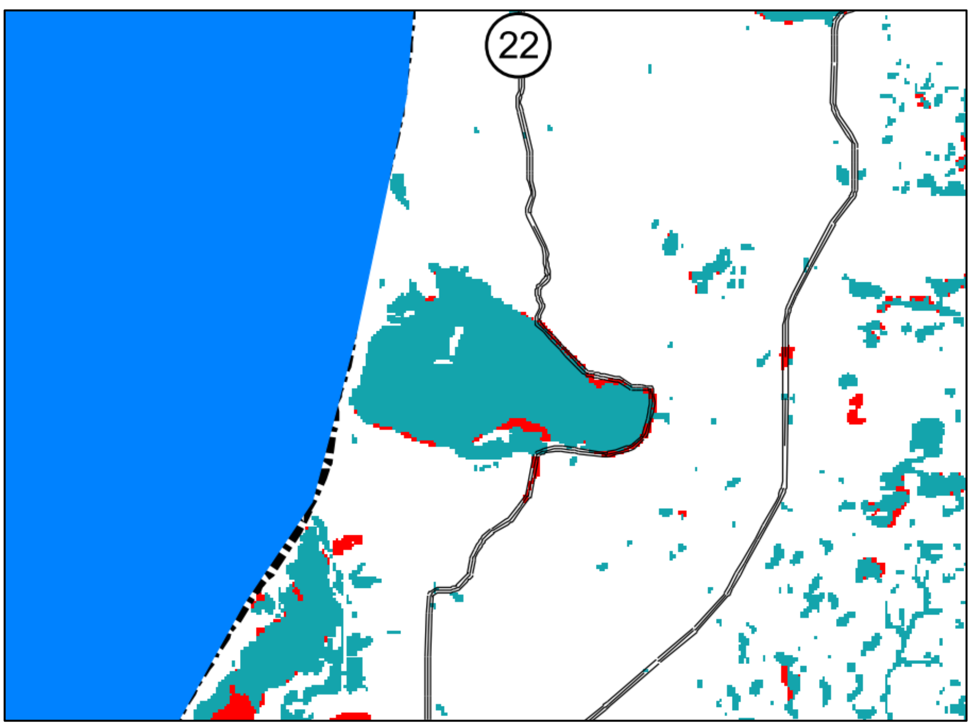


Figure 20. *Portage Lake area wetland loss from 1800s to 1980s (indicated in red)*

SOURCE: Michigan Natural Features Inventory, MSU Extension, 1995.

CURRENT WETLANDS OF POTENTIAL SIGNIFICANCE AND WETLAND LOSSES

The EGLE has completed maps of all Michigan counties that identify potential and approximate locations of wetlands, using overlays of data from the following sources:

- The National Wetland Inventory (NWI), conducted by the U.S. Fish and Wildlife Service through interpretation of topographic data and aerial photographs.
- Land cover, as mapped by the Michigan Department of Natural Resources Michigan Resource Inventory System (MIRIS), through interpretation of aerial photographs.
- Soils, as mapped by the U.S. Department of Agriculture (USDA), Natural Resource Conservation Service.

Figure 21, below, depicts the various types of wetlands identified within the Portage Lake Watershed. Identified within this map shows that the Watershed is comprised of the following types of wetlands: emergent wetland, lowland conifer, lowland hardwood, shrub/scrub wetland, wooded wetland. This map is not as accurate as **Figure 22** which depicts the most precise portrayal of the National Wetland Inventory within the Portage Lake Watershed, provided by the Michigan Department of Environment, Great Lakes, and Energy and shows that there is a total of 1,539.13 acres within the Portage Lake Watershed.

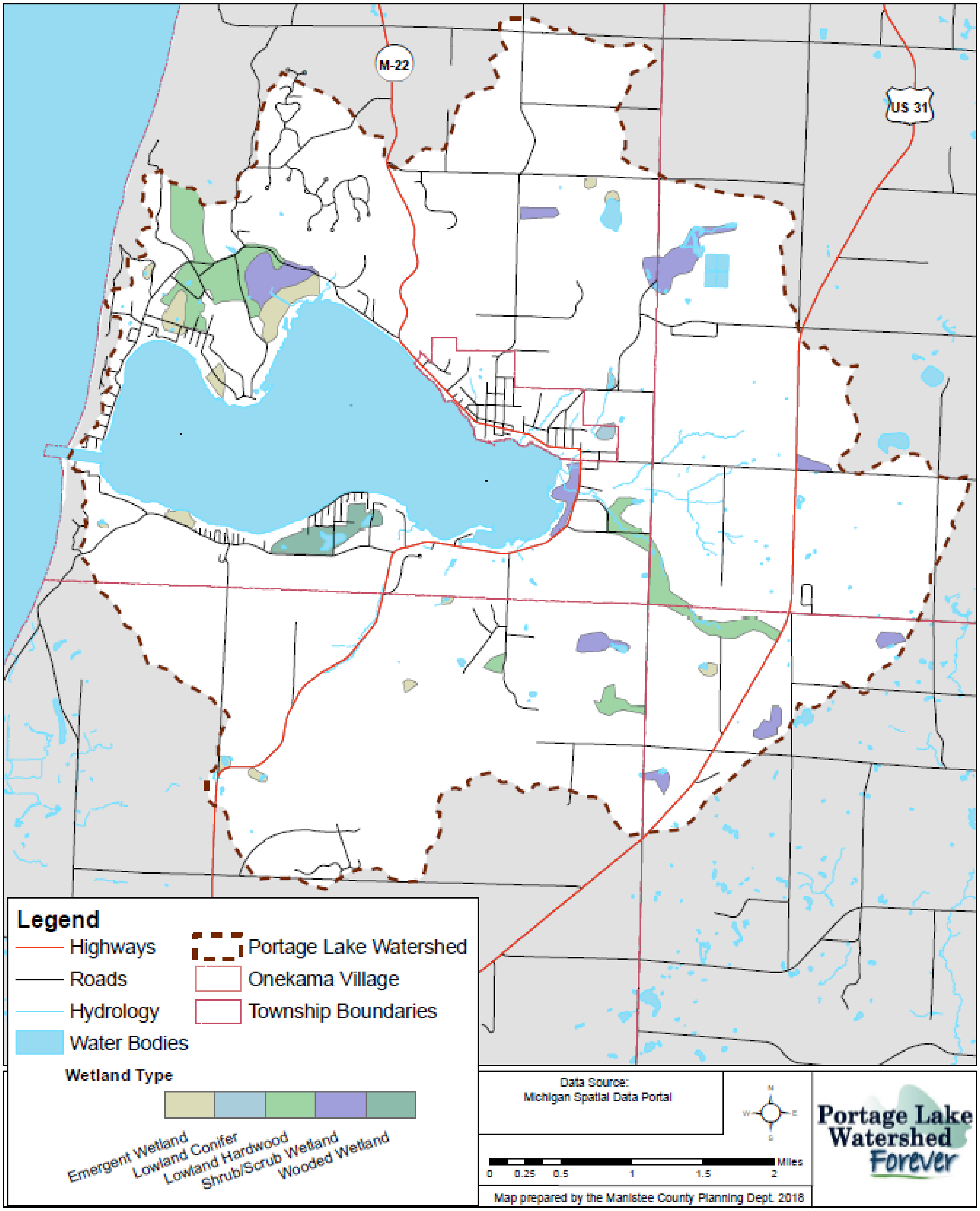


Figure 21. *Portage Lake Watershed wetlands*

SOURCE: Michigan Spatial Data Portal. Map prepared by the Manistee County Planning Dept. 2018.

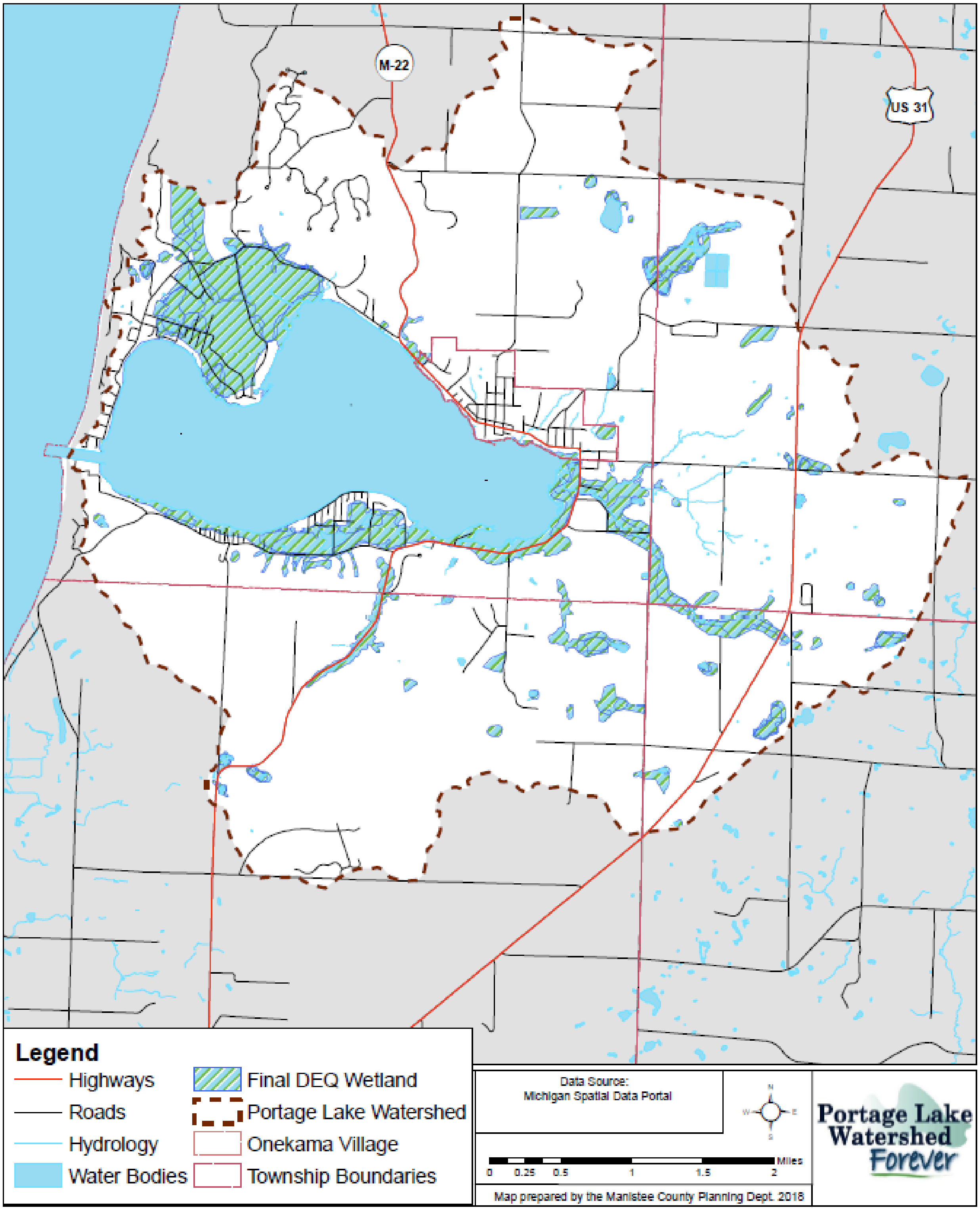


Figure 22. *Portage Lake Watershed wetland (EGLE wetland inventory)*

SOURCE: Michigan Spatial Data Portal. Map prepared by the Manistee County Planning Dept. 2018.

Floodplain

Figure 23 depicts the Portage Lake Watershed's 2017 Floodplain Draft provided by the Federal Emergency Management Agency (FEMA).

The map was prepared by the Manistee County Planning Department in 2018. It should be noted that this is draft data and is subject to change. The floodplain zones depicted within this figure are defined by the following:

1. Zone A – The 100-year or base floodplain where the base floodplain is mapped by approximate methods (i.e. base floodplain elevations (BFEs) are not determined). This is often called an unnumbered A Zone, or an approximate A Zone.

2. Zone AE – The 100-year base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.

3. Zone VE – The coastal area subject to a velocity hazard (wave action) where BFEs are provided on the Flood Insurance Rate Map (FIRM).

It should be noted that X < .02% is not a FEMA Flood Insurance Rate Map Zone, however, there are the following zones classifying the .02%, or 500-year floodplain:

1. Zone B and Zone X (shaded) – Area of moderate flood hazard, usually the area between the limits of the 100-year and the 500-year floods. B Zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from the 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than one square mile.

2. Zone C and Zone X (unshaded) – Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. Zone C may have ponding and local drainage problems that don't warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood and protected by levee from 100-year flood.

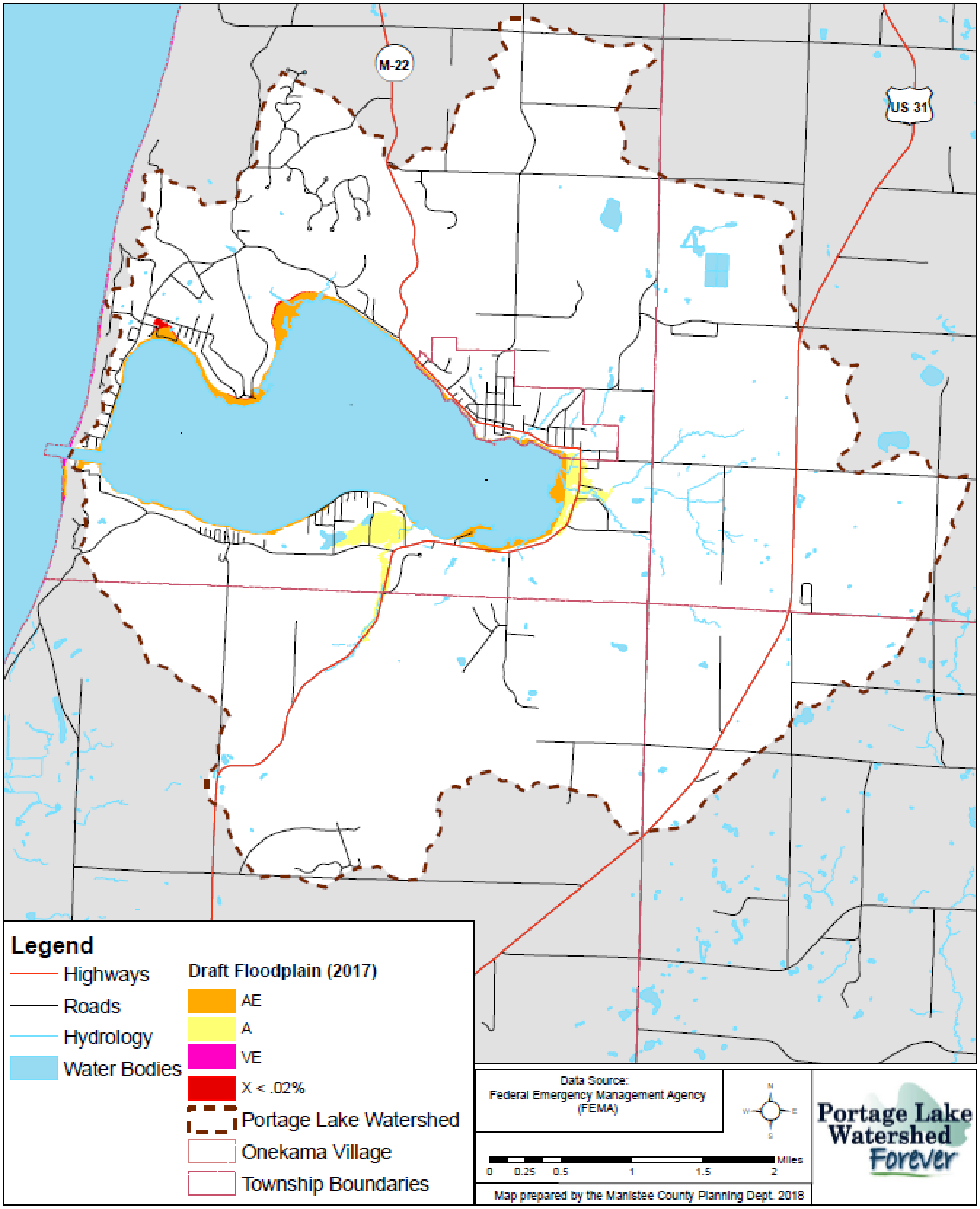


Figure 23. *Portage Lake Watershed floodplain- Draft (2017 FEMA study)*

SOURCE: Federal Emergency Management Agency (FEMA). Map prepared by the Manistee County Planning Dept. 2018.

Land Use Projections

Researchers at Michigan State University have developed a spatialized trend model to project what Michigan's landscape might look like in the future if present trends continue. The analysis was conducted on the Michigan base (1980), provided by the MIRIS, the projected land use in 2020, and the projected land use for 2040. The digital maps for these three-time periods are shown in **Figure 24**.

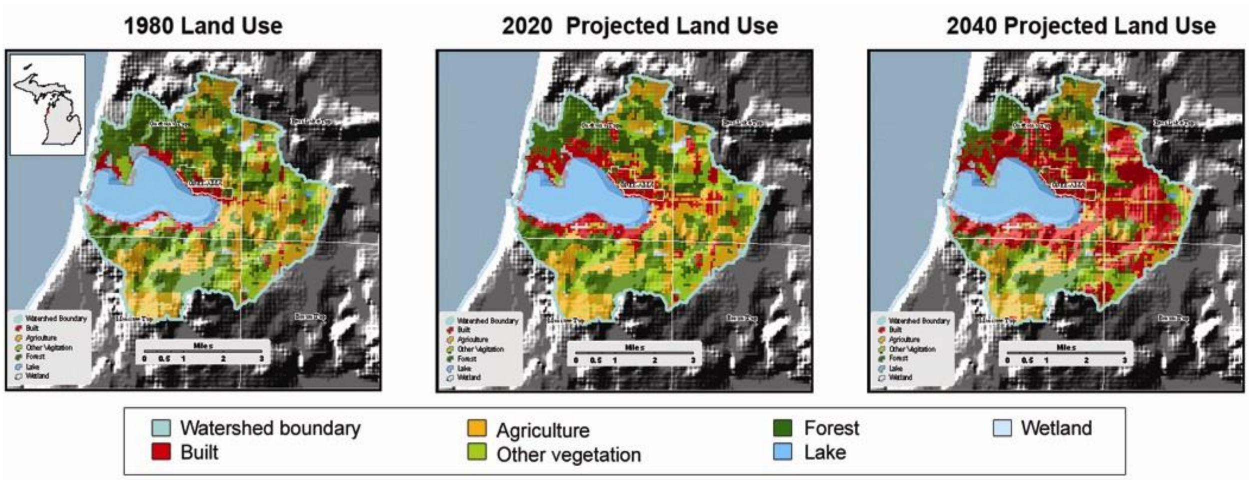


Figure 24. *Portage Lake basin land use in 1980 and projections for 2020 and 2040*

SOURCE: MSU CEVL and LPI, 2007.

By 2040, the built areas of the Portage Lake Watershed are projected by the model to increase by 409 percent. The other vegetation, agriculture, forest, and wetland areas are expected to decline in acreage. **Table 2** summarizes the results from the analysis. This trend indicates that growth comes at the price of forestland, wetland, and agricultural land loss. Given past trends and future projections, the need for structured land use planning and protection becomes evident.

Table 2. *Predicted land use changes, 1980-2040, acres*

Class	1980 (Acres)	2040 (Acres)	Change (Acres)	Percent (%) Increase/Decrease
Agriculture	4,043	2,701	–1,342	–33
Built	1,137	5,790	4,653	409
Forestland	5,508	3,408	–2,100	–38
Wetland	425	175	–250	–59
Other Vegetation	2,493	1,532	–961	–39

SOURCE: MSU CEVL and LPI, 2007.

Surface and Minerals

Currently, the State of Michigan owns approximately 39.68 acres of subsurface minerals within the Portage Lake Watershed, mineral ownership retained by the state mostly from tax reverted lands whose surface ownership was subsequently sold. This acreage has decreased from the 1,700 acres of state owned minerals and subsurface minerals in 2008. The state holds title to fewer than 400 acres of surface land within the Watershed. In 2008, with the exception of small acreage owned by local government, more than 95 percent of the subsurface minerals and over 98 percent of the surface lands within the Watershed were privately owned, see **Figure 25**. There was no or very limited federally owned property within the Watershed. **Figure 26** depicts the Michigan Department of Natural Resources owned mineral and surface areas along with mineral areas within the Portage Lake Watershed.

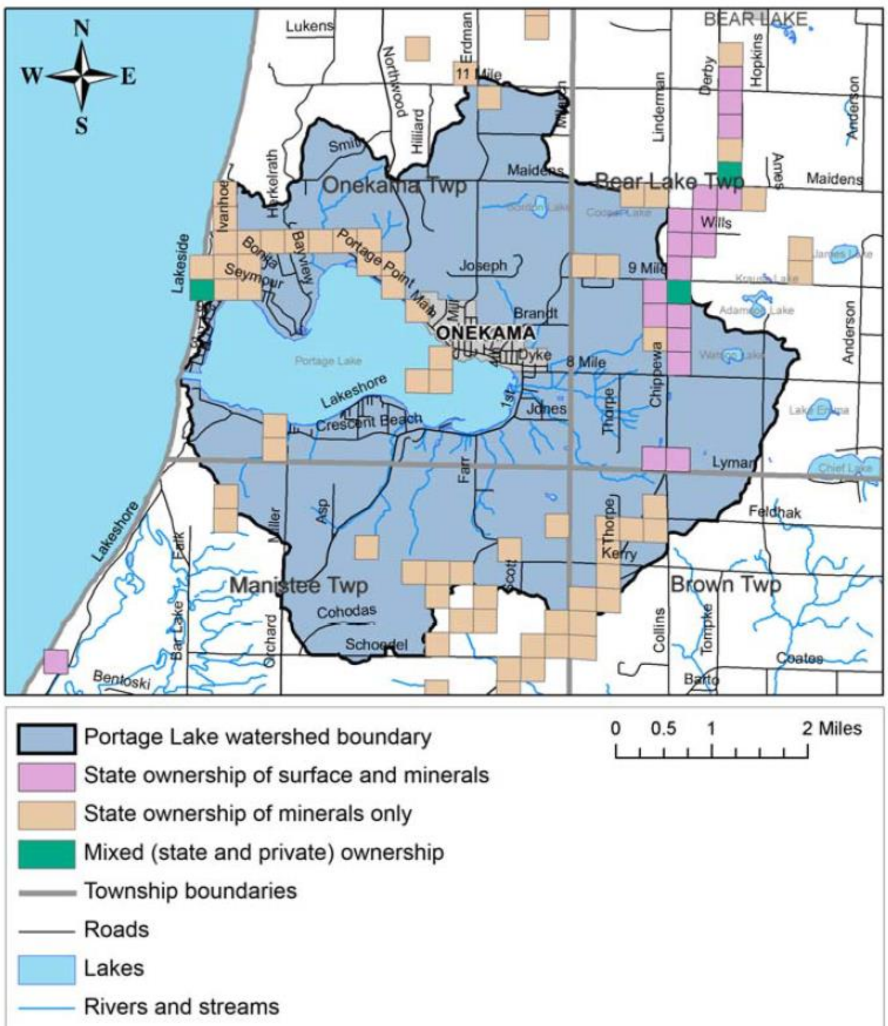


Figure 25. *Portage Lake Watershed ownership of surface and minerals (2007)*

SOURCE: Public Sector Consultants Inc., 2007, using data from MDIT/CGI (Manistee DNR Land and Mineral Ownership).

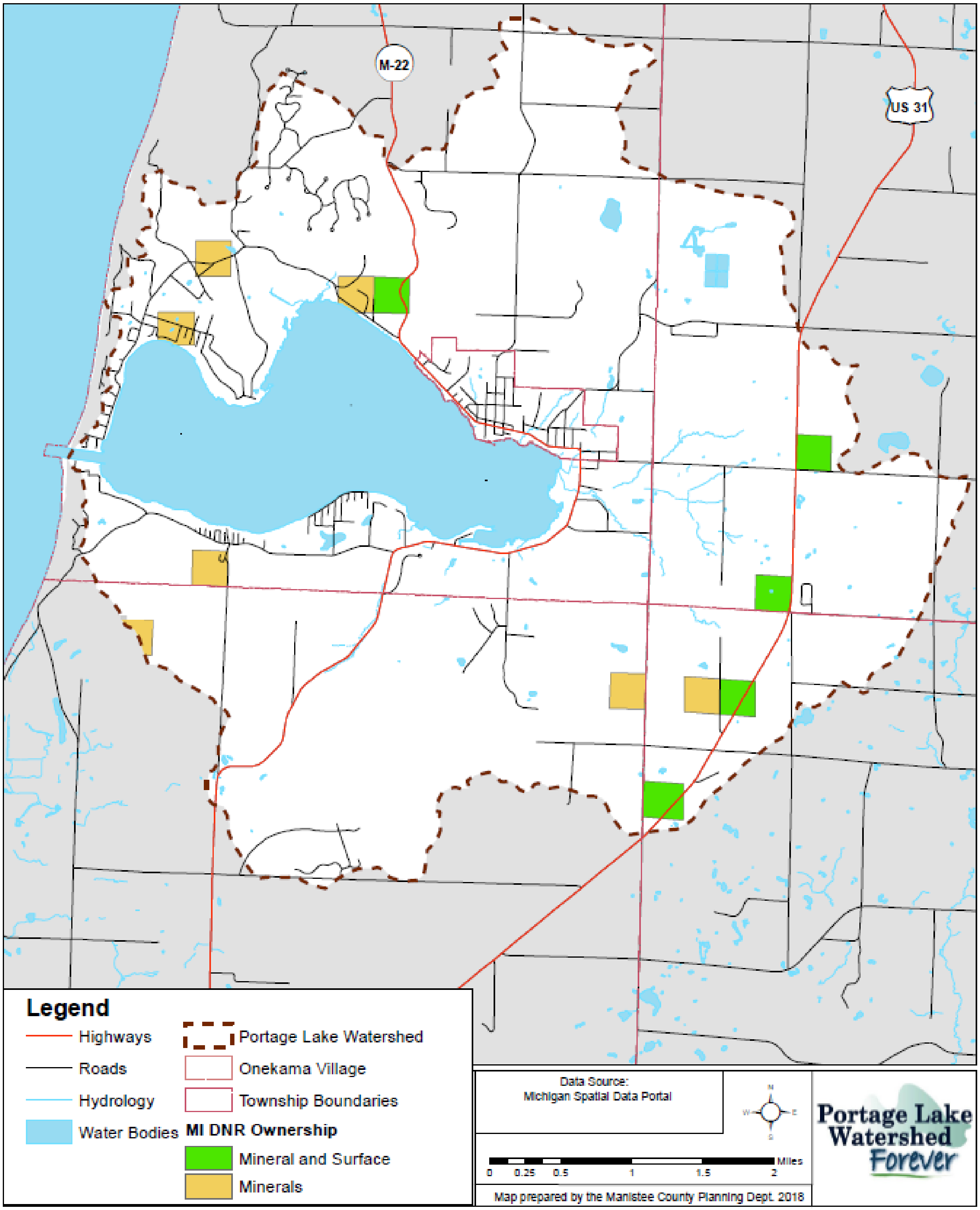


Figure 26. *Portage Lake Watershed MDNR surface/mineral ownership*

SOURCE: Michigan Spatial Data Portal. Map Prepared by The Manistee County Planning Dept. 2018.

CHAPTER 2: LOCAL PROGRAMS, PROJECTS, AND PLANNING

LOCAL GOVERNMENT PLANNING AND ZONING

Protecting water quality requires looking at what happens on the land within a watershed. How communities manage their land use has a direct impact on their water quality. Since watershed boundaries cross jurisdictional boundaries, it is important to consider each jurisdictional unit within a watershed while evaluating the effectiveness of local government planning and regulations in protecting water quality.

Five local government units are represented within the Portage Lake Watershed: Onekama Township, Bear Lake Township, Manistee Township, Brown Township and the Village of Onekama. Onekama Township comprises approximately one-half of the Watershed area; Bear Lake Township and Manistee Township comprise approximately one-fifth each; Brown Township comprises less than one-tenth, and the Village of Onekama constitutes approximately two percent of the Watershed area, **Table 3**. It is important to note that the Village includes Portage Lake frontage.

Table 3. *Communities in the Portage Lake Watershed*

Jurisdiction	Acres Within Watershed	Square Miles Within Watershed	Percent of Jurisdiction Within Watershed	Percent of Watershed
Bear Lake Township	3,019	4.7	13%	19%
Brown Township	1,085	1.7	5%	7%
Manistee Township	3,476	5.4	12%	22%
Onekama Township	7,821	12.2	56%	50%
Village of Onekama	375	0.6	100%	2%

SOURCE: Public Sector Consultants Inc., 2007.

A comprehensive or master plan is a blueprint or set of long-term goals and policies that a community uses to guide development decisions. A master plan can also be used to assist with special land use and site plan reviews; capital improvement programs; special programs such as economic development, parks, trails, gateway improvements, etc.; and leveraging financial support for community efforts. Zoning is a tool for making master plans a reality. Zoning is regulatory and provides specific enforceable standards. Benefits of zoning include local control/autonomy over land use decisions, communicating clear expectations to potential developers based on community needs, and an opportunity for local residents to have input on designing the type of community in which they want to live. A review of master plans and zoning ordinances was conducted for each jurisdiction within the Watershed. The status or lack of such documents is summarized in **Table 4**, below. Zoning maps for selected jurisdictions can also be seen below in **Figures 27**, **28**, **29**, and **30**.

Table 4. *Status of planning and zoning documents for jurisdictional units within the Portage Lake Watershed*

Jurisdiction	**Comprehensive or master plan** (last date of revision or adoption)	**Zoning ordinance** (last date of revision or adoption)
Village of Onekama	Onekama Community Master Plan, 2010 (March 17, 2010 by Village of Onekama)	Multiple; from 2004, 2008, 2011, 2015, March 18, 2016
Onekama Township	Onekama Community Master Plan, 2010 (Adopted March 2, 2010 by Township of Onekama)	Adopted 1991; last revised 2005 (Printed 2014)
Bear Lake Township	Adopted 2002 Lakes to Land Regional Initiative, Adopted 2014	Adopted 1995; last revised 2007
Manistee Township	Adopted 2001 Manistee County Master Plan (2008), Adopted January 20, 2009	Adopted 1986; revised in 2006; last revised October 2009
Brown Township	Adopted 1991 (revision in progress)	Adopted 2001; last revised 2005

SOURCE: Public Sector Consultants Inc., 2007, updated by Spicer Group, Inc., 2018.

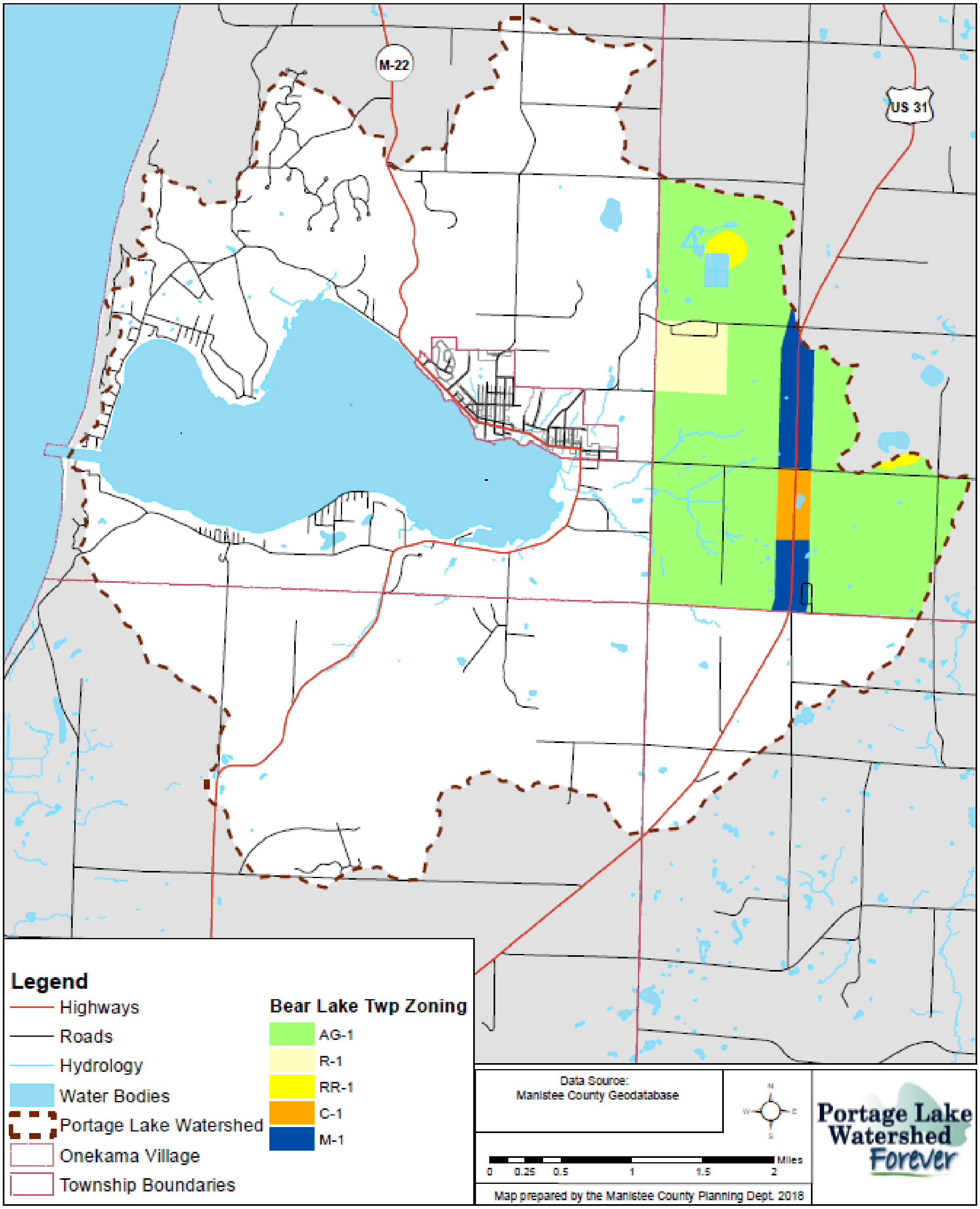


Figure 27. *Portage Lake Watershed Bear Lake Township zoning*

SOURCE: Manistee County Geodatabase. Map prepared by the Manistee County Planning Dept. 2018.
Key: AG-1: Agriculture District   R-1: Residential District   RR-1: Resort Residential   C-1: Commercial District
M-1: Multiple Use District

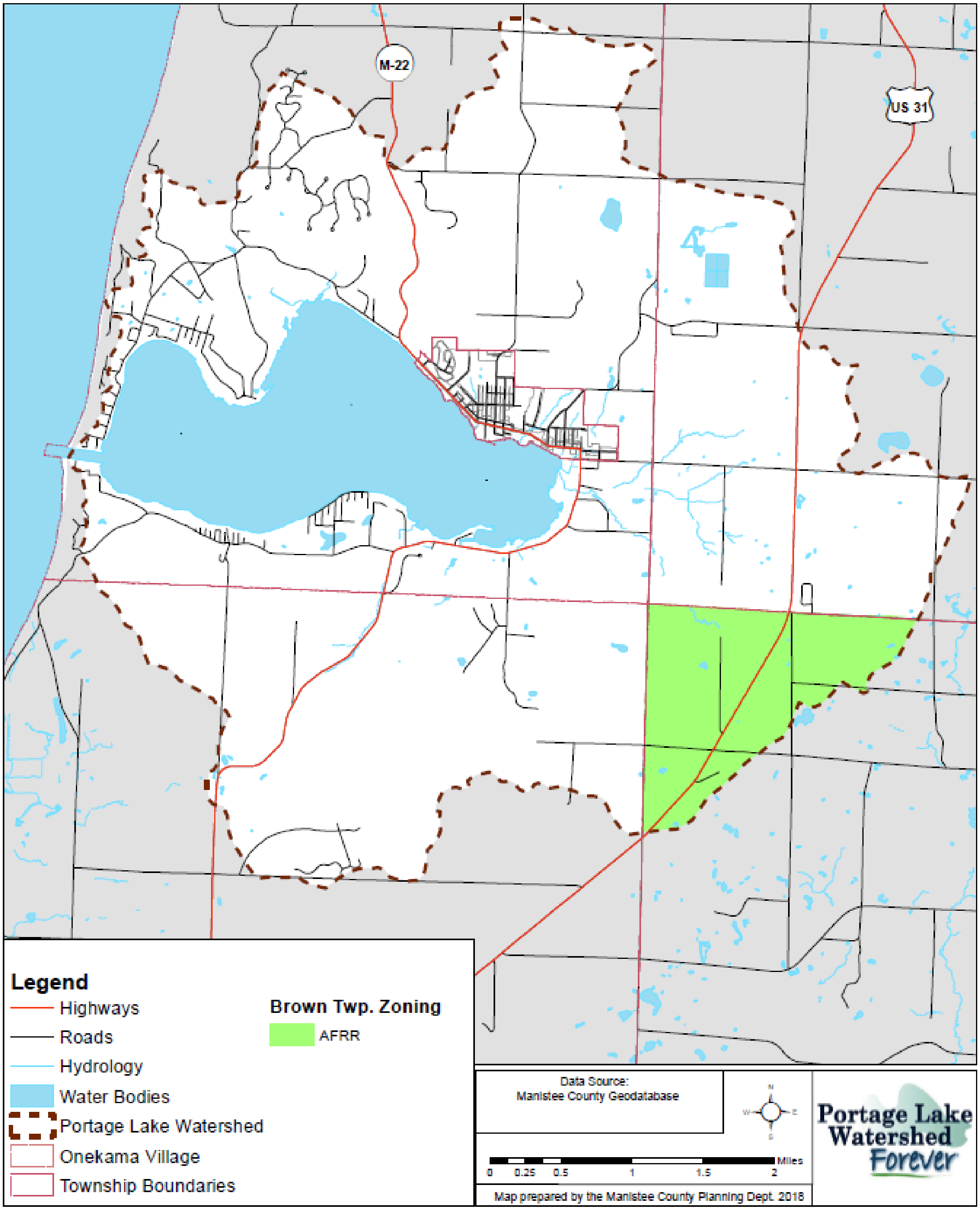


Figure 28. *Portage Lake Watershed Brown Township zoning*

SOURCE: Manistee County Geodatabase. Map prepared by the Manistee County Planning Dept. 2018.
Key: AFRR:

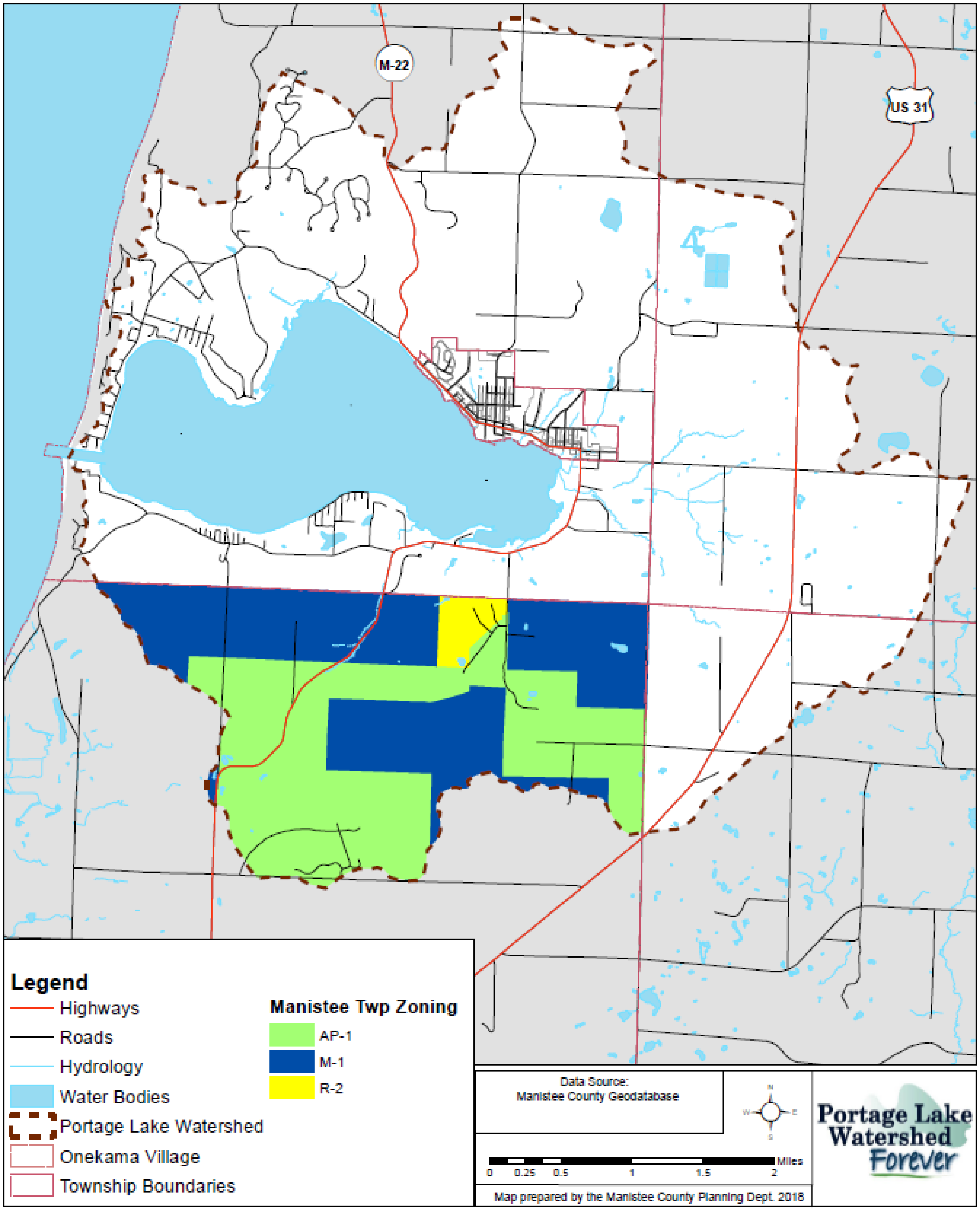


Figure 29. *Portage Lake Watershed Manistee Township zoning*

SOURCE: Manistee County Geodatabase. Map prepared by the Manistee County Planning Dept. 2018.
Key: AP-1: Ag-Forest Preservation   M-1: Multiple Use   R-2: Country Residential

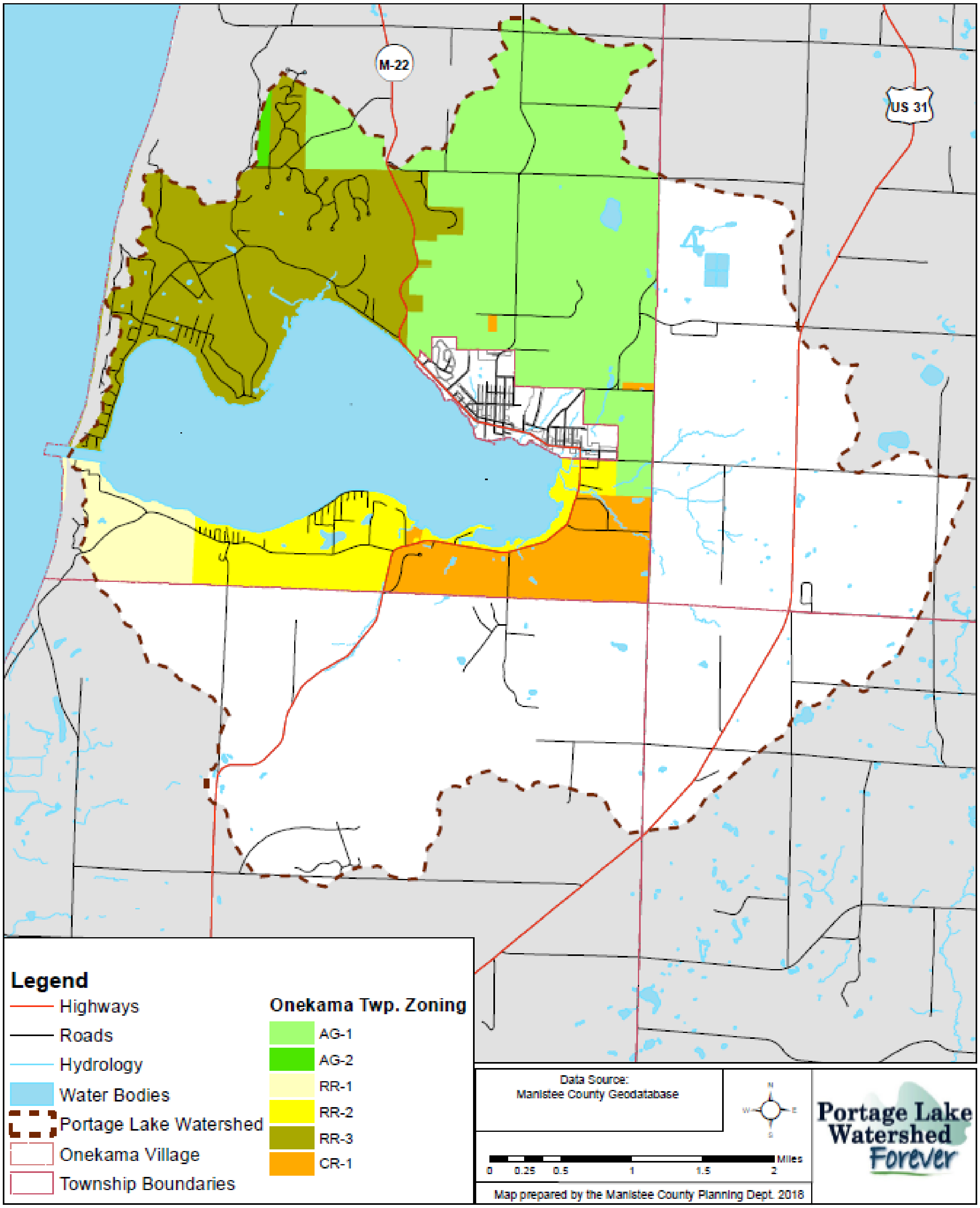


Figure 30. *Portage Lake Watershed Onekama Township zoning*

SOURCE: Manistee County Geodatabase. Map prepared by the Manistee County Planning Dept. 2018. Key: AG-1: Agriculture Residential 1   AG-2: Agriculture Residential 2   RR-1: Resort Residential 1   RR-2: Resort Residential 2   RR-3: Resort Residential 3   CR-1: Commercial Residential

Furthermore, the 2008 Manistee County Master Plan was adopted by the Manistee County Board of Commissioners on January 20, 2009 under the Michigan Planning Enabling Act, P.A. 33 of 2008. This plan serves as a guide to public investment and services provided by Manistee County and is used by the Board of Commissioners and other agencies, departments and boards of the county for future decision making, capital budget planning and guiding where future services and facilities will be needed.

The Manistee County-Wide Park & Recreation Plan was prepared by the Manistee County Planning Department and the Alliance for Economic Success. This plan was adopted by the local municipalities within the plan in the months of January and February of 2016 and was adopted by the Manistee County Board of Commissioners on February 16th of 2016. This plan includes county wide information such as recreation sites, hunting lands, public beach accesses, public boat launches, public canoe and kayak access areas and campgrounds and camping locations.

The Portage Lake Community Five-Year Plan for Parks and Recreation in the Village of Onekama, Onekama Township, and the Onekama Consolidated Schools, February 2009 was prepared by the Onekama Village and Township Community Parks and Recreation Committee, a Committee of the Onekama Township Board, in Cooperation with Representatives of the Village of Onekama and the Onekama Consolidated Schools. This was the third plan that had been written by the Onekama Village and Township Community Parks and Recreation Committee.

How and where a community grows has an enormous impact on water quality. Fortunately, a community can plan for growth in a way that protects water quality through planning and zoning. **Table 5** provides a brief summary of planning and zoning tools that protect water quality.

Table 5. *Planning and zoning tools to protect water quality*

Tool	Description
Joint planning	Stormwater management in a watershed basin typically involves cooperation and integration among several municipalities, jurisdictions, and planning agencies. Michigan's Joint Planning Act (Public Act 226 of 2003) authorizes local governments to pull together regional planning entities - Joint Planning Commissions. These commissions facilitate cooperation and coordination by overseeing issues for the region, or a portion of a region, in which they may have an interest, such as a business district, watershed or greenway.
Septic system point-of-sale ordinance	An ordinance geared to protect water quality by requiring inspections and, if necessary, upgrades to septic systems at the time of property transfer, as well as ongoing septic system monitoring and requirements.

Table 5 cont. *Planning and zoning tools to protect water quality*

Tool	Description
Stormwater management ordinance for site development	An ordinance intending to minimize the potential adverse impacts on natural resources and water quality from stormwater runoff. It can require design guidelines and standards, green infrastructure, low-impact development*, soil erosion and sediment control for development projects (Part 91 of PA 451) and best management practice incentives.
Mixed-use zoning	Allows residential, office and retail buildings to be built close to one another, something traditional zoning forbids. More intense, compact development works best when different uses are within walking distance, so mixed developments can reduce the amount of land needed per unit. It also supports a range of transportation options and facilitates shared parking, thereby reducing the amount of surface needed for roads and parking lots.
Compact lot sizes	Allows land to be used more efficiently by building on smaller lots. Smaller lots also mean smaller lawns-large lawns treated with fertilizers and chemicals are a significant contributor to storm-water pollution.
Maximum setbacks	Establishes a maximum distance between buildings and the street. This change encourages more efficient use of space and pedestrian friendliness.
Minimum setbacks	Establishes a minimum distance from rivers, lakes, streams, wetlands, floodplains, critical areas, etc. for building/development to protect these environmental features.
Open space PUD and noncontiguous PUDs	Allows local governments to approve a planned unit development (PUD) that preserves open space, whether it is connected or not to the rest of the PUD.
Purchase of development rights (PDR)	Allows municipalities, individuals, and organizations to purchase just the rights to develop (or not develop) a piece of land, instead of buying the land outright. PDR is currently available at both the state and local government levels; conservancies and land preservation groups can provide more information about these programs.

Table 5 cont. *Planning and zoning tools to protect water quality*

Tool	Description
Watershed alliances	Public Act 517 of 2004 allows two or more municipalities, by resolution of their governing bodies, to establish a voluntary watershed alliance to study problems and to plan and implement activities designed to address surface water quality or water flow issues.
Urban service districts	Municipalities use urban service districts to define the edge of a community by limiting the extension of urban infrastructure. This encourages growth in areas with existing and adequate infrastructure while discouraging growth in undeveloped and environmentally beneficial areas.
Form-based codes	A method of regulating development to achieve a specific form — including the relationship of buildings to each other, to streets, and to open spaces—rather than allowing a certain use. "Design is more important than use" embodies the underlying philosophy behind the form-based code.

SOURCE: Public Sector Consultants Inc., 2007, updated by Spicer Group, Inc. in 2018.

** Low-impact development includes a series of techniques that equip developments to mimic natural stormwater filtration, managing rainfall at the source using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source; tree planting, green roofs and rain gardens are some commonly used techniques.*

Zoning ordinances were specifically reviewed to help determine regulatory coverage for aquatic resources within the Portage Lake Watershed, in order to help determine what, if any, environmental provisions are in place, refer to **Table 6**.

Although all jurisdictions have some water quality protection measures in their zoning ordinances it is important to keep in mind that the effectiveness of zoning ordinances depends on many factors, including restrictions in the language, enforcement and public support. Zoning can be a sensitive issue for some units of government and there are multiple challenges to implementing and enforcing a strong ordinance, including community understanding and support and fiscal and legal challenges.

Table 6. *Water quality protection regulations from local zoning ordinances*

Minimum Parcel Size	
Village of Onekama	▪ Residential & Commercial Residential- 12,000 ft.^{2} ▪ Impervious Surface Coverage Limits- The percentage of the total land area of a parcel covered by impervious surfaces shall not exceed 35 percent, except that the surface area covered by a dwelling, building, accessory building and other such roofed structures shall not be considered to be impervious if the stormwater runoff from those structures is treated and/or disposed of on the parcel by utilizing innovative stormwater treatment methods such as rain gardens, groundwater infiltration structures or constructed wetlands.
Onekama Township	▪ One acre agricultural, residential, and resort residential 1 (RR1) ▪ 90,000 ft.^{2} special and unique residential ▪ 15,000 ft.^{2} resort residential 2 (RR2), 3 (RR3) and 4 (RR4) ▪ 15,000 ft.^{2} commercial (CR-1)
Bear Lake Township	▪ One acre agricultural ▪ 20,000 ft.^{2} resort residential and residential ▪ 40,000 ft.^{2} commercial and multi-use
Manistee Township	▪ Multiple-Use District (M-1)- Five acres ▪ County Residential District (R-2)- 25,000 ft.^{2} ▪ Big Manistee River Corridor District (BM-1)- Ten acres ▪ Wetlands District (W-1)- Five acres ▪ Agricultural- Forest Preservation District (AP-1)- Ten acres; Minimum and maximum parcel size for a dwelling and other non-farm use: - One acre minimum - Five acres maximum, with a minimum parcel width of 200 ft. ▪ High Density Residential, District (R-1)- 15,000 ft.^{2} ▪ Commercial District (C-1)- 15,000 ft.^{2} ▪ Industrial District (I)- Three acres if the use is connected to a public sanitary sewer system or an on-site sewage system is used for the disposal of only human waste and not a part of the industrial process, and a minimum parcel width of 200 ft., or five acres if an on-site sewage system is used for anything more than human waste, and a minimum parcel width of 300 ft.

__Table 6 cont.__ Water quality protection regulations from local zoning ordinances

Minimum Parcel Size Cont.	
Brown Township	▪ Ten acres for agricultural, forestry and rural residential
Minimum Parcel Width	
Village of Onekama	▪ Residential & Commercial Residential- 75 ft., except for a parcel which is a lot of record. ▪ Portage Lake Overlay Zone- 75 ft. except for a platted lot of record, the minimum width shall be the platted width. For a parcel which is adjacent to Portage Lake, the minimum width shall be measured at the shoreline.
Onekama Township	▪ 200 ft. agricultural residential ▪ 300 ft. special and unique residential ▪ 100 ft. resort residential 1 (RR1), 2 (RR2), 3 (RR3), 4 (RR4) and commercial
Bear Lake Township	▪ 200 ft. road front for agriculture ▪ 100 ft. road front resort residential and residential ▪ 150 ft. road front commercial and multiuse
Manistee Township	▪ Multiple-Use District (M-1)- 300 ft. ▪ County Residential District (R-2)- 100 ft. ▪ Big Manistee River Corridor District (BM-1)- Minimum exterior width (narrowest dimension) for all principal buildings- 20 ft. ▪ Wetlands District (W-1)- 300 ft. ▪ Agricultural- Forest Preservation District (AP-1)- Minimum and maximum parcel size for a dwelling and other non-farm use: One acre minimum; Five acres maximum, with a minimum parcel width of 200 ft. ▪ High Density Residential, District (R-1)- 100 ft. ▪ Commercial District (C-1)- 100 ft. ▪ Industrial District (I)- Three acres if the use is connected to a public sanitary sewer system or an on-site sewage system is used for the disposal of only human waste and not a part of the industrial process, and a minimum parcel width of 200 ft., or five acres if an on-site sewage system is used for anything more than human waste, and a minimum parcel width of 300 ft.
Brown Township	▪ 330 ft.: Ratio of depth to width shall not exceed 4:1

Table 6 cont. *Water quality protection regulations from local zoning ordinances*

Minimum Buildable Area	
Village of Onekama	▪ Not addressed
Onekama Township	▪ Not addressed
Bear Lake Township	▪ Not addressed
Manistee Township	▪ Big Manistee River Corridor District (BM-1)- Minimum ground floor area, all principal buildings- 600 ft.^{2} ▪ Wetlands District (W-1)- Minimum ground floor area, all principal buildings- 600 ft.^{2} ▪ Agricultural- Forest Preservation District (AP-1)- 900 ft.^{2} ▪ Multiple-Use District (M-1)- 900 ft.^{2} ▪ County Residential District (R-2)- 900 ft.^{2} ▪ High Density Residential, District (R-1)- 900 ft.^{2}
Brown Township	▪ 15,000 ft.^{2} of minimum ten-acre parcel including slopes >25 percent, beach contiguous to lake, river or stream, wetlands or part of floodplain where flood waters expected to have destructive current
Maximum Percentage Developed or Open Space	
Village of Onekama	▪ Not addressed
Onekama Township	▪ Not addressed
Bear Lake Township	▪ Not addressed
Manistee Township	▪ County Residential District (R-2)- Maximum usage of a parcel (area occupied by structures) shall not exceed 40 percent of the total parcel area. ▪ High Density Residential, District (R-1)- Maximum usage of a parcel (area occupied by structures) shall not exceed 40 percent of the total parcel area.
Brown Township	▪ Not addressed
Setbacks from Water	
Village of Onekama	▪ The Riparian Setback from the shoreline of Portage Lake shall be 30 ft. measured on a horizontal plane landward from the Ordinary High-Water Mark. The Riparian Setback from the banks of streams or creeks shall be ten feet.

Table 6 cont. *Water quality protection regulations from local zoning ordinances*

Setbacks from Water Cont.	
Village of Onekama Cont.	▪ Portage Lake Overlay Zone- Maintain to the fullest extent possible the healthy state of any natural ground cover or native vegetation which exists within ten feet of the shoreline of Portage Lake and/or within ten feet of the banks of a stream or creek and, when necessary, replace unhealthy or dead plants with native vegetation that is equally effective in retarding runoff and preventing erosion.
Onekama Township	▪ 40 ft. from lakes and ponds, sidewalks, patios and driveways constructed at grade are exempt from setback requirements, excepting that placement of impervious surfaces is prohibited within a setback distance of 40 ft. from the high-water mark of wetlands, streams and water bodies.
Bear Lake Township	▪ 50 ft. from wetlands or flowing bodies of water
Manistee Township	▪ Wetlands District (W-1)- 50 ft. ▪ Agricultural- Forest Preservation District (AP-1)- 50 ft. ▪ Multiple-Use District (M-1)- 50 ft. ▪ County Residential District (R-2)- 50 ft., except in High Risk Erosion Areas where the regulations set forth in Article 73 shall apply. ▪ High Density Residential, District (R-1)- 50 ft. ▪ Commercial District (C-1)- 50 ft. ▪ Big Manistee River Corridor District (BM-1)- 200 ft.
Brown Township	▪ 200 ft. from edge of bodies of water in any district
Wetlands	
Village of Onekama	▪ Permit not issued for any land use or structure that is located on, drains or fills a wetland; Variance if permit issued by State
Onekama Township	▪ No structures shall be erected within an identified environmentally sensitive area (sand dunes, beach, water bodies, wetlands, flood plain, high risk erosion area, water setback areas, high risk erosion set back and slopes over 25 percent) unless specifically identified by the Commission as necessary to protect the environmentally sensitive area or to enhance the environmentally sensitive area for passive recreational value.
Bear Lake Township	▪ No building shall be built, located or constructed within a wetland as determined by the MDNR.

Table 6 cont. *Water quality protection regulations from local zoning ordinances*

Wetlands Cont.	
Manistee Township	▪ Big Manistee River Corridor District (BM-1)- Any parking, camping, playground, dwelling or any other permitted or special use, or any other use or other structures shall not be located on a wetland. ▪ Wetlands District (W-1)- No filling, dredging, channeling, draining, dam construction or earth changing activities shall be permitted in the Wetlands District W-1 without prior written approval from the Department of Environment, Great Lakes, and Energy (EGLE). All permits issued by the EGLE shall be exhibited to the Zoning Administrator as site plan material in addition to the site plan material required.
Brown Township	▪ Not addressed
Floodplains	
Village of Onekama	▪ Not addressed
Onekama Township	▪ Buildable area shall not include any wetland, 199-year floodplain, high risk erosion area, drainage way, lake or similar natural feature which poses an impediment or hazard to safe construction or use of property without sufficient upland property to meet ordinance requirements.
Bear Lake Township	▪ No building or structure shall be built, located or constructed within floodplains of any flowing bodies of water in any land use district as may be determined by the MDNR.
Manistee Township	▪ Planned Unit Development
Brown Township	▪ Not addressed
Groundwater Protection/Hazardous Waste	
Village of Onekama	▪ Not addressed
Onekama Township	▪ Required provisions for businesses or facilities that generate or use hazardous substances.
Bear Lake Township	▪ Required provisions for businesses or facilities that generate or use hazardous substances (Protects the natural environment, including lakes, ponds, streams, wetlands, floodplains, groundwater, street slopes and natural and man-made drainage system)
Manistee Township	▪ Required provisions for businesses or facilities that generate or use hazardous substances.
Brown Township	▪ Required provisions for businesses or facilities that generate or use hazardous substances.

Table 6 cont. *Water quality protection regulations from local zoning ordinances*

Waste Accumulation/Outside Storage	
Village of Onekama	▪ No unwholesome substance, as defined in this section, shall be deposited, buried, stored, kept, dumped or accumulated by any person in any water body or on or under any land, private or public, in the Village. An unwholesome substance includes any trash, garbage, cans, automobile body, inoperable vehicle, trailer body, hazardous compound, harmful substance, debris, waste, junk, rubbish, refuse, offal, abandoned, discarded or unused objects, machinery or equipment such as furniture, stoves, refrigerators, freezers, utensils, containers or other deleterious substance. ▪ No sewage, wastewater or water containing foreign substances shall be deposited onto any parcel or be allowed to drain into any water bodies unless prior approval to do so has been obtained from the proper authority pursuant to State or Federal law. No storing or spreading of manure, non-phosphate fertilizers, or other soil conditioners as part of a permitted farm, forestry, home garden or lawn operation.
Onekama Township	▪ No accumulation of junk, no sewage, wastewater, or water containing foreign substances may be deposited into water bodies unless approved (not including manure, fertilizers, or other soil conditioners for farming, forestry, home garden and lawn uses)
Bear Lake Township	▪ No accumulation of junk, no sewage, wastewater, or water containing foreign substances may be deposited or drained into any open ditch, creek, stream, lake, pond, or other body of water unless the same has first been approved by the state and county health authorities. (not including spreading of manure, fertilizers, or other soil conditioners for farming, forestry, home garden and lawn operation)
Manistee Township	▪ All outside storage areas for trash, auto parts and similar items shall be enclosed by a six-foot obscuring wall with such storage being located in the rear yard. Open Storage: The open storage of junk, scrap or salvage or other waste products where the operations are for the conversion to saleable materials shall be screened from public view, from a public street and from adjoining properties not of a similar nature, by an enclosure consisting of a solid wall or fence not less than six feet in height. The storage of any soil, fertilizer, or similar loosely packaged materials shall be sufficiently contained to prevent any adverse effect on adjacent properties, water bodies, wetlands and drainage-ways.
Brown Township	▪ Not addressed

Table 6 cont. *Water quality protection regulations from local zoning ordinances*

Stormwater	
Village of Onekama	▪ Stormwater runoff from any parcel shall be directed to a non-lake side of any principal structure or accessory building, shall be treated and/or disposed of on the parcel so as to not increase the stormwater runoff from the parcel above pre-development amounts, and shall be controlled by utilizing innovative stormwater treatment methods such as rain gardens, groundwater infiltration structures and/or constructed wetlands.
Onekama Township	▪ Not addressed
Bear Lake Township	▪ Not addressed
Manistee Township	▪ Addressed (Manistee County Drain Commissioner for additional specifications/minimum requirements)
Brown Township	▪ Not addressed
Planned Unit Development	
Village of Onekama	▪ Not addressed
Onekama Township	▪ Included
Bear Lake Township	▪ Included
Manistee Township	▪ Included
Brown Township	▪ Included
Other	
Village of Onekama	▪ Portage Lake Overlay District was created to protect the shoreline of Portage Lake and other bodies of surface water in the Village while providing for development of waterfront uses that are in compliance with Portage Lake Watershed Forever Plan.
Onekama Township	▪ One boat dock for private use on lakefront parcels. ▪ Wind Energy Conversion System
Bear Lake Township	▪ Keyhole Waterfront Access provision to protect integrity of lakes while preserving quality of recreational use. ▪ No structures shall be erected within the identified environmentally sensitive area (sand dunes, beach, water bodies, wetlands, floodplain, high risk erosion area, water setback areas, high risk erosion setback, slopes over 25 percent, unless approved by the Planning Commission)

Table 6 cont. *Water quality protection regulations from local zoning ordinances*

Other Cont.	
Manistee Township	▪ Special provisions for other watersheds not including Portage Lake. ▪ Additional Manistee Lake Regulations (established in the Manistee Lake Management Plan (October,1982)) ▪ High Risk Erosion Overlay Zone District (OZ) requirements.
Brown Township	▪ Special provisions for other watersheds not including Portage Lake.

SOURCE: Spicer Group, Inc. 2018.

Recommendations

While all jurisdictions within the Watershed have some water quality protection measures in place, additions could be made to provide greater protection. The emphasis of the plan and ordinances should be to direct development to areas of the Watershed with existing adequate infrastructure; ensure that compact, mixed use development occurs in those areas; and conserve existing open space and farmland outside of those areas. Specific tools/ordinances that could be considered include the following:

- Stormwater management ordinance
- Illicit Discharge Ordinance (The U.S. Environmental Protection Agency (USEPA) has example ordinance for communities to adopt.)
- Compact development tools including mixed use zoning, compact lot sizes, maximum setbacks, and an urban service district
- Open space Planned Unit Developments (PUDs) and non-contiguous PUDs that encourage low densities near headwater areas and high densities in the Village of Onekama
- Purchase of Development Rights program or other farmland preservation tools
- Buffer ordinances and setbacks along surface waters, wetlands, floodplains and critical areas
- Local wetland protection ordinance
- Groundwater protection regulations
- Form-based code zoning

Effective land use planning is one tool for Watershed protection. It is most effective when used in conjunction with other measures including educational outreach programs, land protection for critical habitat areas, and implementation of best management practices.

OTHER AGENCIES AND LOCAL ORGANIZATIONS

Numerous agencies and local organizations play important roles in enhancing the quality of life and economic well-being of the Portage Lake Watershed. It is important to leverage their expertise and efforts to help further the goals and objectives of the Portage Lake Watershed Forever Plan through the implementation of the plan. In addition to the local government units discussed in the section above, the following federal, state and local agencies should continue to be engaged throughout the implementation of the plan.

- District Health Department #10

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- Manistee County
- Manistee County Road Commission
- Michigan Department of Environment, Great Lakes, and Energy
- Michigan Department of Natural Resources
- Michigan Department of Transportation
- U.S. Army Corps of Engineers
- U.S. Department of Agriculture—Natural Resource Conservation Service
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service

In addition, numerous organizations should also be engaged as partners in the implementation phase of the plan. Some of these organizations and their missions are listed in **Table 7**. Additional entities include Onekama Consolidated Schools, Portage Point Summer Resort Corporation and various service clubs including the Lions, Clio and Garden Clubs.

Table 7. *Mission statement of local organizations*

Organization	Mission Statement
Manistee County Community Foundation	Changing the way we give, enhancing the way we live.
Alliance for Economic Success (formerly known as the Manistee Economic Development Office)	The Alliance for Economic Success has three missions: *Retention, Expansion & Attraction:* To be the recognized leader in customer service and meaningfully improve the economic well-being and quality of life for Manistee County through programs involving the retention, expansion, and attraction of businesses and jobs. *Economic Development Cornerstones:* To ensure and assist in creating an environment that makes Manistee County a first-choice community for new and existing businesses. *Resource Development:* To support the development of financial and human resources in order to meaningfully impact or influence the economic well-being and quality of life for Manistee County.

Table 7 cont. *Mission statement of local organizations*

Organization	Mission Statement
Little River Band of Ottawa Indians	To exercise sovereign powers, organize for their common good, to govern under their own laws, to maintain and foster their tribal culture, provide for the welfare and prosperity of their people and to protect their homeland.
Manistee Conservation District	The Manistee Conservation District will strive to promote good stewardship, protect the natural resources, and provide the education necessary to achieve these goals in partnership with our community.
Michigan State University (MSU) Extension, Manistee County	Helping people improve their lives through an educational process that applies knowledge to critical needs, issues and opportunities.
Northwest Michigan Invasive Species Information Network (NWISIN)	"Protecting, enhancing, and promoting northwest Michigan's natural communities through terrestrial invasive plant management and outreach."
Portage Lake Association	A nonpolitical organization formed to advance, support and promote the welfare of the Onekama and Portage Lake area.

SOURCE: Public Sector Consultants Inc., 2007 and updated by Spicer Group, Inc. in 2018.

CHAPTER 3: WATERSHED CONDITIONS

WATER QUALITY

Historical Water Quality Data

What is known about the condition of the Portage Lake Watershed is derived from the following studies and reports. Various water quality parameters were measured and are reported on in the following sections:

- Michigan Department of Natural Resources Water Quality Data (MDNR, Michigan/USEPA, 1974 and 1985 STORET Water Quality Data)
- A Shoreline Algal Survey, NW Michigan Regional Planning and Development Commission (Northwest Michigan Regional Planning and Development Commission, 1983)
- Portage Lake USEPA Phase I Diagnostic/Feasibility Study 1993 (SEG, 1993)
- Michigan Department of Natural Resources Fish Contaminant Monitoring 1991 (as cited in SEG, 1993)
- Onekama Township Bacteriological Sampling 1985–1990 (as cited in SEG, 1993)
- Onekama High School Water Quality Monitoring 1993–2007 (Onekama High School, 2007)
- Department of Natural Resources Water Quality Monitoring 1999 and 2007 (MDNR, 1999 and 2007)
- Status of the Fishery Resource Report 2000 (MDNR, 2000)
- Little River Band of Ottawa Indians (LRBOI) Walleye Recruitment Assessments of Portage Lake (LRBOI, 2005 and 2006)
- A Biological Survey of McGowan's and Schimke Creeks, Manistee County (MDEQ, 2007d)
- Onekama Township Bacteriological Sampling 2007 (Onekama Township, 2007)
- State of the Lake 2009 (Lakeshore Environmental, INC., 2009)
- State of the Lake 2010 (Lakeshore Environmental, INC., 2010)
- Why Aquatic Herbicides Affect Aquatic Plants and Not You (Carole Lembi, Purdue University, 2010)
- State of the Lake 2011 (Lakeshore Environmental, INC., 2011)
- State of the Lake 2012 (Restorative Lake Sciences, LLC, 2013)

- Basic Limnology (Herb Lenon, Tuesdays with Water series, 2012)
- State of the Lake 2013 (PLM Lake & Land Management Corp., 2013)
- State of the Lake – Portage Lake, Summary of 39 Years of Water Quality Monitoring (Herb Lenon, 2013)
- State of the Lake Community Program (PLM Lake & Land Management Corp., 2013)
- State of the Lake 2014 (PLM Lake & Land Management Corp., 2014)
- State of the Lake 2015 (PLM Lake & Land Management Corp., 2015)
- State of the Lake Summary 2015 (Herb Lenon, 2015)
- Survey of Swimmer's Itch Parasites in Michigan Lakes (Thomas R. Raffel, 2016)
- State of the Lake 2016 (PLM Lake & Land Management Corp., 2016)
- State of the Lake Summary 2016 (Herb Lenon, 2016)
- State of the Lake 2017 (PLM Lake & Land Management Corp., 2017)
- 2017 Forest Health Highlights (Michigan Department of Natural Resources, 2017)
- 2016 Michigan Fish Consumption Data & Recommendation Sheets (Michigan Department of Natural Resources, 2016)
- 2014 Portage Lake Creel Report (Michigan Department of Natural Resources, 2017)
- Invasive Species Treatment and Concerns for the Walleye Fishery in Portage Lake (Herb Lennon, 2010)

For more detail for each study and report, refer to **APPENDIX A: HISTORICAL WATER QUALITY DATA**.

Portage Lake Water Quality

Water quality data has been collected on Portage Lake since 1974. The scope of water quality analysis has changed through the years and has been compiled in order to observe trends in water quality data over time.

SECCHI DEPTH

Secchi disk transparency readings indicate the depth of light penetration from the surface of the water. The deeper the Secchi depth, the clearer the water. In many instances, Secchi depth can be used to indirectly measure algae growth, which decreases the depth of light penetration (i.e. lower Secchi readings may indicate higher algal productivity). In addition to algal growth, Secchi disk transparency can be decreased by wind turbulence that resuspends sediments, by suspended solids from lake tributaries and, in some cases, by high levels of dissolved solids in the form of calcium carbonate (limestone).

Secchi depth may dramatically increase with the introduction of the invasive filter-feeder mussels the zebra mussel, *Dreissena polymorpha*, and the Quagga mussel, *Dreissena rostriformis bugensis*. The mussels are believed to have arrived in the Great Lakes Basin in ballast water and were first observed in the Great Lakes and Lake St. Clair in 1988, and 1989, respectively. Consistent with the introduction of the invasive spices, Portage Lake had an average Secchi reading of 8.3 feet in 1990, and an average of 20.5 feet in 1995, **Figure 31**. In the last decade, Secchi depth has ranged between 13.6 and 20 feet and has averaged around 16.3 feet.

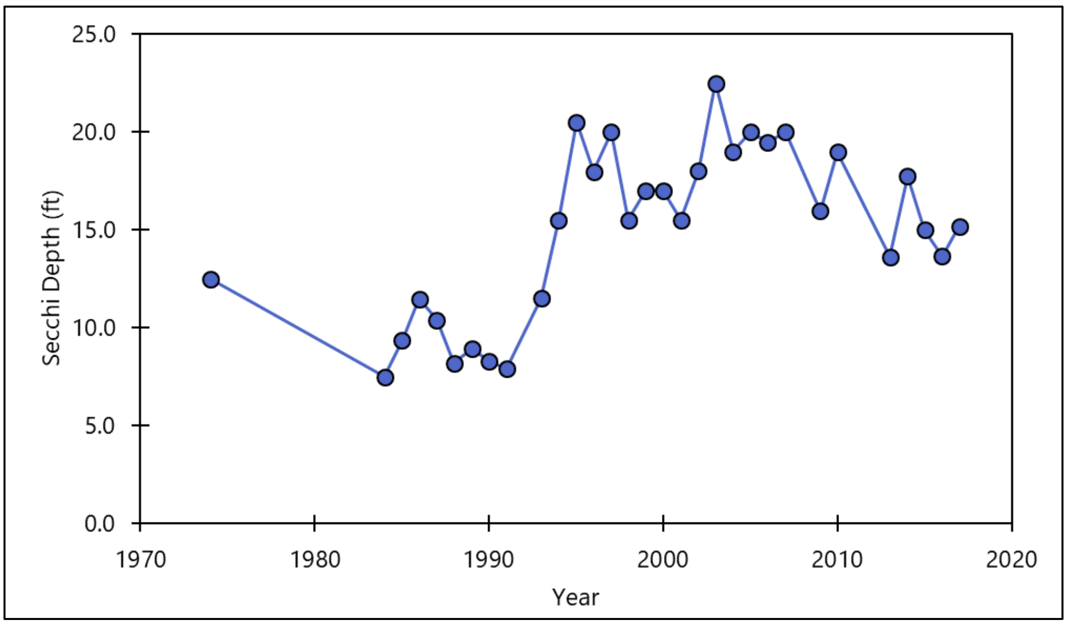

Figure 31. *Average Secchi depth in deep basins of Portage Lake 1974 - 2017*

SOURCE: Spicer Group, Inc., 2018, using data from MDNR, Michigan/USEPA 1974 and 1985 STORET Water Quality Data, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

DISSOLVED OXYGEN

A standard measure of lake productivity is dissolved oxygen (DO). It is imperative that surface waters have adequate levels of DO in order to support aquatic life, as well as support the natural aerobic breakdown various compounds in the water column. In lakes, the level of DO is determined by a number of factors, including the time of year, depth, level of plant productivity, time of day, water temperature, weather conditions, oxygen demand from organisms, decomposition of organic matter, and the oxidation of chemicals in the water or sediments. Temperature determines the concentration of DO, typically measured in units of mg/L that water will contain at 100 percent saturation; the lower the water temperature, the higher the dissolved oxygen concentration at levels of saturation. During times of daylight in the growing season, rooted aquatic plants and algae produce oxygen through photosynthesis, and at the same time use oxygen for cellular respiration. Therefore, DO levels in the photic zone (the euphotic zone, or sunlight zone which is the uppermost layer of water in a like or ocean that is exposed to intense sunlight) vary from daylight to nighttime, called diurnal variation.

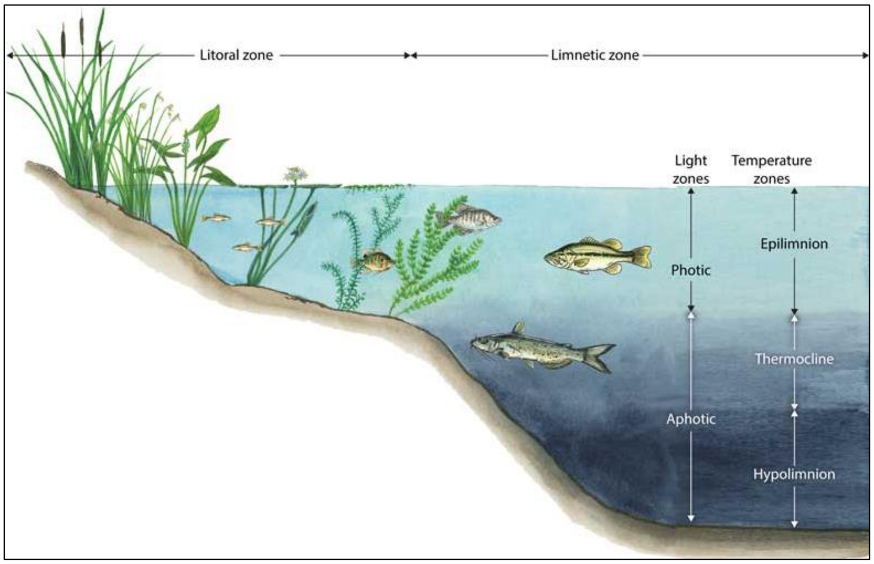

Figure 32. *Zoning of lake or pond*

SOURCE: https://kascomarine.com/pond-lake-zone-identification/, 2018.

Michigan lakes typically stratify beginning in the spring when warmer, less dense water on the surface isolates cooler, denser water in the deeper portions of the lake from oxygen-producing rooted plants and algae. In the fall, colder air temperatures cool the surface water, equalizing the temperature of the epilimnion (warmer, upper level of lake) and the hypolimnion (cooler, lower level of lake), which causes a "turn over," where the upper and lower levels of the lake mix. Eventually, temperatures at the bottom of a lake are warmer than near the surface. Thus, the turnover can impact DO seasonally and by depth.

DO is essential to the survival and growth of aquatic organisms. For this reason, water quality standards for minimum DO levels have been established by the State of Michigan to protect certain groupings of fish species. For coldwater species[1], such as trout and salmon, the minimum DO level is seven milligrams per liter (mg/L) in any 24-hour period. For warmwater[2] species, such as largemouth bass and sunfish, the minimum DO level is five mg/L in any 24-hour period.

[1] Fish that prefer clear waters; are not tolerant of extreme temperature changes; and thrive in temperatures that range from 50–65°F.

[2] Fish that have low oxygen requirements and thrive in temperatures 76°F and higher.

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DO monitoring in 1976, 1985, 1993 Phase I Study, and 2012 – 2017 State of the Lake Reports show that DO levels in Portage Lake at depths of 25 feet and below begin to decrease in June of each year. During all nine sampling years, DO concentrations were 3.2 mg/L or less at 50 feet in the two deepest basins of Portage Lake. For seven of those years, DO concentrations reached near zero at 60 feet. Every year between 2010 and 2017 DO profiles were taken in both Basin 1 (the western basin) and Basin 2 (the central basin) during July and September. These results, **Figures 33**, **34**, **35**, and **36**, show the concentrations relative to the warmwater and coldwater fishery standards.

Potential causes of consistent reduced oxygen at lower levels of the lake could be caused by lack of wave action, lack of vegetation producing oxygen via photosynthesis, and biochemical oxygen demand near bottomland detritus. An anoxic environment is a threat to resident fish populations, as the majority of species require five mg/L of dissolved oxygen or higher to survive. Additionally, in low-oxygen environments, phosphorus in organic bottomland sediment may become soluble once again, whereas environments with sufficient dissolved oxygen may keep the phosphorus bound to sediment. This process can become problematic and is called internal nutrient loading. Internal loading may also occur at a faster rate when pH is elevated.

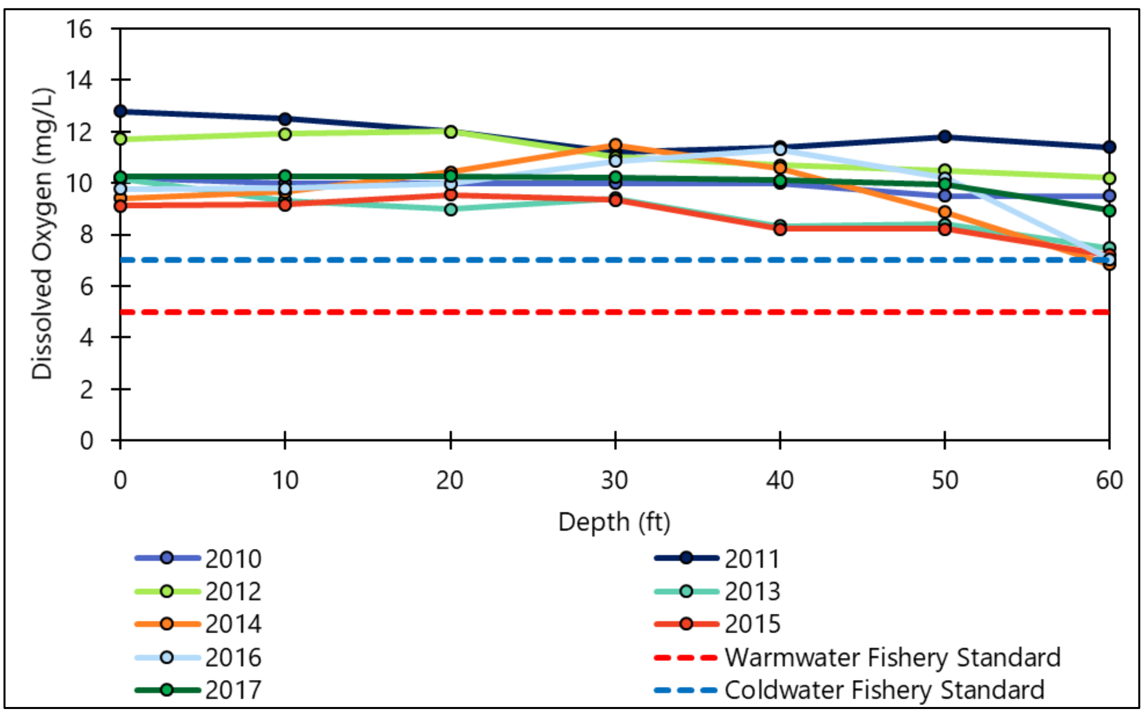

Figure 33. *Basin 1 dissolved oxygen (July 2010 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from MDEQ, 2018, Lakeshore Environmental, INC., 2009-2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013- 2017.

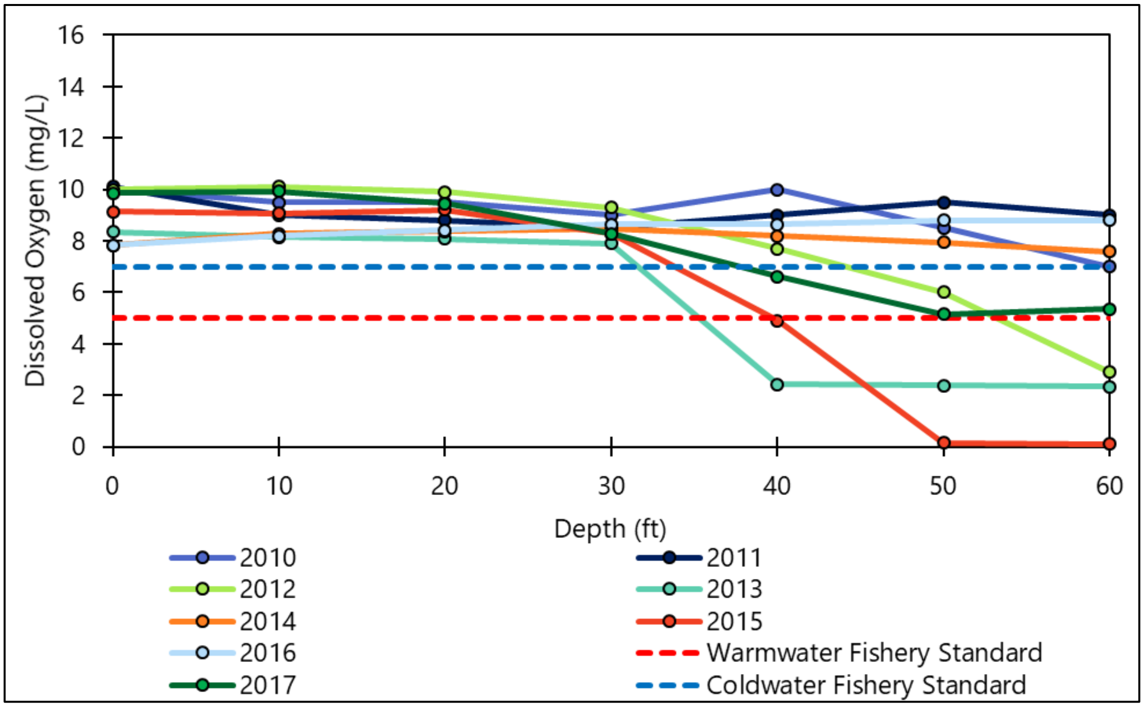

Figure 34. *Basin 1 dissolved oxygen (September 2010 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from MDEQ, 2018, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

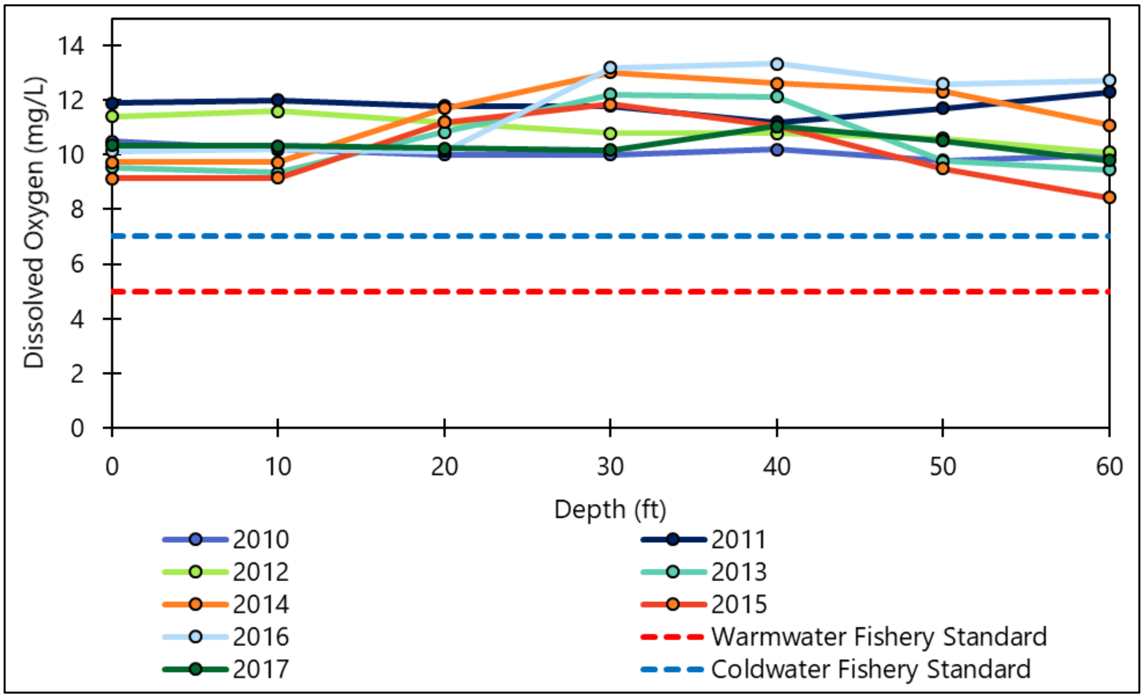

Figure 35. *Basin 2 dissolved oxygen (July 2010 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from MDEQ, 2018, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

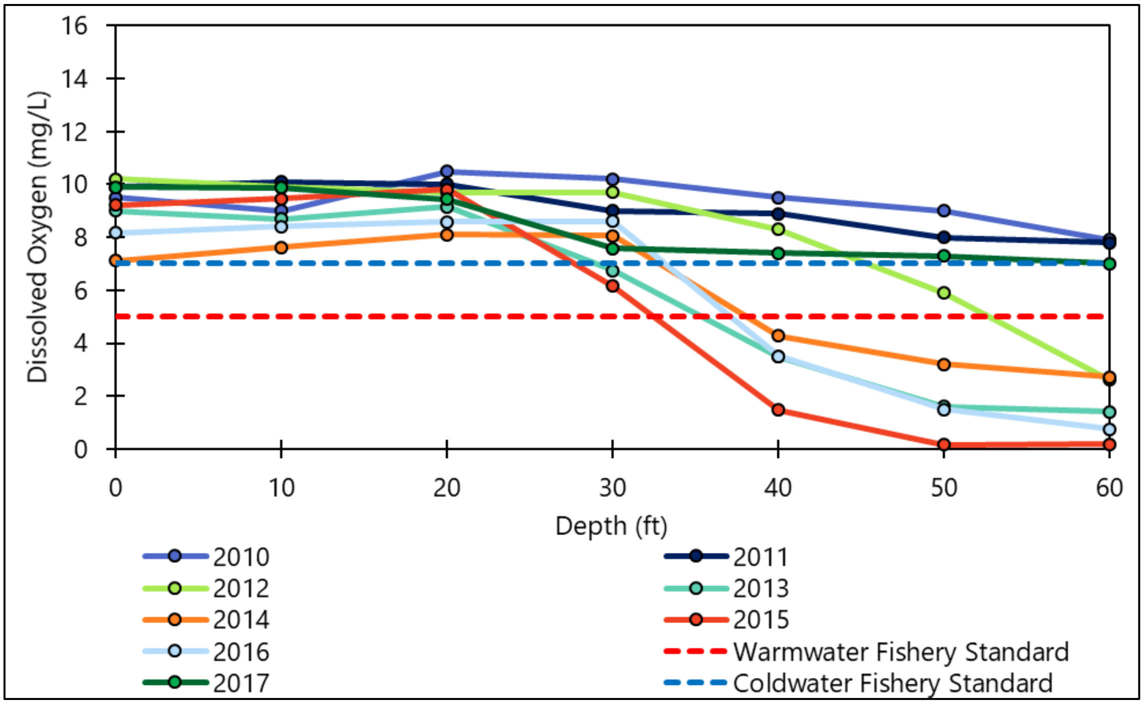

Figure 36. *Basin 2 dissolved oxygen (September 2010 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from MDEQ, 2018, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

The data from the past decade tends to support that dissolved oxygen levels in Portage Lake, including the seasonal depletion of dissolved oxygen in the hypolimnion, has remained the same. There is not sufficient evidence to support a general trend of DO increase or decrease.

ALKALINITY

Alkalinity is the measurement of how much acid a substance can neutralize. Alkalinity is an indicator as to how effective a water body is at buffering a sudden change in pH, which may be important if there is a chemical spill or acid rain. Alkalinity is affected by calcium carbonate concentration, rain, and other factors. According to the United States Environmental Protection Agency (USEPA), a body of water is not sensitive if the measured concentration of calcium carbonate (alkalinity) is greater than 20 mg/L. Portage Lake has consistently had alkalinity measurements well above 20 mg/L since 1974 at both the surface level and 60 feet in depth, **Figure 37**.

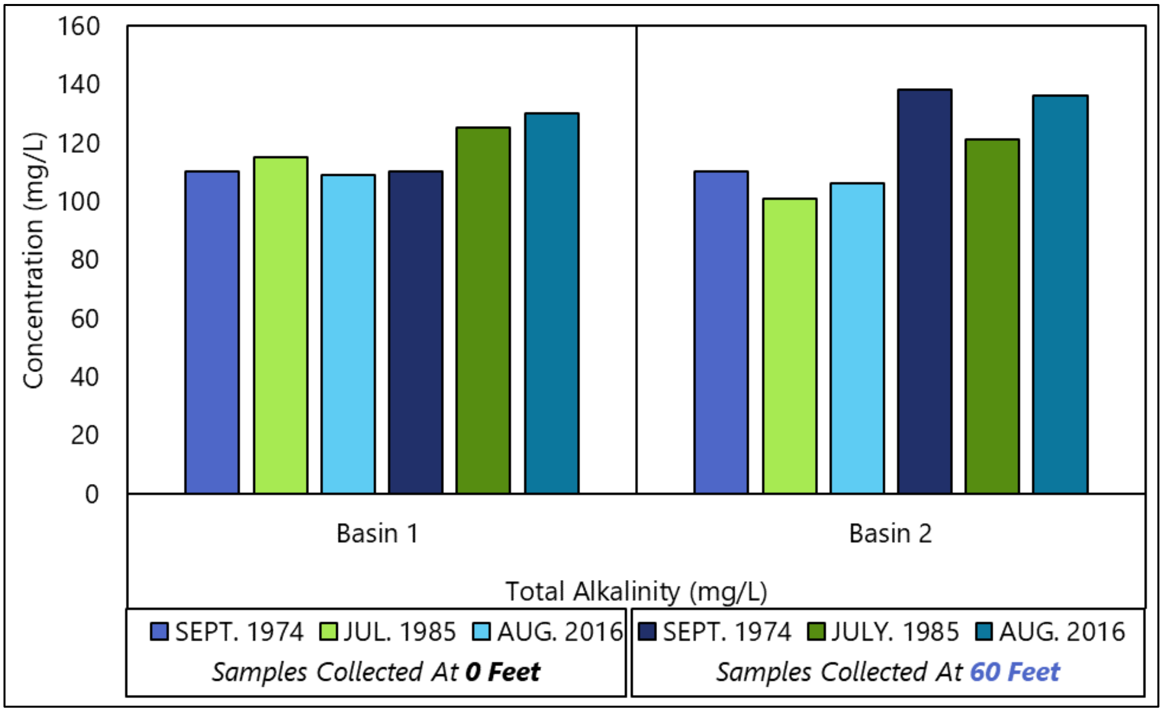

Figure 37. *Portage Lake total alkalinity at 0 and 60 feet*

SOURCE: Spicer Group, Inc., 2018, using data from MDNR, Michigan/USEPA 1974 and 1985 STORET Water Quality Data, PLM Lake & Land Management Corp., 2016.

DISSOLVED OXYGEN, SECCHI DEPTH, PH

Figures 38 and **39** compares dissolved oxygen, pH and Secchi depths for samples collected at zero feet and 60 feet for Basin 1 and Basin 2, western and central basins respectively, from 1974, 1985, and 2016. Over the years it can be concluded that the pH remained basic and was fairly consistent at zero and 60 feet. Also, the Secchi depths remained the same at zero and 60 feet from 197, 1985, and 2016.

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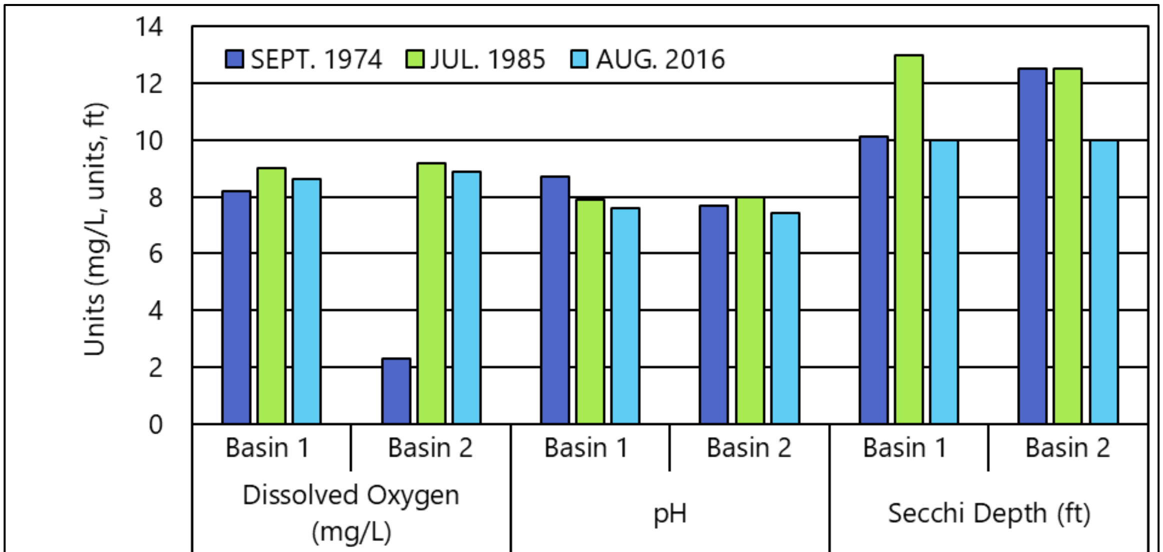
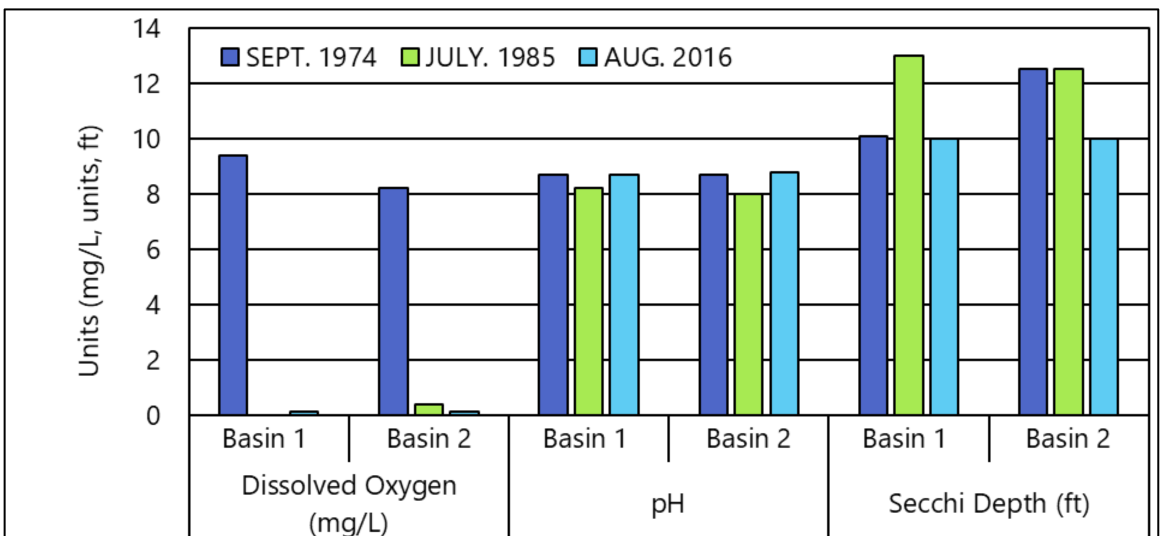


	Dissolved Oxygen (mg/L) Basin 1	Dissolved Oxygen (mg/L) Basin 2	pH Basin 1	pH Basin 2	Secchi Depth (ft) Basin 1	Secchi Depth (ft) Basin 2
SEPT. 1974	8.2	2.3	8.7	7.7	10.1	12.5
JUL. 1985	9	9.2	7.9	8	13	12.5
AUG. 2016	8.62	8.9	7.58	7.42	10	10

Figure 38. *Portage Lake standard water quality parameters at 0 feet*

SOURCE: Spicer Group, Inc., 2018, using data from MDNR, Michigan/USEPA 1974 and 1985 STORET Water Quality Data, PLM Lake & Land Management Corp., 2016.



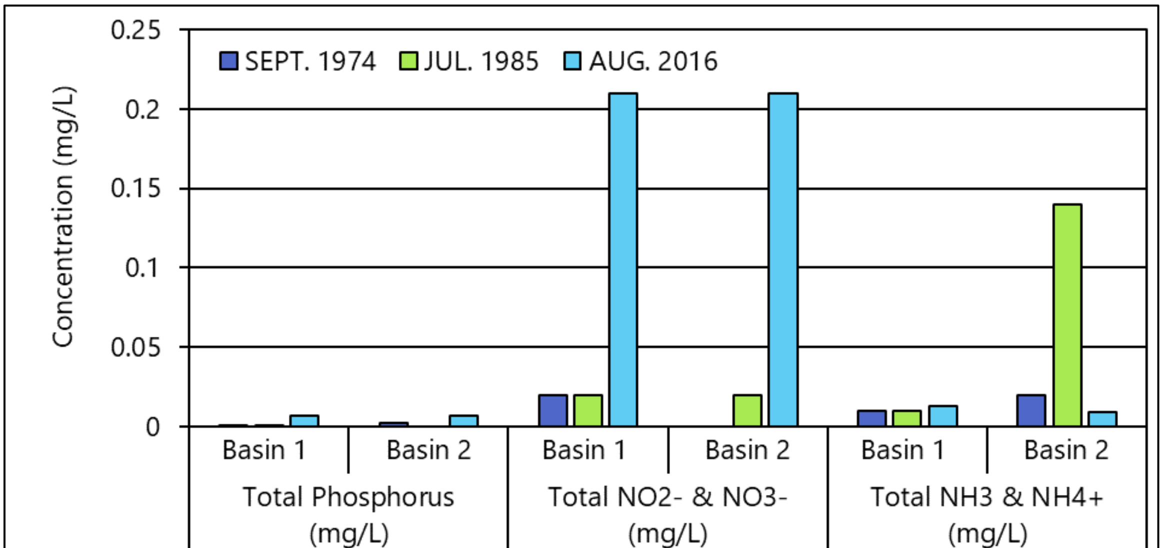
	Dissolved Oxygen (mg/L) Basin 1	Dissolved Oxygen (mg/L) Basin 2	pH Basin 1	pH Basin 2	Secchi Depth (ft) Basin 1	Secchi Depth (ft) Basin 2
SEPT. 1974	9.4	8.2	8.7	8.7	10.1	12.5
JULY. 1985	0	0.4	8.2	8	13	12.5
AUG. 2016	0.15	0.12	8.71	8.78	10	10

Figure 39. *Portage Lake standard water quality parameters at 60 feet*

SOURCE: Spicer Group, Inc., 2018, using data from MDNR, Michigan/USEPA 1974 and 1985 STORET Water Quality Data, PLM Lake & Land Management Corp., 2016.

NUTRIENT WATER QUALITY: PHOSPHORUS AND NITROGEN

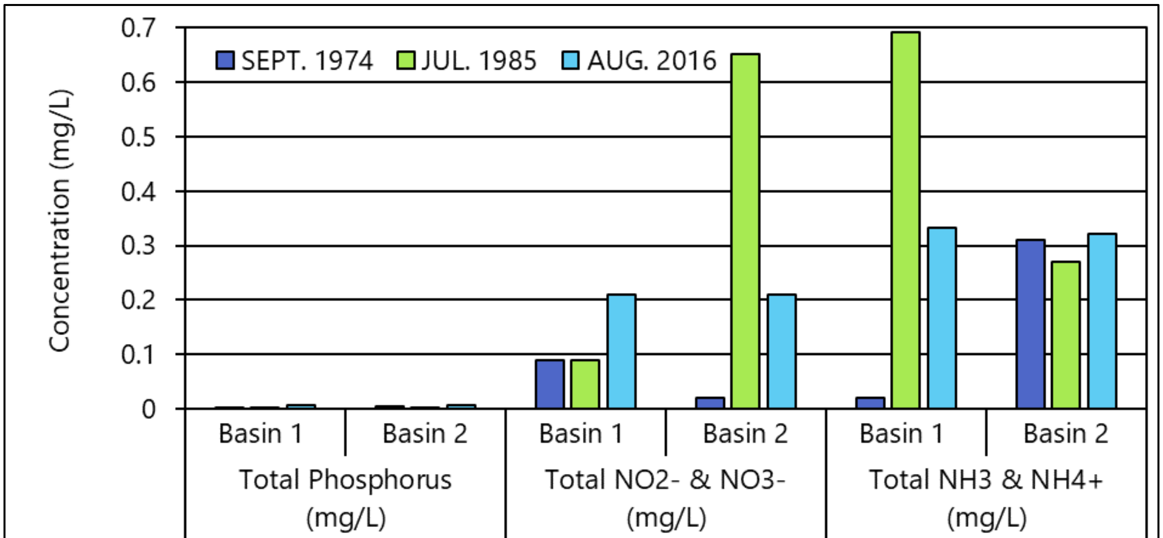
As previously mentioned, Portage Lake has traditionally been, and continues to be, a phosphorus-limited waterbody (>17 to 20 times more nitrogen than phosphorus), and has higher concentrations of nutrients (phosphorus, nitrogen) near the bottom of the lake, versus the top of the lake. The following figures, **Figure 40** and **Figure 41**, show the relationship between total phosphorus, nitrite/nitrate (NO_2^-, NO_3^-), and ammonia (NH_3, NH_4^+). Data from September 1974 is sourced from STORET Data, provided by the Department of Environment, Great Lakes, and Energy (EGLE), July 1985 data is sourced from STORET Data, provided by the EGLE, and August 2016 data is sourced from 2016's State of the Lake Report.



	Total Phosphorus (mg/L) Basin 1	Total Phosphorus (mg/L) Basin 2	Total NO2- & NO3- (mg/L) Basin 1	Total NO2- & NO3- (mg/L) Basin 2	Total NH3 & NH4+ (mg/L) Basin 1	Total NH3 & NH4+ (mg/L) Basin 2
SEPT. 1974	0.001	0.002	0.02	0	0.01	0.02
JUL. 1985	0.001	0	0.02	0.02	0.01	0.14
AUG. 2016	0.007	0.007	0.21	0.21	0.013	0.009

Figure 40. *Portage Lake nutrient concentrations at 0 feet*

SOURCE: Spicer Group, Inc., 2018, using data from MDNR, Michigan/USEPA 1974 and 1985 STORET Water Quality Data, PLM Lake & Land Management Corp., 2016.



	Total Phosphorus (mg/L) Basin 1	Total Phosphorus (mg/L) Basin 2	Total NO2- & NO3- (mg/L) Basin 1	Total NO2- & NO3- (mg/L) Basin 2	Total NH3 & NH4+ (mg/L) Basin 1	Total NH3 & NH4+ (mg/L) Basin 2
SEPT. 1974	0.003	0.004	0.09	0.02	0.02	0.31
JUL. 1985	0.002	0.001	0.09	0.65	0.69	0.27
AUG. 2016	0.008	0.007	0.21	0.21	0.332	0.321

Figure 41. *Portage Lake nutrient concentrations at 60 feet*

SOURCE: Spicer Group, Inc., 2018, using data from MDNR, Michigan/USEPA 1974 and 1985 STORET Water Quality Data, PLM Lake & Land Management Corp., 2016.

The above figures show a sharp contrast in total phosphorus concentration versus nitrogen species (nitrite/nitrate and ammonia) concentrations for years 1974, 1985, and 2016 at 60 feet in depth, and also shows a difference, albeit to a lesser degree, at 0 feet in depth for both basins. Notable changes in nitrate concentrations include high nitrite/nitrate concentrations in both Basin 1 and Basin 2 at zero feet in 2016 compared to previous years. Concentrations of nitrite/nitrate at 60 feet were greatest in 1985 in Basin 2 and greatest for ammonia at 60 feet in the Basin 1 that same year.

TOTAL PHOSPHORUS

Phosphorus is often the primary factor limiting the productivity of lakes in Michigan. Total phosphorus (TP) measurements can be used to evaluate the potential impacts of increased phosphorus loadings from septic tanks, and runoff from various land uses and from atmospheric deposition. Sampling conducted for the 2009 – 2017 Portage Lake Management Plans indicated a total nitrogen-to-phosphorus ratio in the range of 60:1, confirming that phosphorus is most likely the limiting nutrient in Portage Lake. This ratio has increased from the 2008 value of 22:1, as phosphorus concentration have declined, and total nitrogen concentration has slightly increased.

Figure 42 shows the average concentration of total phosphorus measured at Basin 1 and Basin 2 of Portage Lake at three depths, 0 feet, 30 feet, and 60 feet.

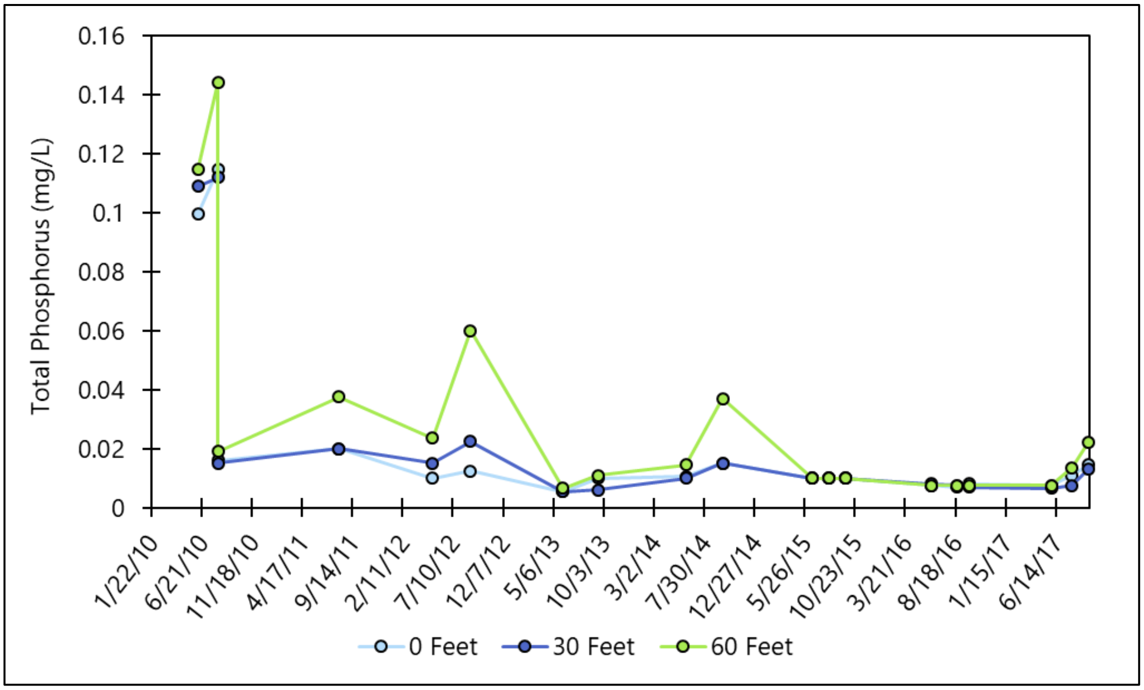


Figure 42. *Average deep basin total phosphorus*

SOURCE: Spicer Group, Inc., 2018, using data from MDEQ, 2018, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

On average, the highest measured concentrations of total phosphorus for all three depths was in June and August of 2010. Concentration of total phosphorus during June 2010 averaged 0.100 mg/L, 0.109 mg/L, and 0.115 mg/L at 0 feet, 30 feet, and 60 feet, respectively. Concentration of total phosphorus during August 2010 averaged 0.115 mg/L, 0.112 mg/L, and 0.144 mg/L at 0 feet, 30 feet, and 60 feet, respectively. Since 2010, total phosphorus concentrations have tended to have an average of 0.011 mg/L at 0 feet, and 0.018 mg/L at 60 feet. There tends to be higher concentrations of TP at 60 feet in depth compared to shallower sample sites, most notably during the peak of summer lake stratification. This increase may be attributed to the anoxic conditions at that depth, which leads insoluble phosphorus to become soluble, and therefore re-suspends in the water column. In general, measured total phosphorus concentration at all three depths from the past decade are typical of lakes that classify as oligotrophic to mesotrophic.

CHLOROPHYLL *A*

Chlorophyll *a* measurements provide an index of algal growth. High levels, particularly in shallow areas, can indicate significant nutrient loadings from riparian properties. Samples for chlorophyll *a* have been collected periodically at depths of 0 and 60 feet at both the deep basins, Basin 1 and Basin 2, of Portage Lake. The data presented in **Figure 43** includes data from 1974, 1985, and 2016.

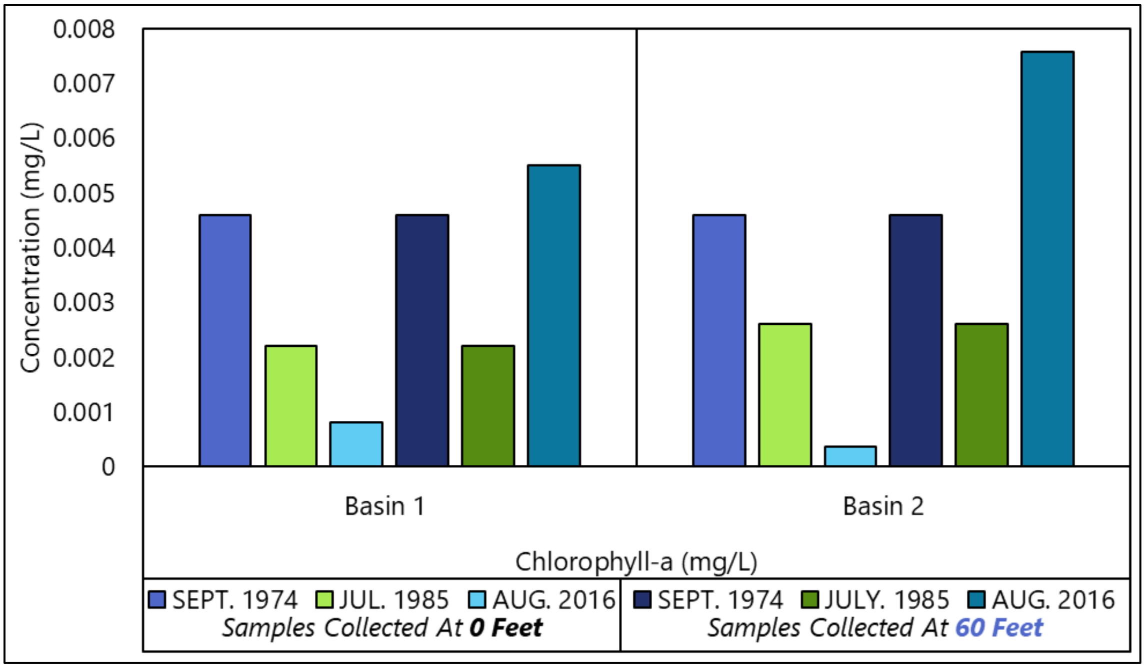


Figure 43. *Portage Lake chlorophyll a averages from 0 to 60 feet*

SOURCE: Spicer Group, Inc., 2018, using data from MDNR, Michigan/USEPA 1974 and 1985 STORET Water Quality Data, PLM Lake & Land Management Corp., 2016.

At zero feet in the central basin and the western basin, there has been a steady decrease in chlorophyll *a* since 1974. The data shows that in the western basin at 60 feet, chlorophyll *a* decreased from 1974 to 1985, and then increased again from 1985 to 2016. The same pattern was observed in the central basin at 60 feet in depth.

ESCHERICHIA COLI (E. COLI)

Historical Data (1985 – 2007)

In a five-year period from 1985 through 1990, representatives of Onekama Township collected lake water samples for fecal coliform analyses. Concurrently, the State of Michigan used fecal coliform bacteria as the standard indicator bacteria group of potential sources of human waste. During this five-year period, only five of the 144 samples from two sites in Portage Lake exceeded the state standard for total body contact recreation at that time, 100 fecal coliform bacteria per 100 mL. Four of the high levels were located off the shoreline of the Village of Onekama and one was located near Sandy Point, on the south side of the lake.

In the months from May through September of 1991 the Phase I Study (SEG, 1993) again sampled fecal coliform bacteria at 12 locations around the perimeter of Portage Lake. By 1991, the Village of Onekama had sanitary sewers serving its residents adjacent to the lake while the remainder of homes around the lake operated on septic systems. In 1991, the state standard for total body contact recreation (still 100 fecal coliform bacteria count per 100 mL) was exceeded only once at one sampling site. This site, located near Eagle Point on the south side of Portage Lake adjacent to residential development, had 200 counts per 100 mL. The Phase I Study attributed the high level to potential septic tile field sources associated with the residential development (SEG, 1993).

The 1991 one-time tributary surveys indicated elevated levels of fecal coliform in Schimke Creek and an unnamed small tributary; the bacteria were potentially attributed to cattle raised in the upper portions of both tributaries. Onekama Creek and another small unnamed tributary also had elevated levels which were attributed to potential residential septic tile field drainage in the relatively high-density residential areas upstream of the sampling locations.

Five popular swimming beaches were sampled during July and August 2007 for *Escherichia coli (E. coli)*[3]. All samples met the current Michigan water quality standards for total body contact recreation of 130 or fewer counts of *E. coli* per 100 mL of water monthly average and 300 *E. coli* counts or less at any time, **Table 8**.

Table 8. *Portage Lake E. coli bacteria, composited: 2007*

Sample Location	July 26, 2007 *E. coli* MPN/100mL	August 24, 2007 *E. coli* MPN/100mL
Portage Point Inn	1.4	4.9
Little Eden Camp	16.6	21.9
Onekama Village Beach	5.6	7.0
Covenant Lake Bible Camp	22.9	1.7
Wik-A-Te-Wak	4.4	3.0

SOURCE: Onekama Township, 2007.

Current Data

In the last decade, *E. coli* monitoring has become a priority for the Watershed in order to ensure healthy, clean water for the area's residents and visitors. *E. coli* data has been collected Watershed-wide by various entities, including District Health Department #10, the Village of Onekama, Onekama Township, PLM Lakes & Land Management Corp., and others. Between 2009 and 2018, 264 composite samples were collected around Portage Lake and in its tributaries. Only four of these samples exceeded total body contact recreation criteria of 300 MPN/100 mL. Of the four, two exceeded partial body contact recreation criteria of 1,000 MPN/100 mL. All samples that

[3] In 1995, the indicator of potential sources of human waste was changed from fecal coliform to a more specific organism, *Escherichia coli (E. coli)*.

exceeded these water quality standards were collected in Schimke Creek and Stream #9. **Table 9**, below, summarizes the results of the *E. coli* monitoring performed between 2009 and 2018.

Table 9. *Portage Lake and tributaries E. coli sample results*

E. COLI SAMPLE RESULTS (2009 - 2018)				
Year	**Sample Location**	**# of Samples Collected**	**# of Samples Exceeding Total Body Contact Recreation Criteria**	**Sampled By**
2009	*Village Beach*	12	0	Health Dept.
	Lake Michigan Beach	12	0	Health Dept.
2010	*Village Beach*	10	0	Health Dept.
	Lake Michigan Beach	10	0	Health Dept.
2011	*Village Beach*	11	0	Health Dept.
	Lake Michigan Beach	11	0	Health Dept.
2012	*Village Beach*	10	0	Health Dept.
	Lake Michigan Beach	10	0	Health Dept.
2013	*Schimke Creek*	1	0	PLM
	Sample 2 Camp	1	0	PLM
	Sample 3 Camp	1	0	PLM
	Village Beach	10	0	Health Dept.
	Lake Michigan Beach	10	0	Health Dept.
2014	*Marina (South Side)*	1	0	PLM
	Portage Point Inn	1	0	PLM
	Little Eden	1	0	PLM
	Covenant Camp	1	0	PLM
	Village Beach	3	0	Health Dept.
	Lake Michigan Beach	3	0	Health Dept.
2015	*Marina (South side)*	1	0	PLM
	Portage Point Inn	1	0	PLM
	Covenant Camp	1	0	PLM
	Village Beach	10	0	Health Dept.
	Lake Michigan Beach	10	0	Health Dept.
2016	*Little Eden Beach*	1	0	PLM
	Marina (South Side)	1	0	PLM
	Portage Point Inn	1	0	PLM
	Covenant Camp	1	0	PLM
	Village Beach	9	0	Health Dept.
	Lake Michigan Beach	9	0	Health Dept.
2017	*Little Eden Camp*	1	0	PLM

DRAFT

Table 9 cont. *Portage Lake and tributaries E. coli sample results*

E. COLI SAMPLE RESULTS (2009 - 2018)				
Year	**Sample Location**	**# of Samples Collected**	**# of Samples Exceeding Total Body Contact Recreation Criteria**	**Sampled By**
2017	*Portage Point Inn*	1	0	PLM
	Resident Beach, SW active	1	0	PLM
	Covenant Camp	1	0	PLM
	Village Beach	10	0	Health Dept.
	Lake Michigan Beach	10	0	Health Dept.
2018	*Portage Point Road (Hilltop)*	6	0	Health Dept.
	Bayview (Batemore)	6	0	Health Dept.
	Ardmore Road (Public Access)	6	0	Health Dept.
	Portage Point Inn Beach	6	0	Health Dept.
	3rd Street Public Access Portage Point	6	0	Health Dept.
	Schimke Creek	**6**	**1**	**Health Dept.**
	Stream # 9	**6**	**3**	**Health Dept.**
	Portage Lake Covenant Bible Camp	6	0	Health Dept.
	Leonard Road Public Access	4	0	Health Dept.
	Morey Road Public Access	4	0	Health Dept.
	Village Beach	10	0	Health Dept.
	Lake Michigan Beach	10	0	Health Dept.
4 OF **264** *E. COLI* SAMPLES COLLECTED EXCEEDED TOTAL BODY CONTACT RECREATION CRITERIA (300 MPN/100ML), **2** SAMPLES EXCEEDED PARTIAL BODY CONTACT RECREATION CRITERIA (1,000 MPN/100ML).				

SOURCE: Onekama Township, 2018, Onekama Village, 2018, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

The scope of *E. coli* monitoring expanded to include road end beaches and tributary streams in the year 2018. A total of six sample events took place between June and August five of which were dry weather events and one which took place during a rain event. As previously mentioned, Schimke Creek and Stream #9 had elevated *E. coli* levels over the total body contact criteria of 300 MPN / 100 mL, and partial body contact recreation criteria of 1,000 MPN / 100 mL during this timeframe. From these results, it was determined that both tributary drains are areas of concern and are under further inspection in order to improve upon the current water quality conditions. 2018 results are displayed below in **Table 10**. The majority of sample sites in the Portage Lake Watershed that have been monitored for *E. coli* have had consistently low concentrations, meaning that in the context of *E. coli* water quality is high, and public health risk is low.

Table 10. *2018 Portage Lake Watershed composite E. coli monitoring results (MPN/ 100 mL)*

Sample Location	Sample Date						Sampled By
	6/15/18	6/27/18 (Rainfall)	7/11/18	7/25/18	8/8/18	8/22/18	
Portage Point Road (Hilltop)	23.2	3.4	10.1	4.7	2.0	2.0	Health Dept.
Bayview (Batemore)	25.0	6.6	1.8	1.8	1.0	1.6	Health Dept.
Ardmore Road (Public Access)	62.7	4.8	1.4	2.1	<1.0	<1.0	Health Dept.
Portage Point Inn Beach	6.6	7.6	3.6	10.2	<1.0	2.0	Health Dept.
3rd Street Public Access Portage Point	57.5	2.8	5.6	2.0	1.0	<1.0	Health Dept.
Schimke Creek*	146.8	**2,164.8**	240.4	227.4	202.5	294.6	Health Dept.
Stream 9⁺	**920.8**	**2,027.0**	30.6	270.2	81.8	**320.6**	Health Dept.
Portage Lake Covenant Bible Camp	4.6	82.1	11.3	2.1	60.3	2.0	Health Dept.
Leonard Road Public Access	3.6	1.3	2.1	2.0	NA	NA	Health Dept.
Morey Road Public Access	5.2	4.7	6.5	1.4	NA	NA	Health Dept.
* Composite samples collected at M22 crossing, 100 ft, and 200 ft upstream from M22							
⁺ Composite samples collected at M22 crossing, canal, golf course pond							
Numbers highlighted in green exceeded total body contact recreation criteria of 300 MPN / 100 mL							

SOURCE: Onekama Township, 2018, Onekama Village, 2018, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

TROPHIC STATE INDEX

The Trophic State Index (TSI) is a classification system designed to rank water bodies on a scale of "least productive" to "most productive." Classifications include oligotrophic (least productive), mesotrophic, eutrophic, and hypereutrophic (most productive). For context, water bodies such as Lake Michigan and Lake Superior are oligotrophic, whereas Silver Lake (Oceana County, MI) is eutrophic (Fuller and Taricska, 2012).

TSI may be calculated using various water quality parameters, with the most common and standardized method utilizing chlorophyll *a*, total phosphorus, and Secchi depth as variables. The TSI calculation method utilized to determine Portage Lake's trophic status was Carlson's (1977), as adapted by the Minnesota Pollution Control agency (MPCA, 1991) and used by the EGLE to guide the interpretation of data collected under its Cooperative Lakes Monitoring Program (MDEQ, 2003). This index was developed specifically for lakes in the Great Lakes region, and uses the variables of Secchi depth, chlorophyll *a* concentration, and total phosphorus concentration to classify lakes into their respective trophic states. The TSI is a good metric for phosphorus-limited water bodies such as Portage Lake[4].

Table 11 compiles the annual range in values for Secchi depth, chlorophyll *a*, and total phosphorus measured in Portage Lake. The compiled data is sourced from the Onekama High School Monitoring Program (1993 – 2007), and the 2009 – 2017 Portage Lake Management Plans.

Table 11. *Average TSI variables in Portage Lake (1996 – 2017)*

Year	Secchi Disk Transparency (ft)	Chlorophyll *a* (mg/L)	Total Phosphorus (mg/L)
1993	11.5	0.005	0.008
1994	15.5	0.006	0.010
1995	20.5	0.002	0.008
1996	18.0	0.007	0.007
1997	20.0	0.002	0.006
1998	15.5	0.003	0.006
1999	17.0	0.011	0.008

[4] The biological productivity of a lake is based on the availability of plant nutrients and is referred to as the lake's "trophic" condition. Extremely high or low productivity usually limits aquatic life. High productivity leads to a lot of algae and other aquatic plants. Low productivity leads to very little aquatic life. The trophic condition of lakes ranges from the least productive (oligotrophic) to moderately productive (mesotrophic) to highly productive (eutrophic). Hypereutrophic lakes are the most productive of all.

Table 11 cont. *Average TSI variables in Portage Lake (1996 – 2017)*

Year	Secchi Disk Transparency (ft)	Chlorophyll *a* (mg/L)	Total Phosphorus (mg/L)
2000	17.0	0.003	0.008
2001	15.5	0.005	0.009
2002	18.0	0.003	0.006
2003	22.5	0.002	0.006
2004	19.0	0.003	0.009
2005	20.0	0.003	0.008
2006	19.5	0.003	0.007
2007	20.0	0.001	0.004
2009	16.0	0.007	0.066*
2010	19.0	0.004	U
2012	27.0	0.004	0.027
2013	13.6	0.003	0.012
2014	16.5	0.002	0.017
2015	15.3	0.010	U
2016	14.3	0.001	0.008
2017	15.2	0.001	0.011

SOURCE: MDEQ, 2018, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.
NOTE: U indicates samples that were under the reporting limit
**One sample event took place in 2009, compared to the 2 – 3 events in other years.*

Portage Lake's composite trophic level, which is calculated using chlorophyll *a* concentration, Secchi depth, and total phosphorus concentration, has remained unchanged since the 1993 Phase I study, where it was classified as mesotrophic. Trophic status calculated using only chlorophyll *a*, and trophic status calculated using only Secchi depth data have both seen a decrease since the 1993 dataset. Whereas trophic status based on total phosphorus concentration has had an increase. Calculated TSI's for 1993, 1994 – 2007, and 2008 – 2017 are shown below in **Figure 44**. It should be noted that TSI calculations for 2008 – 2017 data use averaged concentrations from 0 ft, 30 ft, and 60 ft in depth. Meaning that certain parameters, such as total phosphorus, may be elevated in concentration in comparison to the 1993 and 1994 – 2007 datasets.

With trophic status comes certain environmental conditions. For example, an oligotrophic lake has clear water and oxygen throughout the water column, including the hypolimnion. As a lake ages towards mesotrophy, the lake's hypolimnion becomes anoxic, in particular during the summer, and the water is moderately clear. Additionally, relationships between various calculated TSI's (i.e. total phosphorus, chlorophyll *a*, and Secchi depth) give insight to the lake's environmental conditions as well. For example, Portage Lake has the following relationship between TSI's at play in the most recent data set, TSI(TP) > TSI(Chl-a) = TSI(SD), which may indicate algae dominate light attenuation, but some factors such as nitrogen limitation, zooplankton grazing, or toxics limit algal biomass. However, the previous datasets (1993 and 1994 – 2007) had the following relationship, TSI(SD) = TSI(Chl-a) > TSI(TP), which indicates that phosphorus limits the algal biomass in the water column, or in other words, the water body is "phosphorus limited." Relationships between TSI and environmental conditions are outlined in **Table 12** and **Table 13**.

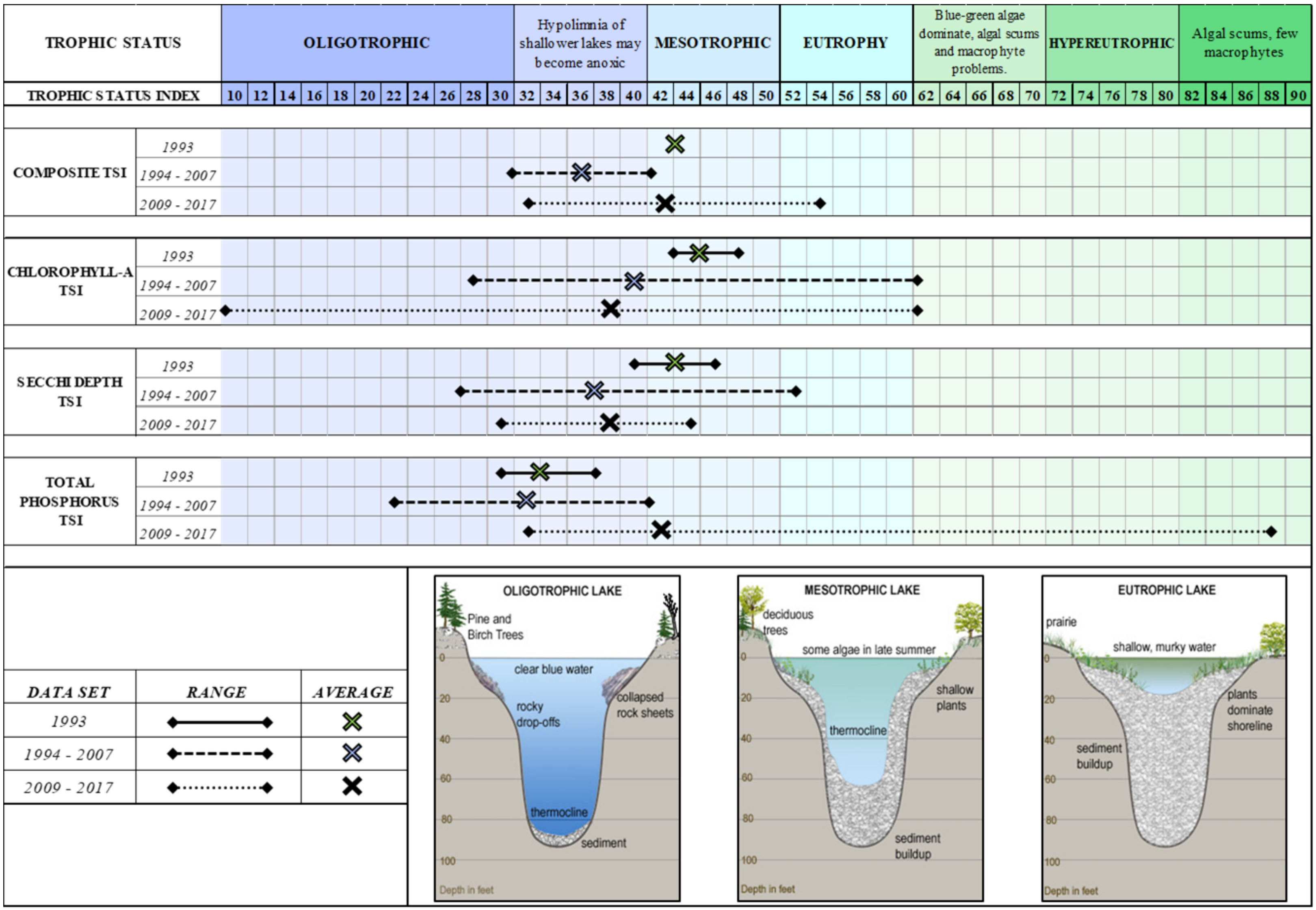


Figure 44. *Portage Lake trophic status*

SOURCE: Spicer Group, Inc., 2018, using data from MDNR, Michigan/USEPA 1974 and 1985 STORET Water Quality Data, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

Table 12. *Trophic status index classifications*

Trophic Status	Trophic State Indicator	Chlor-a (mg/L)	Secchi (ft)	TP (mg/L)	Fisheries and Recreation
Oligotrophy – Clear water, oxygen throughout the year in the hypolimnion	<30	<0.00095	>26	<0.006	Salmonid fisheries dominate.
Hypolimnia of shallower lakes may become anoxic	30 – 40	0.00095 – 0.0026	13 – 26	0.006 – 0.012	Salmonid fisheries in deep lakes only.
Mesotrophy – Water moderately clear; increasing probability of hypolimnetic anoxia during summer.	40 – 50	0.0026 – 0.0073	7 – 13	0.012 – 0.024	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate.
Eutrophy – Anoxic hypolimnia, macrophyte problems possible	50 – 60	0.0073 – 0.0200	3 – 7	0.024 – 0.048	Warm-water fisheries only. Bass may dominate.
Blue-green algae dominate, algal scums and macrophyte problems.	60 – 70	0.0200 – 0.0560	1.6 – 3	0.048 – 0.096	Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating.
Hypereutrophy – Light limited productivity. Dense algae and macrophytes	70 – 80	0.0560 – 0.1550	0.8 – 1.6	0.096 – 0.192	-
Algal scums, few macrophytes	>80	>0.1550	<0.8	0.192 – 0.384	Rough fish dominate; summer fish kills possible.

SOURCE: Simpson, R. E., 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods.

Table 13. *Trophic status index relationships and lake conditions*

Relationship Between TSI Variables	Lake Conditions
TSI (Chl-a) = TSI(TP) = TSI(SD)	Algae dominate light attenuation; TN:TP ~33:1
TSI(Chl-a) > TSI (SD)	Large particulates, such as *Aphanizomenon* flakes, dominate
TSI(TP) = TSI(SD) > TSI(Chl-a)	Non-algal particulates or color dominate light attenuation
TSI(SD) = TSI(Chl-a) > TSI(TP)	Phosphorus limits algal biomass (TN:TP > 33:1)
TSI(TP) > TSI(Chl-a) = TSI(SD)	Algae dominate light attenuation, but some factors such as nitrogen limitation, zooplankton grazing, or toxics limit algal biomass

SOURCE: Simpson, R. E., 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods.

Tributary Water Quality

1993 Phase I Study

The streams monitored on a monthly basis in the 1993 Portage Lake USEPA Phase I Diagnostic/Feasibility Study (Phase I study) included Glen, Dunham, Onekama, and Schimke Creeks, which had average flows of 1.2, 1.6, 3.2, and 17.8 cubic feet per second (cfs), respectively at each of their outlets. 11 additional streams, monitored three separate times during the Phase I Study, had flows ranging from one to three cfs. All streams were considered relatively high quality with steady base flow throughout the year.

During the Phase I study, stream flow, total phosphorus, and suspended solids were measured in Glen, Dunham, Onekama, and Schimke Creeks during base flow and following wet weather events to determine annual variations. Glen and Dunham Creeks show similar patterns throughout the year as well as during storm flow conditions. Both have forested or vegetated watersheds that reduce erosion and surface runoff, especially during storm events. Although both showed normal increases in flow, suspended solids, and total phosphorus during spring and fall, the increases were relatively small. Even during storm events these two streams showed little increase in suspended solids or flow, but total phosphorus did increase. The increase in total phosphorus was believed to be primarily the result of direct input of phosphorus from precipitation.

Onekama and Schimke Creeks exhibited different patterns. The Onekama Creek Watershed consists of a residential area within the Village of Onekama and has the next highest discharge after Schimke and Hansen Creeks (3.2 cfs). The relationship between suspended solids and total phosphorus was strongly correlated in Onekama Creek. Every time suspended solids increased, so did total phosphorus, but this was not always associated with an increase in flow. This implies that loading of phosphorus was coming from surface runoff from residential lawns and streets and is carried with sediment load. Other than during storm events, Onekama Creek had relatively low concentrations of phosphorus and suspended solids for a stream that flows through a residential area.

Schimke Creek and its sub-watershed are unique in the larger Portage Lake Watershed because this sub-watershed is by far the largest and the least vegetated/forested with the most agricultural activities. The creek itself has the highest flow (average 17.8 cfs). However, excluding the spring high runoff period and storm events, this creek still maintained relatively low concentrations of phosphorus and suspended solids. During storm events, phosphorus, suspended solids and flow significantly increased.

2009 – 2017 State of the Lakes Tributary Monitoring

In recent years, stream monitoring has been incorporated into the annual State of the Lake Reports. Data for flow, total dissolved solids (TDS), nitrate, ammonia, temperature, dissolved oxygen, pH, turbidity, oxidation reduction potential (ORP), conductivity, *E. coli*, total Kjeldahl nitrogen (TKN), and total phosphorus has been collected at McGowan, Stream #9, Onekama, Glen, McCormick, Hansen, Schimke, and Dunham Creeks, shown in **Figure 45**. The earliest data was collected in 2009 and continues through 2017. Early season and late season averages for these parameters were compared. On average, there tends to be higher stream flows, turbidity, and dissolved oxygen earlier in the season, meaning spring and early summer. There tends to be higher nitrate and total phosphorus concentrations, total dissolved solids, and higher temperatures later in the season, meaning late summer and early fall. Early and late averages were about the same for ammonia. Additionally, the data was compared to Portage Lake's water quality data. Typically, the streams were higher in concentration for many of the parameters both early and late in the season when compared to Portage Lake's values. Stream monitoring data is summarized in **Figures 46** through **55**, below.

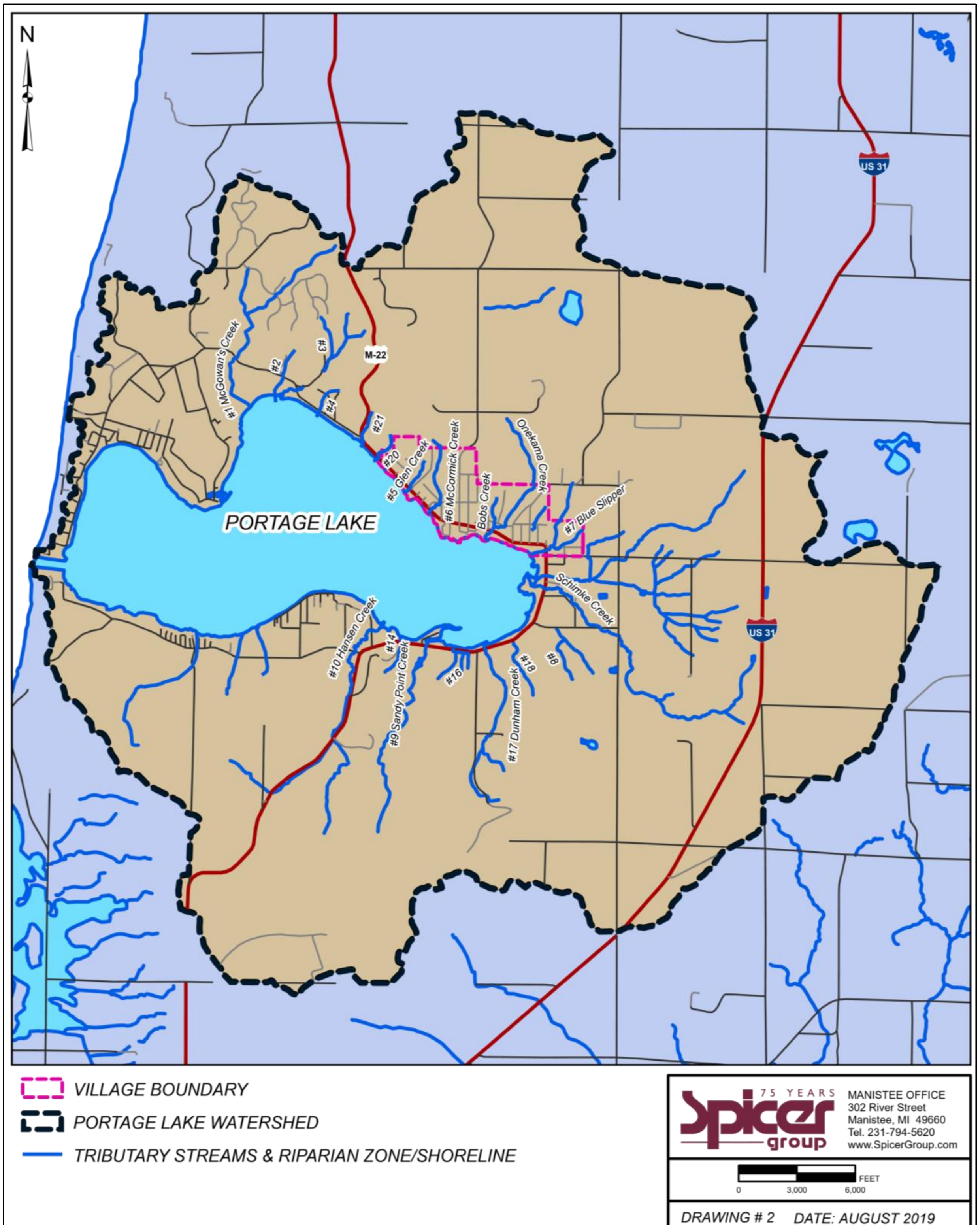


Figure 45. *Location of tributaries discharging to Portage Lake*

SOURCE: Spicer Group, Inc., 2019, using data from USEPA 1993 Phase I Study

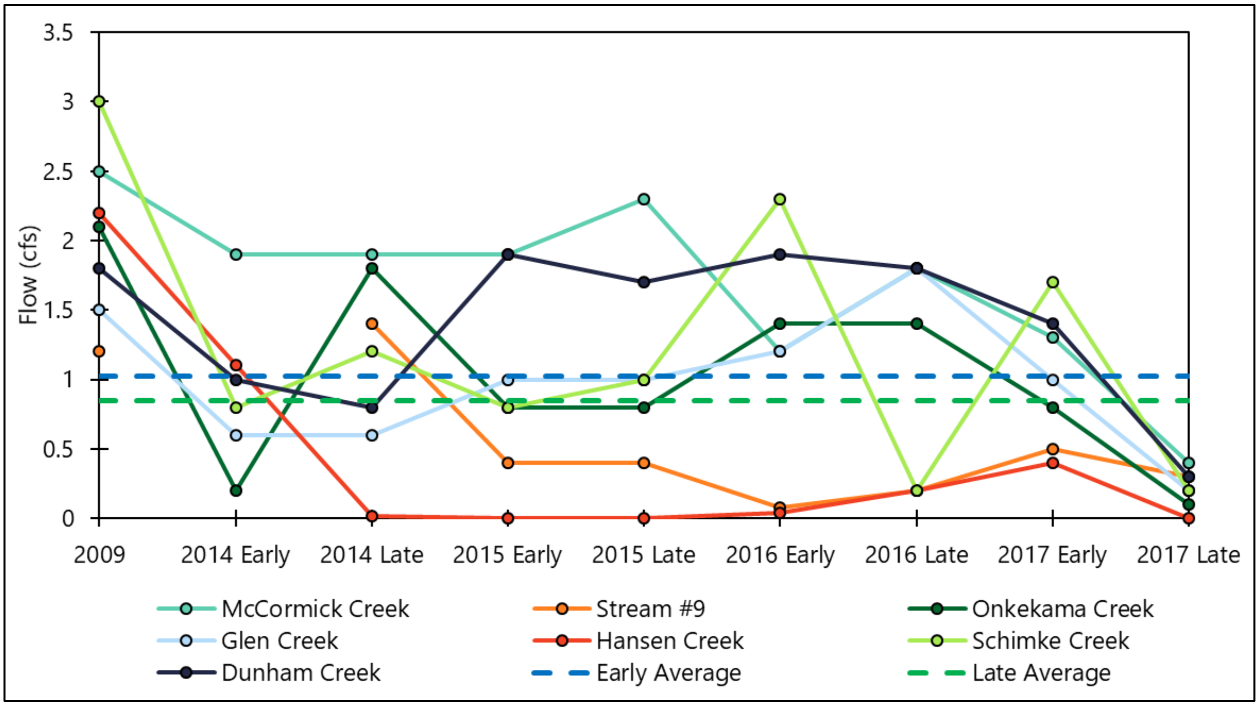


Figure 46. *Tributary streamflow, cfs (2009 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from MDEQ, 2018, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

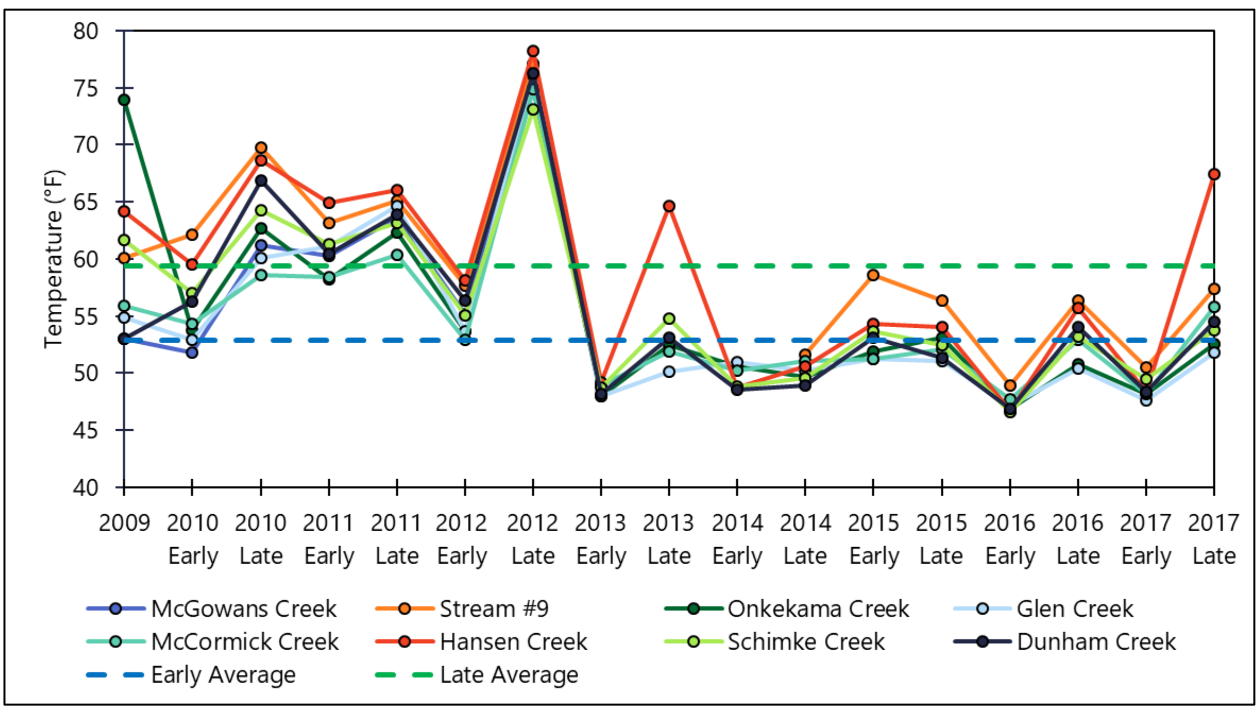


Figure 47. *Tributary stream temperature, °F (2009 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from MDEQ, 2018, Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

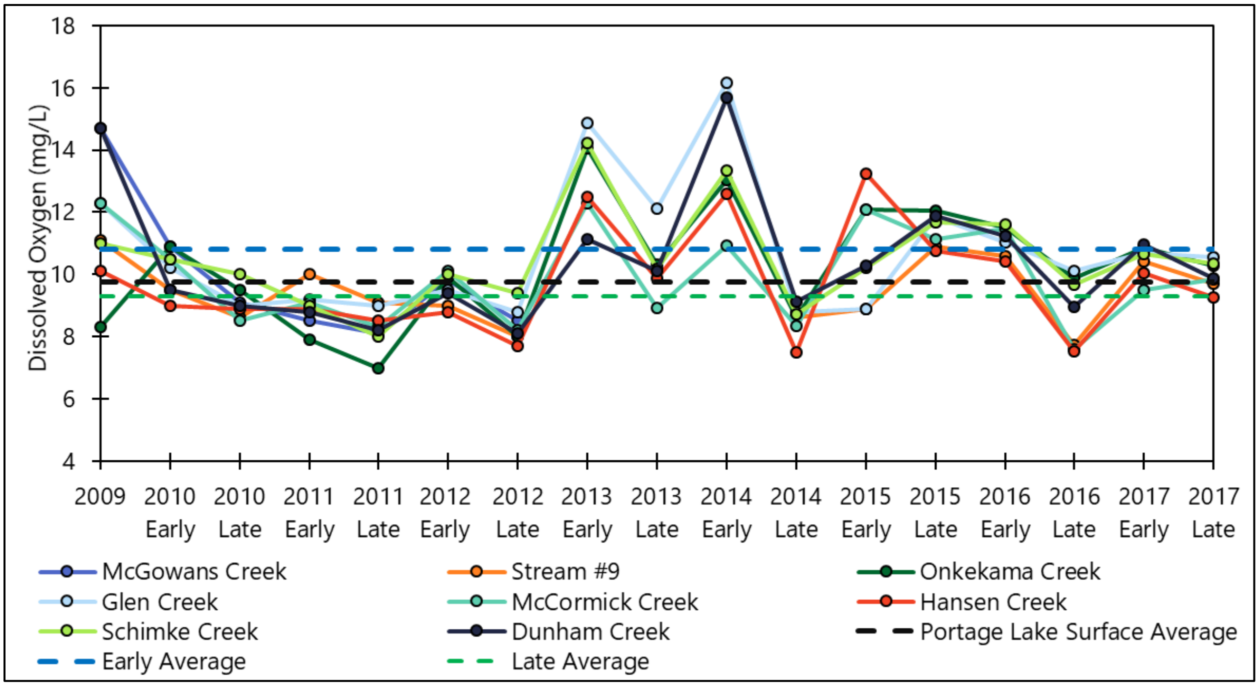


Figure 48. *Tributary stream dissolved oxygen, mg/L (2009 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

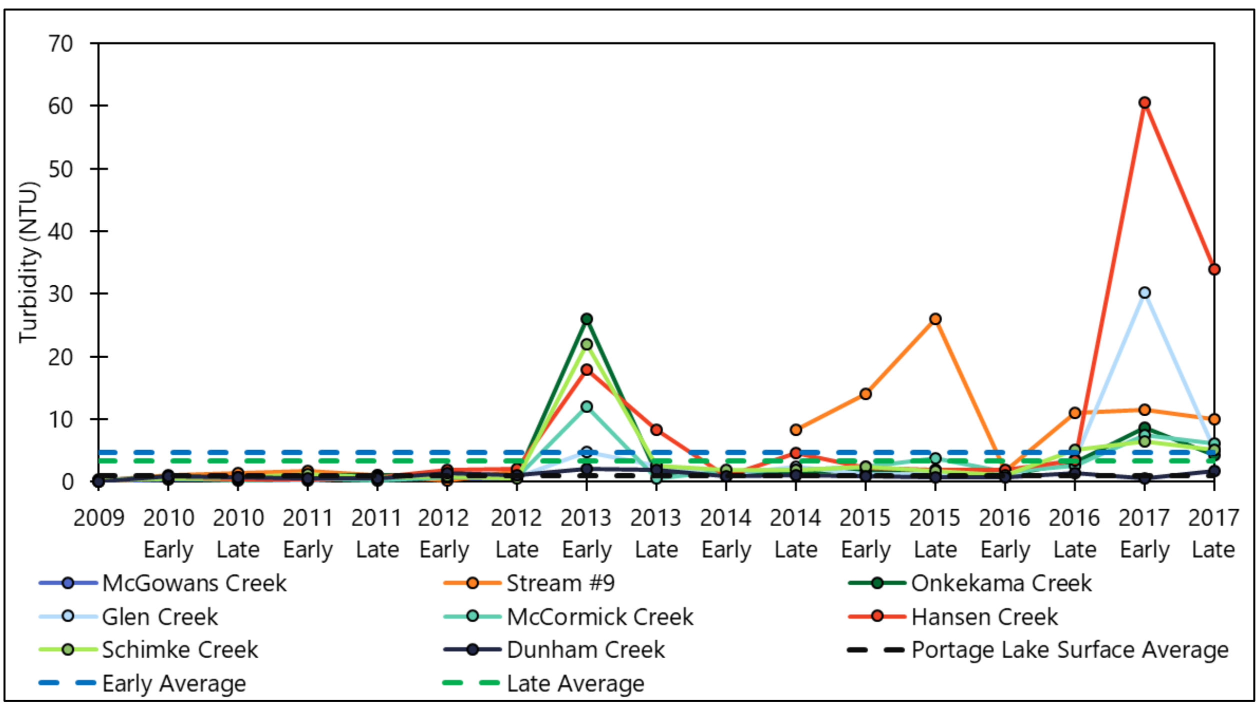


Figure 49. *Tributary stream turbidity, NTU (2009 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

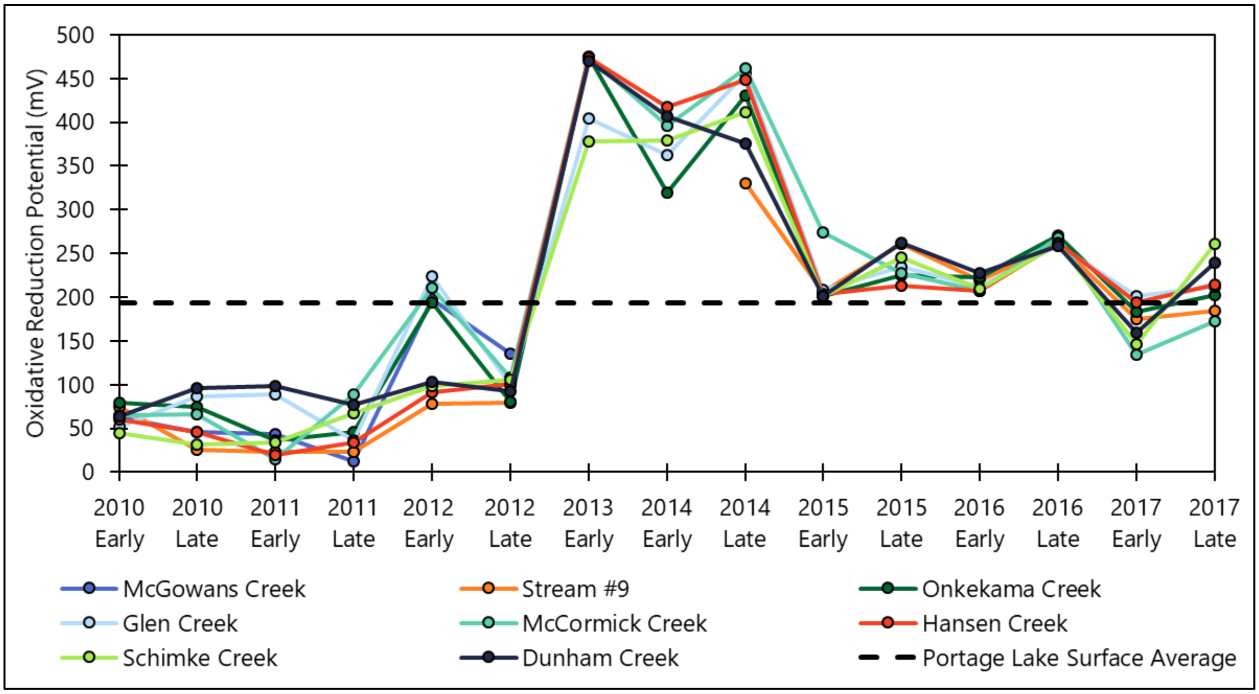


Figure 50. *Tributary oxidative reduction potential (ORP), mV (2009 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

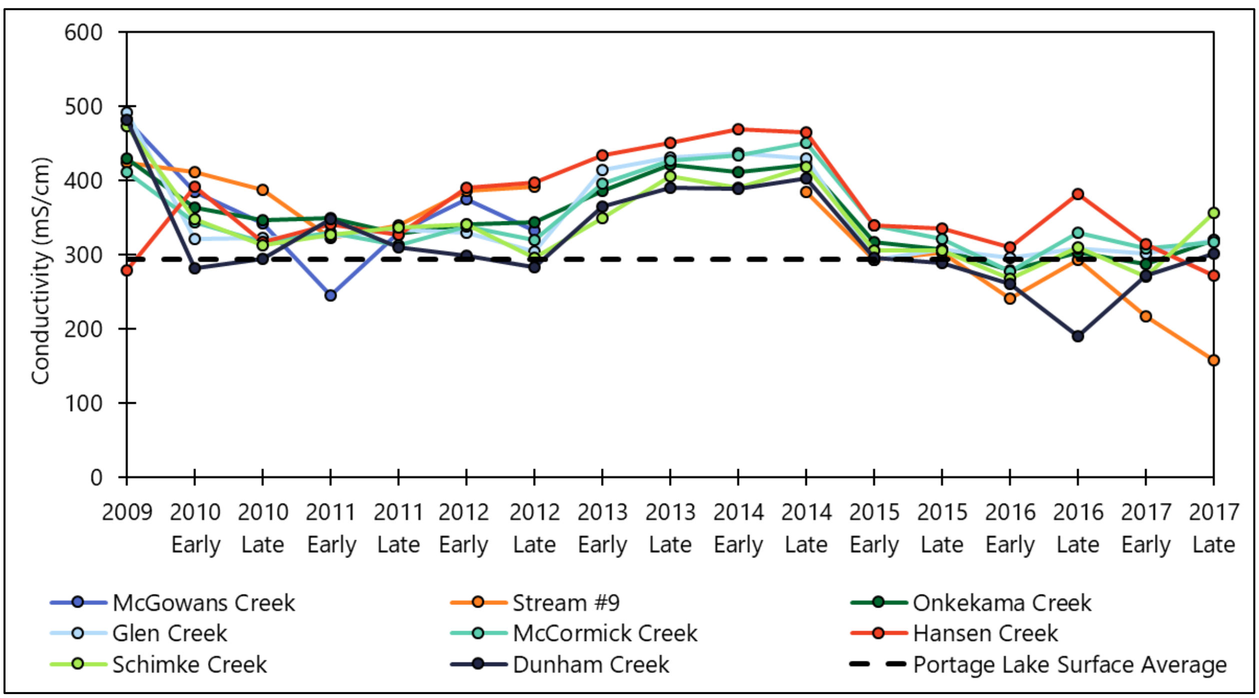


Figure 51. *Tributary stream conductivity, mS/cm (2009 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

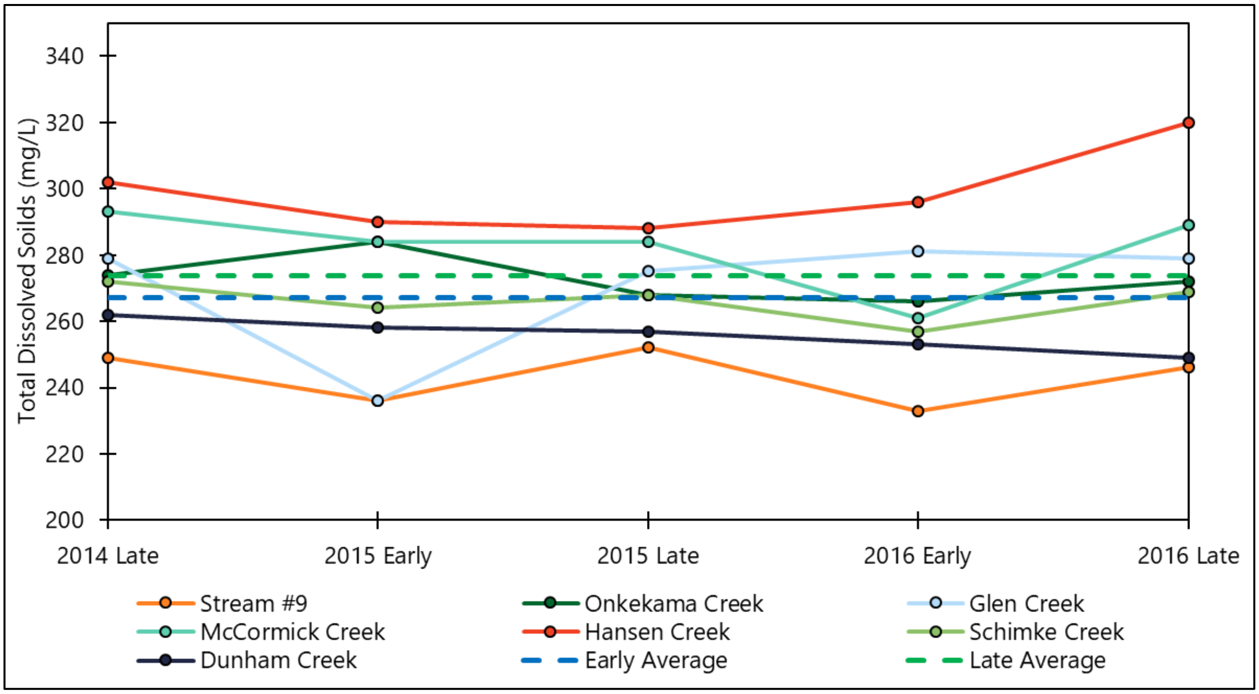


Figure 52. *Tributary stream total dissolved solids (TDS), mg/L (2014 - 2016)*

SOURCE: Spicer Group, Inc., 2018, using data from Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

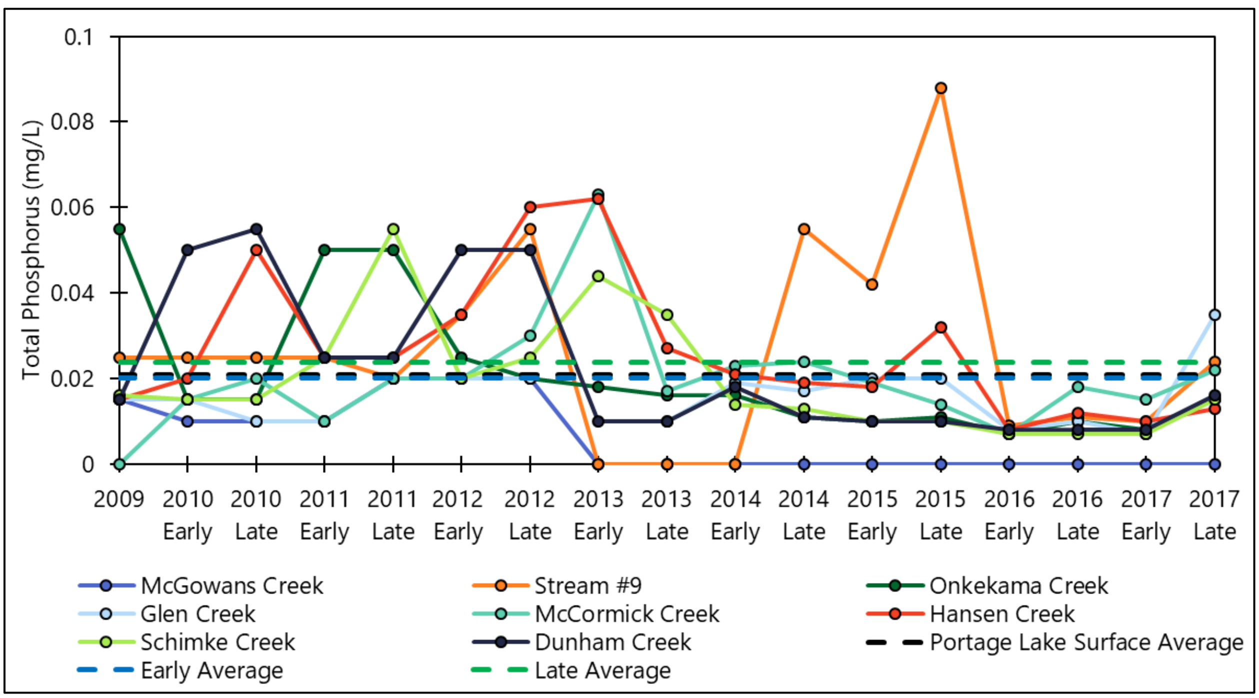


Figure 53. *Tributary stream total phosphorus, mg/L (2009 - 2017)*

SOURCE: Spicer Group, Inc., 2018, using data from Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

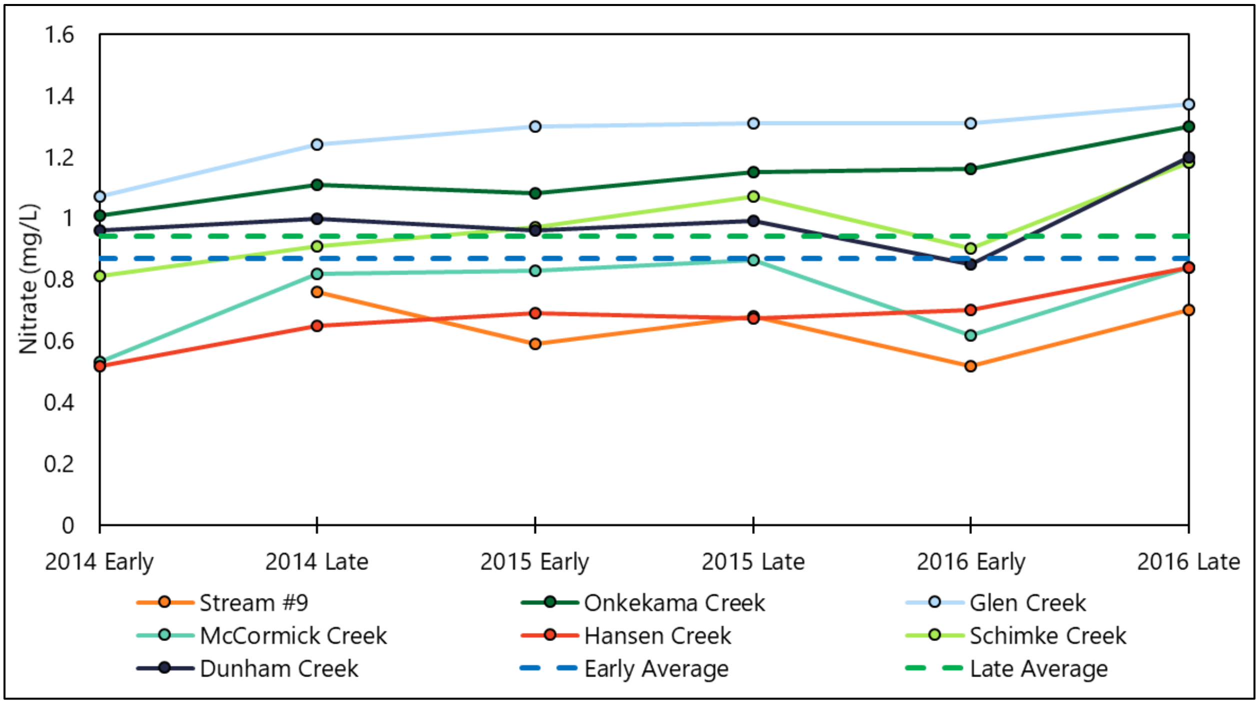


Figure 54. *Tributary stream nitrate concentration, mg/L (2014 - 2016)*

SOURCE: Spicer Group, Inc., 2018, using data from Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

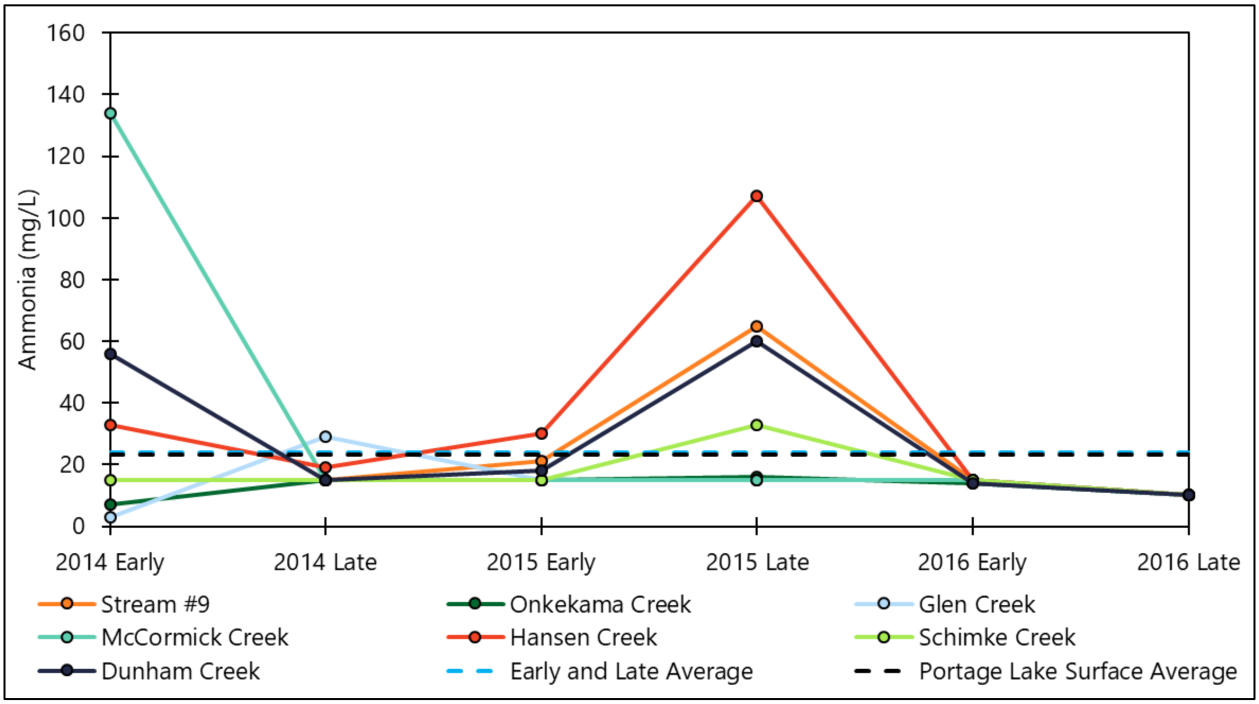
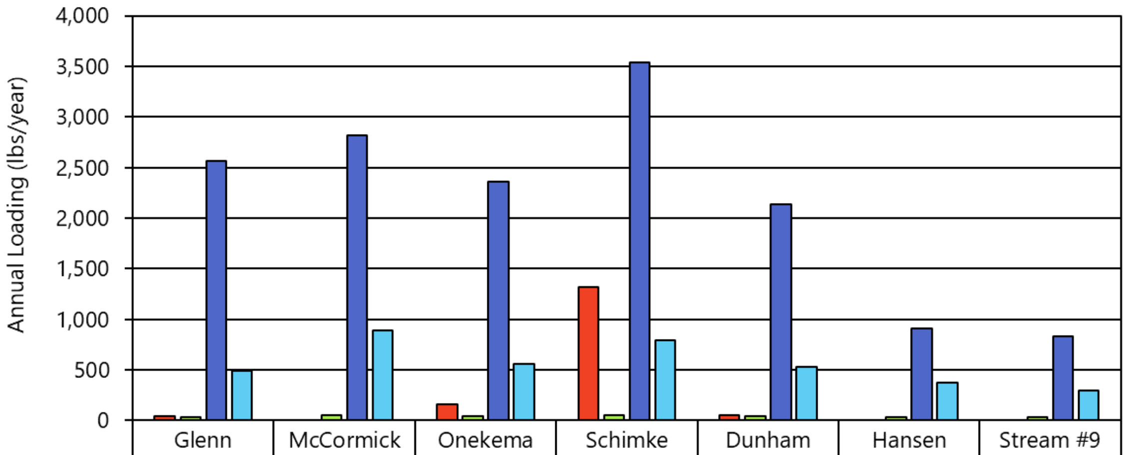


Figure 55. *Tributary stream ammonia concentration, mg/L (2014 - 2016)*

SOURCE: Spicer Group, Inc., 2018, using data from Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

Annual loads of total phosphorus, nitrate, and total dissolved solids were calculated utilizing average concentrations for each parameter as well as averaged stream flow, **Figure 56**.



	Glenn	McCormick	Onekema	Schimke	Dunham	Hansen	Stream #9
TP 1991 - 1992	47	0	159	1314	56	0	0
TP 2009 - 2017	29	58	46	49	46	29	37
Nitrate 2009 - 2017	2568	2813	2364	3536	2139	915	836
TDS 2009 - 2017	489	894	561	794	532	378	296

Figure 56. *Tributary stream loading, pounds per year*

SOURCE: Spicer Group, Inc., 2018, using data from Lakeshore Environmental, INC., 2009 – 2011, Restorative Lake Sciences, LLC, 2013, PLM Lake & Land Management Corp., 2013 – 2017.

Additionally, stream flow and total phosphorus loadings from 1991 – 1992 were compared to stream flow and total phosphorus loadings from 2009 – 2017, shown below in **Table 14**. 1991 – 1992 data for average flow was likely biased high for Schimke Creek as the measurement was taken during spring melt, and not during other timeframes when the creek is not flowing as fast and deep.

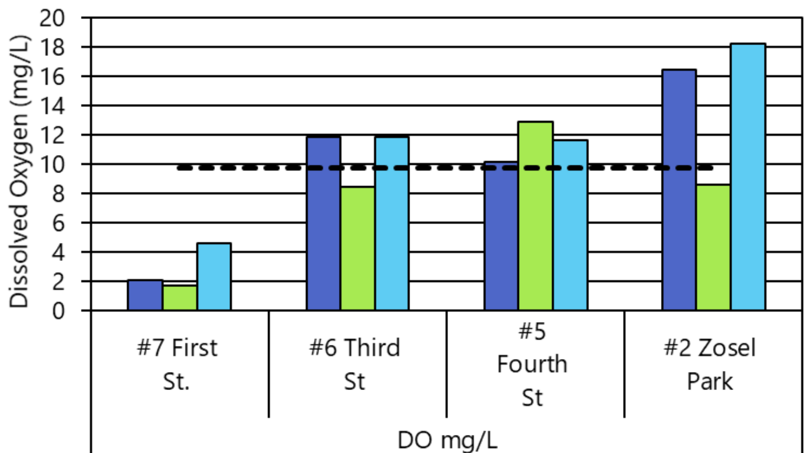
Table 14. *Portage Lake tributary total phosphorus loading data (1991 - 1992) and (2009 - 2017)*

Monitored Stream	Average Flow (cfs)		Total Phosphorus Loading (lb/year)	
	1991 - 1992	2009 - 2017	1991 - 1992	2009 - 2017
Glenn	1.2	1.0	47	29
Onekema	3.2	1.2	159	46
Schimke	17.8	1.6	1314	49
Dunham	1.6	1.1	56	46

SOURCE: SEG, 1993.

Storm Drain Water Quality

Beginning in 2014 as a component of the State of the Lake Reports, local storm drains were monitored for dissolved oxygen, conductivity, dissolved solids, and total phosphorus among other water quality parameters. The first street storm drain (sample site #7) consistently was the storm drain with the lowest concentration of dissolved oxygen. The other sample sites, Third Street (sample site #6), Fourth Street (#5), and Zosel Park (#2), tended to be similar in concentration to Portage Lake's dissolved oxygen surface average, **Figure 57**.

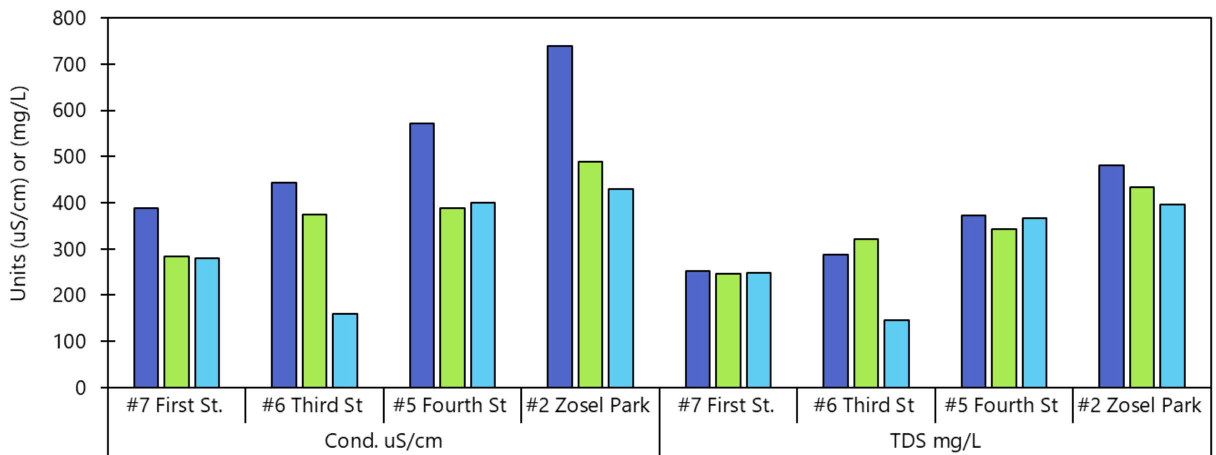


	#7 First St.	#6 Third St	#5 Fourth St	#2 Zosel Park
2014	2.09	11.87	10.18	16.45
2015	1.67	8.47	12.92	8.59
2016	4.56	11.83	11.66	18.25
Portage Lake Surface Average	9.76	9.76	9.76	9.76

Figure 57. *Storm drain dissolved oxygen, mg/L (2014 - 2016)*

SOURCE: Spicer Group, Inc., 2018, using data from PLM Lake & Land Management Corp., 2014 – 2016.

Both conductivity and dissolved solids, **Figure 58**, saw similar trends in concentration decrease from 2014 to 2016 at all four sample sites. If conductivity decreased, then TDS decreased, and vice versa. Zosel Park (sample site #2) exhibited the highest concentrations of TDS and highest level of conductivity. All sample sites either decreased or remained at similar levels of conductivity and TDS during all three years of monitoring.

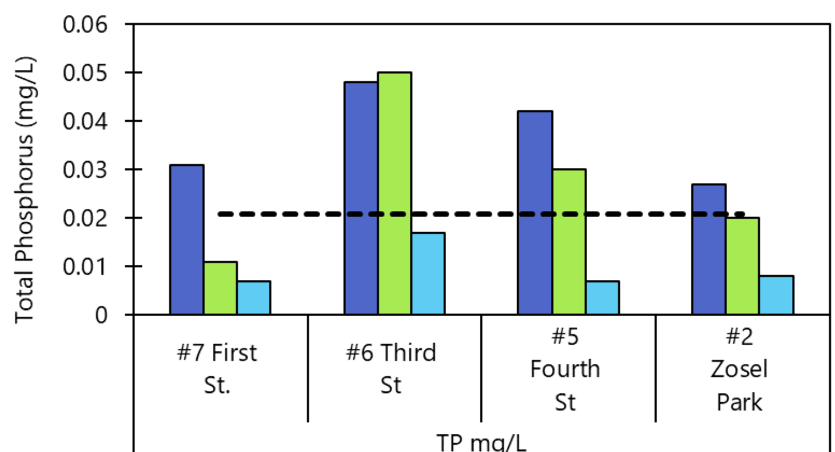


	#7 First St. (Cond. uS/cm)	#6 Third St (Cond. uS/cm)	#5 Fourth St (Cond. uS/cm)	#2 Zosel Park (Cond. uS/cm)	#7 First St. (TDS mg/L)	#6 Third St (TDS mg/L)	#5 Fourth St (TDS mg/L)	#2 Zosel Park (TDS mg/L)
2014	388	443	572	739	252	288	372	480
2015	283	375	389	489	247	322	342	433
2016	279	159	399	429	249	145	366	396

Figure 58. *Storm drain conductivity and dissolved solids (2014 - 2016)*

SOURCE: Spicer Group, Inc., 2018, using data from PLM Lake & Land Management Corp., 2014 – 2016.

Total phosphorus was monitored at the same four storm drain sample sites in the years 2014, 2015, and 2016, shown in **Figure 59**. At all four sites, TP concentrations significantly decreased. The first two years of monitoring, TP was highly elevated above Portage Lake's average surface concentration of 0.0209 mg/L, however, 2016's data was well below the average.



	#7 First St.	#6 Third St	#5 Fourth St	#2 Zosel Park
2014	0.031	0.048	0.042	0.027
2015	0.011	0.05	0.03	0.02
2016	0.007	0.017	0.007	0.008
Portage Lake Surface Average	0.0209	0.0209	0.0209	0.0209

Figure 59. *Storm drain total phosphorus, mg/L (2014 - 2016)*

SOURCE: Spicer Group, Inc., 2018, using data from PLM Lake & Land Management Corp., 2014 – 2016.

Drinking Water Quality

The EGLE reports levels of nitrate, arsenic, and volatile organic compounds in drinking water (MDEQ, 1983–2003). Between 1983 and 2003, no drinking water samples from within the Portage Lake Watershed were reported with arsenic levels above the maximum contaminant level (MCL) of 0.010 mg/L (10 ppb). During the same period, two samples out of approximately 100 samples had nitrate levels above the MCL of 10 mg/L (10 ppm). Maps available from the EGLE indicate that those samples were from agricultural areas that may experience fertilizer applications. Samples from three sites within the northern and northwestern portions of the Watershed were positive for volatile organic compounds between 1983 and 2002.

Several samples were taken from wells within the Watershed between 2014 and 2018. Each sample was tested for 12 parameters that pertain to consumption quality, including the following: total coliform, *E. coli*, nitrate, nitrite, calcium, magnesium, hardness, iron, sodium, chloride, fluoride, and sulfate. In total, 105 water quality tests were run during this time period. 97.1 percent of the tests were well below suggested maximum contaminant levels. The exceptions, or the remaining 2.9 percent of samples, being Pierport Spring, Little Eden Spring, and the Onekama Township Office well, which exceeded the USEPA's secondary maximum contaminant level for iron in drinking water (0.3 mg/L). Pierport Spring, Little Eden Spring, and the Onekama Township Office had measured iron concentrations of 0.4 mg/L, 0.4 mg/L, and 0.5 mg/L, respectively during one sample event on the same day, July 20, 2016. Although this parameter exceeded criteria, it is not a health concern. The maximum suggested contaminant level was set for aesthetic reasons, meaning when the concentration is higher than 0.3 mg/L discoloration, metallic taste/odor, staining and scaling may occur.[5]

FISHERIES

Based upon fisheries surveys conducted periodically over the last 40 years, Portage Lake supports a wide range of naturally reproducing, resident coldwater[6] and warmwater fish populations, including largemouth and smallmouth bass, northern pike, yellow perch, black crappie, rock bass, hybrid sunfish, bluegill, and pumpkinseed. With the support of an annual stocking program, Portage Lake also has a popular year-round walleye fishery and a seasonally important brown

[5] USEPA's secondary maximum contaminant levels are non-mandatory water quality standards for 15 contaminants. The USEPA does not enforce these criteria but has set them to assist public water systems in managing their drinking water for aesthetic considerations, including taste, color and odor.

[6] Walleye, northern pike, muskellunge, yellow perch, white suckers, crappie and other fish species that thrive in temperatures that range from 65–70^{o}F.

trout, Coho, and Chinook fishery. Many of the tributary streams support naturally reproducing brook trout populations and at least one supports a naturally reproducing brown trout population.

The fish survey data from 1999 indicate that resident fish populations are generally in good condition with growth rates that approximate or exceed statewide averages for the same species. Significant differences between the 1976 and 1999 surveys is the decrease in bluegill and bass frequency. The reduction in observed bass is likely attributed to electrofishing not being utilized in the 1999 survey.

The most recent survey was published in 2009 and again confirmed a game fishery whose growth rates exceed the state average. Most notably, the walleye in Portage Lake are 3.7 inches larger than the state average. It has also been observed that there are two distinct perch populations that inhabit Portage Lake. The year-round resident population consist of small, slower growing fish who measure 0.9 inches below the state average. Due to the channel that connects to Lake Michigan there is a seasonal fishing opportunity for larger "Lake Michigan" perch. These schools tend to migrate to Portage Lake beginning in the winter months and concluding after the final ice cover thaws out in mid-May. These faster growing perch have been frequently observed at 14 inches. It was also noted in the Status of the Fishery Resource Report that Portage Lake offers a high-quality Brown Bullhead fishery with many individuals at or exceeding the minimum 14-inch Master Angler threshold.

The Michigan Department of Natural Resources (MDNR) fishery management objectives emphasize the need to protect the remaining, undisturbed shoreline areas as spawning, nursery and foraging areas for existing, naturally reproducing game and forage fish populations. They also emphasize the need to protect the coldwater fishery habitat of tributary streams, citing past developments that have destroyed spawning habitat for trout and salmon.

Portage Lake Fish Populations and Management

MICHIGAN DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENT STATUS OF THE FISHERY RESOURCE REPORT (2000)

Included within the 2008 Portage Lake Watershed Management Plan is the following summary prepared using information excerpted from the intensive survey of the fisheries of Portage Lake, completed in June of 1999 and reported in the MDNR *Status of the Fishery Resourc*e report (2000):

Very little fisheries management occurred on Portage Lake prior to the 1970s. MDNR records indicate that smallmouth bass, bluegill and rainbow trout were stocked in the lake in the late 1920s and early 1930s, with little evidence of an enhanced fishery. In the 1950s, 70 brush shelters were placed in the lake in a then-popular effort designed to enhance fishery habitat and concentrate fish to improve angling success of rock and smallmouth bass.

Because of its open connection to Lake Michigan through the 400-foot-wide, 12-foot- deep Portage Lake Channel, Great Lakes fish populations of yellow perch, cisco, rainbow smelt, round whitefish (Menominee), lake whitefish, lake trout and other Great Lakes species may, under certain wind and temperature conditions, be present in Portage Lake supplementing resident populations. In addition to the resident coldwater and warmwater game fish species, non-game and forage species are also common in Portage Lake. These include bowfin, common carp, yellow and brown bullhead, several species of suckers, alewife, and banded killifish, as well as a variety of other small forage species such as shiners. The fish survey data from 1999 indicated that resident fish populations were generally in good condition with growth rates that approximated or exceeded statewide averages for the same species. Fall walleye recruitment assessments conducted by the Little River Band of Ottawa Indians in 2005 and 2006 indicated average walleye growth rates similar to state averages (LRBOI, 2005 and 2006).

Beginning in 1971, Portage Lake has been intensively managed with the annual stocking of trout and salmon, primarily intended to support a Great Lakes fishery in Lake Michigan in the proximity of the Portage Lake Channel. Stocking rates were as high as 300,000 Coho (yearlings) and Chinook (fingerlings) in 1974. However, consistent with the overall management goal of reducing stocked predators in Lake Michigan to match available forage, the number of stocked fish was reduced to a total of 100,000 to 200,000 each year between 1980 and 2000; the stocked species during this period included a combination of Coho, Chinook, and brown trout (fingerlings and yearlings), as shown in **Figure 60**. Since 1987, fingerling walleye have been stocked to support a resident fishery in Portage Lake.

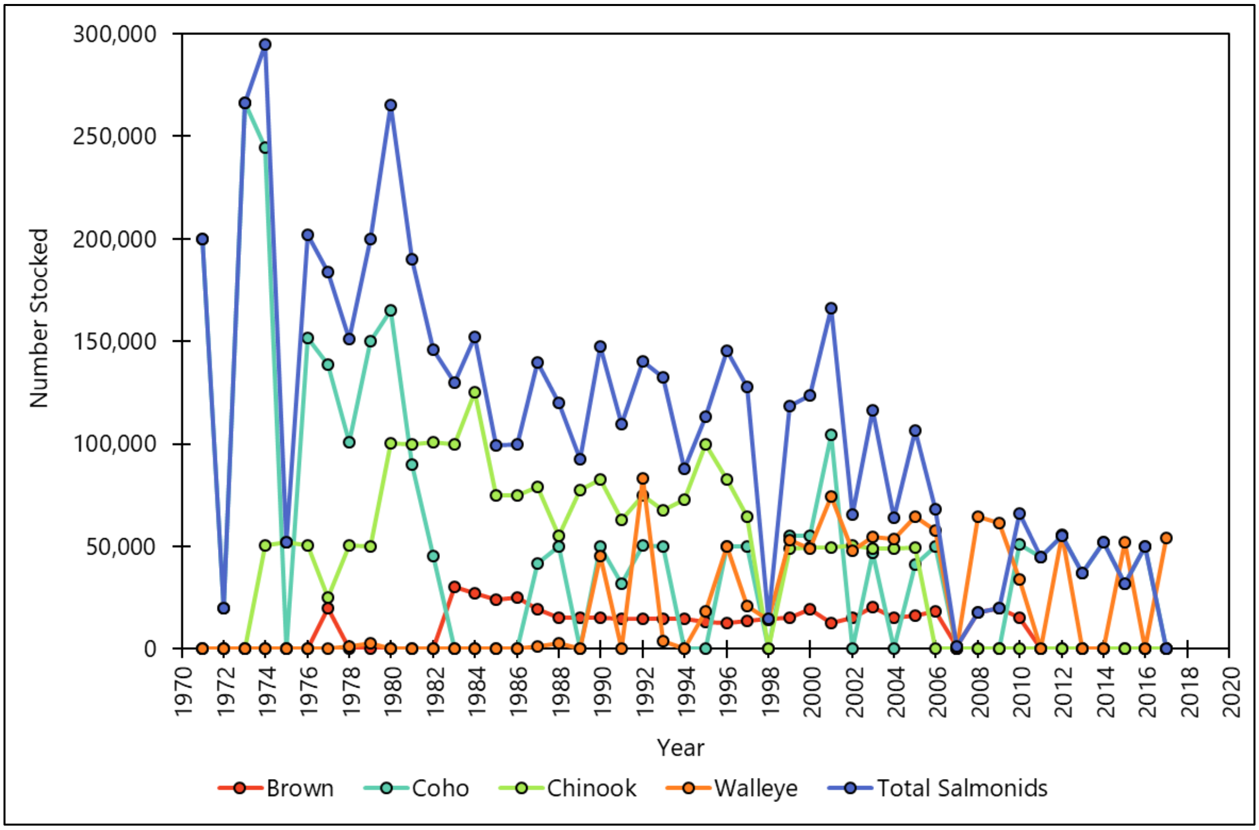


Figure 60. *Portage Lake trout, salmon, and walleye stocking 1971 - 2017*

SOURCE: MDNR, 1971-2017.

The fishery management target established in 2000 called for an annual stocking of Portage Lake with 50,000 Coho, 50,000 Chinook and 15,000 brown trout to maintain a Lake Michigan fishery near the Portage Lake Channel as well as provide a seasonal salmon and trout fishery in Portage Lake itself. In addition, the target included the stocking of approximately 15,000 walleye fingerlings each year. Lake trout were stocked in Portage Lake once in 1989 (157,000) but have not been planted since.

It should be noted that statewide, Great Lakes trout and salmon stocking rates have been significantly reduced since 2000 because of food web disruptions involving benthic (bottom-dwelling) organisms and an associated decrease in available forage fish in Lake Michigan and Lake Huron. The mix of species and number of trout and salmon stocked in Portage Lake have been adjusted accordingly. Since 2000, approximately 170,000 brown trout have been stocked in Portage Lake, with their stocking concluding in 2010. The last Chinook salmon stocking in Portage Lake was in 2005, and from 2001 through 2005 approximately 50,000 Chinook were planted in the lake each year. Coho stocking ceased in 2006 temporarily to allow alewife populations to make a resurgence and was also a result of MDNR budget reductions. From 2010 – 2016, Coho were introduced again to Portage Lake at a rate of 45,000 per year resulting in 320,000 total Coho salmon introduced. Walleye stocking has continued since 2000 with plants of about 57,000 spring fingerlings each year from 2001 – 2006.

In 2007, the MDNR temporarily suspended stocking certain warmwater and coldwater fish species produced from eggs taken from wild fish as a precautionary measure to control the spread of viral hemorrhagic septicemia (VHS). The implications of VHS for the future of the fisheries of Portage Lake are discussed further in the Invasive Species section of this report.

Walleye stocking began once again with 60,000 fingerlings added in both 2008 and 2009. The 2009 Status of the Fishery Resource report stated there are sufficient adult walleye residing in Portage Lake to sustain a consistent fishery and has resulted in decreased fingerling stocking since. Thus, 2010 concluded the final year of annual stocking with only 30,000 fingerlings added. The MDNR has shifted to a biennial stocking regiment of 50,000 fingerlings beginning in 2012 and continuing to the most recent addition in June 2018.

The overall fisheries management objectives for Portage Lake currently are to maintain a mixed coldwater/warmwater resident fishery, supplemented by the stocking of walleye fingerlings. The MDNR has indicated that salmon plants and natural reproduction in other locations are expected to support the Lake Michigan fishery near the Portage Lake Channel and no future salmon plants are planned for Portage Lake. Limited natural reproduction in tributaries and straying from other planting sites are expected to continue to provide a limited fall salmon fishery in Portage Lake. The MDNR's future fisheries management plans still include annual stocking of brown trout in Portage Lake. The objectives assume that the intact littoral zone and shoreline habitat as well as remaining contiguous wetlands in Portage Lake will be protected, and that natural reproduction and recruitment of other resident game and forage species will be adequate to sustain fishable populations.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENT STATUS OF THE FISHERY RESOURCE REPORT (2009)

The following summary was prepared using information excerpted from the intensive survey of the fisheries of Portage Lake, completed in 2009 and reported in the MDNR *Status of the Fishery Resourc*e report (2009):

Another more recent MDNR Portage Lake fish survey was conducted in 2009 using Status and Trend protocols (Wehrly et al., 2009). Trap nets and inland gill nets were set from May 18th to May 21st for a total of 23 nets nights. Six minnow seine hauls and three 600 second boom shocker electrofishing passes were performed on July 14th. During the 2009 survey, a total of 2,266 fish representing 30 species were caught; brown bullhead, rock bass and sand shiners comprised the largest portion of the catch while the game fish caught include yellow perch, northern pike, smallmouth bass, bluegill, walleye, largemouth bass and black crappie. Most species caught in the May netting survey showed above average growth when compared to Michigan averages. The July electroshocking and seining survey showed almost identical results as the May survey.

The fish community of Portage Lake has changed in the 33 years since it was first surveyed. Some of the variation observed in these surveys can be attributed to the weather at the time that the surveys were conducted, the month they were conducted in, and variations in the types of gear and amount of effort expended on various surveys. In the surveys conducted in 1976, 1999, and 2009 a total of 38 different species were captured; of those, eight species were caught only in the 1976 survey (trout perch, brown trout, cisco, lake whitefish, round whitefish, rainbow smelt, black bullhead, and quillback), two species were caught only in the 1999 survey (hybrid bluegill and greater redhorse), and seven species were caught only in the 2009 survey (freshwater drum, round goby, brook silversides, longnose gar, silver redhorse, logperch, and Johnny darter).

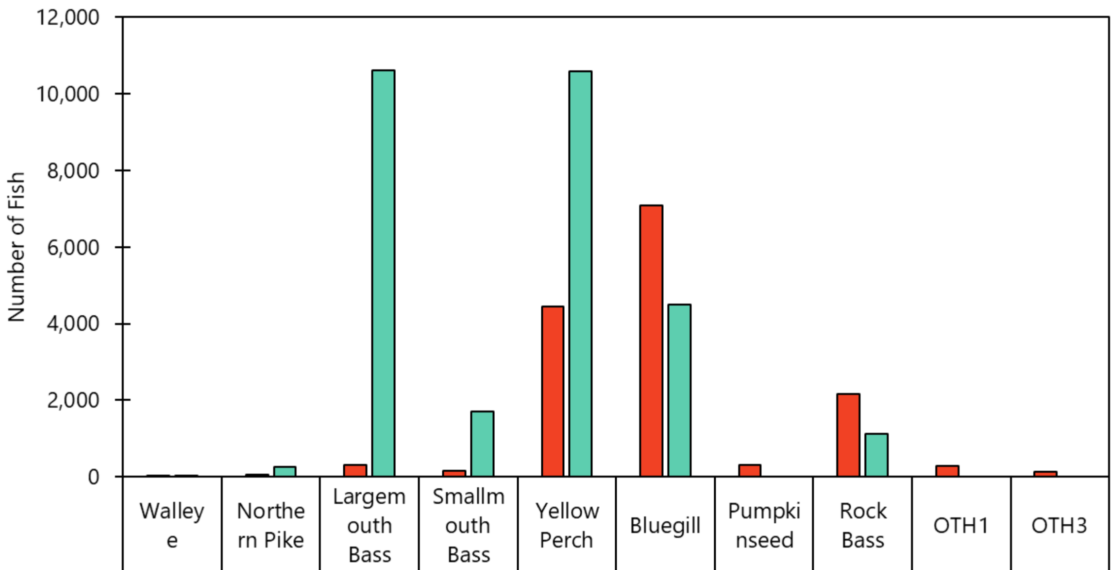
The 2009 MDNR fisheries netting survey showed Portage Lake has a healthy fish population. The overall fish population in Portage Lake is highly diverse and dominated by brown bullhead, rock bass, yellow perch and multiple species of shiners. Game fish species were well represented in this survey, and with the exception of yellow perch, all of the game species captured exhibited growth rates above the state average. Largemouth bass, smallmouth bass, and northern pike were well represented in this survey by number and by size. One surprising aspect of the 2009 survey was the decline in bluegill and pumpkinseed sunfish collected in comparison to the 1999 fisheries survey. The movement of species such as walleye, gizzard shad, freshwater drum and yellow perch from Lake Michigan provides for increased diversity and angling opportunity, as does the migratory movements of salmonids such as coho salmon and brown trout.

According to the MDNR 2009 report, the next fisheries survey of Portage Lake should be conducted within ten years using the same gear types as used in the 2009 survey, in order to make better comparisons and allow for meaningful analysis of trends in the fish community.

FISHERIES DIVISION OF THE MICHIGAN DEPARTMENT OF NATURAL RESOURCES SUMMER 2014 SURVEY REPORT

The following summary was prepared using information excerpted from the survey of the fisheries of Portage Lake, completed in 2014 and reported in the Survey Report for Portage Lake, Manistee County, Summer (2014) Report:

A survey was conducted and funded by the MDNR April 1st through October 31st of 2014 to survey the current fishery within Portage Lake and compare it to previous years' data. The species documented for catch, release, and harvest were walleye, northern pike, largemouth bass, smallmouth bass, yellow perch, bluegill, pumpkinseed, and rock bass. The method of collection was fishing from a boat, open ice, dock, and shore. **Figure 61** shows the results of this survey.



	Walleye	Northern Pike	Largemouth Bass	Smallmouth Bass	Yellow Perch	Bluegill	Pumpkinseed	Rock Bass	OTH1	OTH3
Number Harvested	15	51	322	149	4,437	7,097	306	2,173	294	121
Number Released	15	251	10,606	1,710	10,594	4,497	-	1,112	-	-

Figure 61. *Species harvested, released during April - October 2014*

SOURCE: MDNR, 2014.

Tributary Fisheries and Habitat

The MDNR fishery report also discussed a 1966 fish electroshocking survey of tributary streams conducted by the Fisheries Division of the Michigan Department of Conservation (now the MDNR) and a 1987 survey by W. Creel of the MDNR Surface Water Quality Division (now housed in the EGLE). The 1966 study indicated that the Dare, Glen, Hansen, McCormick, McGowan's and Schimke tributaries to Portage Lake were coldwater trout streams with brook trout and that brown trout were also present in Schimke Creek. Evidence in the 1987 survey of fish populations indicated that some limited Coho reproduction was occurring in McGowan's Creek. Based upon the presence of brook trout, it is expected that limited salmon and steelhead reproduction may occur in most of the larger tributaries to Portage Lake. Another study mentioned in the report, conducted in 1988 by B. Sayles of the MDNR Surface Water Quality Division, indicated alterations associated with the development of the Links of Portage Golf Course may have eliminated habitat that supported trout and salmon reproduction and recruitment in McGowan's Creek.

Biological integrity and physical habitat conditions of selected sections of McGowan's and Schimke Creeks were assessed by staff of the Surface Water Assessment Section of the EGLE Water Bureau in 2003 (MDEQ, 2007d). The macroinvertebrate community was sampled at two sites including Station 1 (McGowan's Creek and Portage Point Road), which was rated as "excellent," and Station 4 (Schimke Creek and M-22), rated as "acceptable." Habitat quality was assessed at four locations. Habitat quality for Station 1 (McGowan's Creek) scored in the "excellent" range while the three stations on Schimke Creek scored "good." Water chemistry samples were collected at five stations. Concentrations of ions and metals in McGowan's and Schimke Creeks typically varied from less than quantifiable levels to low concentrations. Low concentrations of nutrients were also present, with the exception of elevated concentrations of nitrate/nitrite/nitrogen, suggesting land use influences on water chemistry. According to the macroinvertebrate, habitat, and water chemistry results, water quality standards were being met at all stations sampled in both McGowan's and Schimke Creeks.

Surveys conducted periodically between 1967 and 2007 by the U.S. Fish and Wildlife Service for sea lamprey were consistent with the MDNR fishery resource report (2000) findings of brook and brown trout in Portage Lake tributaries, and neither adult nor larval sea lamprey were ever documented. Various United States Fish and Wildlife Service (USFWS) surveys note that good spawning gravel is present in Dare, Dunham, Hansen, McCormick, McGowan's and Schimke Creeks and that some spawning gravel is present in Erikson Creek (USFWS, 2007).

Smelt and many other non-salmonid[7] species from Lake Michigan and Portage Lake use the tributaries as spawning and nursery areas. The MDNR fishery resource report (2000) emphasizes that the protection of the aquatic habitats in Portage Lake tributaries is critical to (1) maintaining stream populations of brook trout, (2) the general health of the Portage Lake fisheries and (3) the stability of the nearby Lake Michigan ecosystem. The report also expresses concern that efforts to chemically treat aquatic weeds in Portage Lake and to "stabilize shorelines" could further limit littoral zone habitat essential to natural reproduction, growth and survival of existing fish populations.

The 2009 MDNR fisheries netting survey showed Portage Lake having a healthy fish population. The species abundance and diversity found in this lake was determined to be very similar to nearby drowned river mouth lakes such as Pere Marquette Lake in Mason County and Manistee Lake in Manistee County (MDNRE Fisheries Division, unpublished data).

[7] A family of soft-rayed fishes including the trouts, salmons, whitefishes, and graylings.

The 2009 survey emphasized on the long-term goals for Portage Lake which included:

- Maintaining the excellent warmwater and coldwater fish.
- Conserve remaining undeveloped riparian areas (i.e. wetland areas).
- Educating riparian owners in the best management practices for their property.
- Maintaining the nearshore areas, as they are an important habitat for the fish community and are crucial for maintaining the lake's water quality.

Fish and Sediment Contaminant Monitoring

Portage Lake fish were tested by the State of Michigan for a wide range of organic chemical and heavy metal contaminants in 1990 and again in 2004. Only polychlorinated biphenyls (PCBs) and mercury (Hg) were detected in fish from Portage Lake at levels of concern to human consumption. Between 1990 and 2004, PCB levels in fish from Portage Lake declined consistent with similar trends elsewhere in the state following controls on their use and disposal.

Based upon the most recent information, 2018 Eat Safe Fish Guide for Northwest Michigan, PCBs and mercury are the two chemicals of concern found in fish in Portage Lake. The recommended Michigan serving (approximately one ounce for every 20 lbs a person weights so for a 90 lb individual 1 serving = 4 ounces) per month varies by fish species and size, as shown in **Table 15**. For servings with a 2x by them, double the amount can be consumed if care is taken when choosing, cleaning, and cooking the fish. For fish species not listed and for Lake Michigan species, the publication provides statewide consumption advisories. For more information/ to view to full regional guide visit:https://www.michigan.gov/mdhhs/0,5885,7-339-71548_54783_54784_54785-301465--,00.html.

***Table 15**. Fish consumption servings for species caught in Portage Lake*

Type of Fish	Chemicals of Concern	Length of Fish (in inches)	MI Servings per Month
Carp	PCBs & Mercury	Under 24”	4
	PCBs	Over 24”	1 [2x]
Largemouth Bass	PCBs & Mercury	Under 18”	2
		Over 18”	1
Northern Pike	PCBs & Mercury	Under 30”	4
	Mercury	Over 30”	2
Smallmouth Bass	PCBs & Mercury	Under 18”	2
		Over 18”	1

SOURCE: MDHHS 2018.

NOTE: 2x indicates double the amount can be consumed if cleaned and cooked properly

Following the analyses of the 2004 fish contaminant monitoring results, the EGLE concluded that the sources of mercury and PCB contamination were due to either atmospheric deposition from sources outside of the Watershed or the result of Lake Michigan fish entering Portage Lake from other locations. The EGLE report recommended no further testing of contaminants in Portage Lake fish (MDEQ, 2007e).

Fish Diseases

Bacterial Kidney Disease (BKD)

This disease has shown to be ubiquitous in both Chinook and Coho salmon in Lake Michigan, but capable of infecting trout as well. There are seasonal effects upon the spread and presence of BKD. The highest number of infections is generally observed in the spring, specifically March and May. The rise in water temperature throughout July is thought to strengthen immune responses from fish, thus lowering infection rates. The Michigan DNR accuses this bacterial organism (*Renibacterium salmoninarum*) to be responsible for the deterioration of the Great Lakes salmonid fishery in the last decade. Since 1993, the Fisheries Division has actively screened all stocking specimens and removed those infected. This process expedites natural selection by forming a bottle neck that allows only those less susceptible to be released into the environment. Presence of BKD may be confirmed by off-white bacterial legions in the kidney. If the infection has been in place for an extended period, there may be a buildup of fluids within the body cavity and negative impacts on organ function. This is not transmittable to humans.

Figure 62. *BKD in a spring Chinook salmon*
Photo from USGS

Black Grubs

This parasite is more common in waterbodies containing a highly organic benthic environment. The disease begins when the parasite burrows into the skin of a victim. This nematode is spread by a complex lifecycle involving life forms that inhabit fish eating birds, snails, mammals and fish. It is in rare cases that these parasites cause an observable hinderance to fish survival. Consumption of fish infected is nothing but an aesthetic issue for it causes no changes to the taste or texture of the fillet.

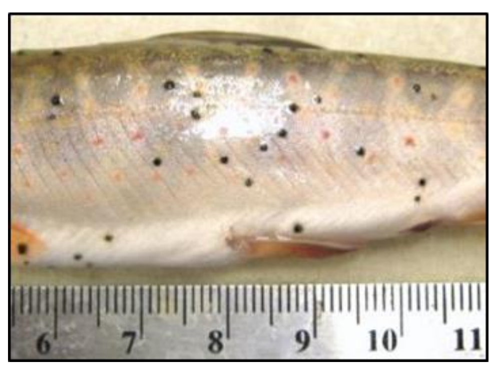


Figure 63. *Black grubs*
Photo from Fish Pathogens

TAIL ROT (PEDUNCLE DISEASE)

This infection is caused by an unidentified bacterium and is usually found in intensive culturing. Since there is occasional stocking of fish in Portage Lake, this disease may be present. The bacteria begin by degrading the adipose fin until it has rotten away. When the fin is completely gone, the degradation of flesh will continue down to the vertebrate. When progression exceeds the adipose fin, it is always fatal. Controlling the spread of Tail Rot is currently being focused in state hatcheries. Maintaining high grade water conditions and applying chemical treatments when needed is the best method to control its spread.

Figure 64. *Deteriorated fins due to tail rot*
Photo from MDNR

COLDWATER DISEASE

This bacterial infection is only present in young salmonids in cases where the water temperatures are 45° to 50°F. During the spring and fall months, Portage Lake will fall within this range and pose as a threat to coldwater fish. This disease is noted by legions present on the rear part of the fillet, or under the mouth between the gills. When temperatures exceed 50°F, the disease will generally begin to diminish. There are chemical treatments for this disease, but they are generally reserved for extreme cases. Since this temperature range is only temporary in Portage Lake, the natural cycle should keep this infestation in check.

Figure 65. *Legions caused by coldwater disease*
Photo from Western Regional Aquaculture Center

FUNGUS

Fungus is also often called "Water Mold". It is a common parasitic disease that can affect any species of fish. Fungus is most commonly found after the appearance of an injury or poor environmental conditions within a habitat. Fungus can be identified by cottony or fuzzy growths usually partnered with discolored areas or lesions. These types of infections can infect other fish within the infested rearing area if left untreated. Since Portage Lake maintains healthy water, fungus will likely not be prolific in this region.

Figure 66. *Fungus patches*
Photo from MDNR

Yellow Grub

The most common type of grub found in freshwater fish is said to infect many types of fish, it is said no fish is immune to it. These yellow worms must be eaten by birds such as herons and bitterns to develop fully. After hatching, the larva must find a snail, if not they will die within hours of hatching. After developing within the snail, a cercariae, they must then find a fish, again within a few hours or they will die. It is possible for the grub to kill a fish under some circumstances, but typically the fish is unaware of the grub's presence. These grubs are easily killed off during the cooking of a fish and will not affect humans.

Figure 67. *Yellow grubs*
Photo from Wisconsin DNR

Viral Hemorrhagic Septicemia

A recent exotic organism, viral hemorrhagic septicemia virus (VHSv), has already had an indirect impact on the fisheries of Portage Lake and deserves special note. VHSv causes viral hemorrhagic septicemia (VHS); this disease was confirmed in 2003 in muskellunge taken in Lake St. Clair. Since that time, it has been observed in coldwater and warmwater species in Lakes Ontario, Huron, Michigan and Erie and in connecting Great Lakes waters. VHS has also been documented in a few inland lakes in Michigan, New York, and Wisconsin.

Figure 68. *VHS clinical signs*
Photo by Mohamed Faisal, Michigan State University, 2007

While not a human pathogen, VHS has been associated with significant massive fish die-offs for a number of species in the Great Lakes region and elsewhere. Infected fish often exhibit hemorrhaging in the skin in large red patches, particularly on the sides and anterior portion of the head. The genetic fingerprint of the virus in the Great Lakes linked it to a variant previously seen in salmon in the Canadian Maritime provinces. It is believed that this virus was brought into the Great Lakes region through the discharge of ballast water from oceangoing freighters using the Great Lakes.

Because the presence of VHS is relatively new, very little information is available on species potentially affected, species that may serve as carries of the disease and how infections spread from one area to another. While extensive research is under way to answer questions about this new virus, the MDNR, along with similar fish management agencies in the Great Lakes, has adopted a precautionary approach to taking certain species from the wild for reproduction and hatchery facilities. Conversely, walleye stocking in Portage Lake was temporarily suspended pending the results of investigations of the presence of VHS to determine how the virus is transmitted and what steps can be taken in hatchery operations to prevent transmission (Whelan 2007).

AQUATIC PLANT AND ALGAL INVENTORIES

An increase in the abundance of rooted aquatic plants and algal blooms that interfere with water uses is often the first sign observed by boaters, anglers, and swimmers that a problem with over-enrichment may be occurring. In 1991, both algal and rooted aquatic plant growth were measured. In 2008, a survey was done of both native and invasive aquatic plants and emergent, invasive phragmites. Algae has not posed a problem in Portage Lake since 2008, however monitoring is still done to ensure that it does not become an issue.

Cladophora

In response to local concerns about potential water quality degradation in Portage Lake due to the increased use of septic systems around the lake, a preliminary plan was developed in 1976 to provide sanitary sewers in all or a portion of the area surrounding the lake. After reviewing the plan and its updates in 1981, the Northwest Regional Planning Commission expressed concerns echoed by local residents that the plan lacked documentation of pollution problems that would necessitate a perimeter sanitary sewer system and proposed a study subsequently implemented in 1983 with support from the USEPA.

The *1983 Water Quality of Portage Lake, A Shoreline Algal Survey* (NWRPDC 1983) focused on the use of *Cladophora,* filamentous green algae, as an indicator algal species in combination with models to evaluate phosphorus loadings and sources. Phosphorus was determined to be a limiting factor in the productivity of lakes in the area and excessive phosphorus loadings from septic systems or other sources could lead to eutrophication (an abundant accumulation of nutrients that support dense growth of algae and other organisms, the decay of which depletes waters of oxygen), and associated water quality problems. Based on work in other areas, *Cladophora* abundance in shoreline areas was used as an indicator of excessive phosphorus loading and potential pollution from shoreline septic systems.

The 1983 report concluded that sources of phosphorus related to septic tank/tile fields represented less than four percent of the total phosphorus loading to Portage Lake and that the total loading for the lake at the time of the study was below critical levels. Only one area on the shoreline was found to have excessive *Cladophora* growths attributable to the presence of septic leaching; the shoreline area adjacent to the Portage Point Inn. The septic failure has since been corrected, and a new study is needed in 2019. Phosphorus loading from runoff and atmospheric deposition were estimated to contribute more than 96 percent of the total phosphorus inputs to the lake. The report recommended periodic sampling to detect any changes that might occur in Portage Lake related to pollution from septic tank/tile field failures.

The Phase I study reported visual observations made of *Cladophora* in August of 1991 (SEG, 1993). The length of filament growth within one square foot was used to create a Cladophora Status Index (CSI). Of the 47 observations of *Cladophora* growth, 22 were attributed to possible human uses associated with lawn fertilization and septic systems. Seven of the observed sites with the highest CSI were clustered on the south side of the lake adjacent to high residential development and attributed to possible septic system drainage, the highest of which was in the lake at the Portage Point Inn site. The other 15 CSI sites associated with human activity were attributed to fertilizer use on riparian lawns and lakeshore disposal of lawn waste. All sites with a suspiciously high CSI were located on the south side and west end of Portage Lake where sanitary sewers were not available.

Rooted Aquatic Plant Survey

The Phase I Study of rooted aquatic plants (macrophytes) in Portage Lake identified six major zones where macrophyte growth was most extensive. The areas were mapped and correlated to a large extent to lake contour levels between ten and 15 feet. Macrophyte growth was highest in areas protected from wind and wave action with suitable organic, bottom substrate. According to the 2017 Portage Lake Management Plan, the dominant species present in the lake where identified as Muskgrass (*Chara*) and Wild Celery. These submerged plants reach covers of 37.72 percent and 38.70 percent of the littoral zone, respectively. Emergent native plants where dominated by Cattail and Bulrush reaching covers of 32.18 percent and 32.95 percent, respectively. Portage Lake has superb native plant diversity (15 native species) due to the successful abetment of exotic species. Phase I Study indicated that while the growth of these species was widespread, their abundance in 1991 did not appear to be impairing human activities on the lake (SEG, 1993). Continued monitoring and treatment of invasive species is proposed to continue, see **Portage Lake Watershed Monitoring Plan** for more details.

ENDANGERED, THREATENED, AND SPECIES OF CONCERN

Michigan's endangered and threatened species are protected under the Natural Resources and Environmental Protection Act, Public Act 451 of 1994. The Michigan Department of Natural Resources designates and maintains information on the status and location of threatened and endangered species. This work is coordinated by the Michigan Natural Features Inventory (MNFI), a part of Michigan State University Extension. Federally listed species are protected under the

Endangered Species Act of 1973. The U.S. Fish and Wildlife Service is the federal agency responsible for federally listed species in Michigan.

Endangered species are those species near extinction throughout all or a significant portion of their range. Threatened species are those species likely to become classified as endangered within the foreseeable future throughout all or a significant portion of their range. Species of concern are species that are extremely uncommon or have a unique or highly specific habitat requirement, whose status deserves careful monitoring. A species on the edge or periphery of its range that is not listed as threatened may be included in this category along with any species that was once threatened or endangered but now has an increasing or protected, stable population.

The MNFI data was reviewed for Manistee County, as it could not be specified for the Portage Lake Watershed; the data was then adjusted in scenarios where a species required habitat is not present in Portage Lake Watershed. According to the MNFI, federally, there are two species listed endangered (LE) and three species listed threatened (LT). On state lists, there are four species listed endangered (E), 14 species listed threatened (T) and 21 species listed as special concern (SC). **Table 16**, below, includes the species of plants and animals found within Manistee County that are state or federally listed as threatened or of special concern.

Table 16. *Manistee County threatened species and species of concern*

Scientific Name	Common Name	Federal Status	State Status
Charadrius melodus	Piping plover	LE	E
Lanius ludovicianus migrans	Migrant loggerhead shrike		E
Myotis sodalist	Indiana Bat	LE	E
Notropis anugenus	Pugnose shiner		E
Accipiter gentilis	Northern goshawk		SC
Ammodramus savannarum	Grasshopper sparrow		SC
Botaurus lentiginosus	American bittern		SC
Circus cyaneus	Northern harrier		SC
Cirsium hillii	Hill's thistle		SC
Cistothorus palustris	Marsh wren		SC
Emydoidea blandingii	Blanding's turtle		SC
Glyptemys insculpta	Wood turtle		SC
Haliaeetus leucocephalus	Bald eagle		SC
Lipocarpha micrantha	Dwarf-bulrush		SC
Microtus pinetorum	Woodland vole		SC

Table 16 cont. *Manistee County threatened species and species of concern*

Scientific Name	Common Name	Federal Status	State Status
Myotis lucifugus	Little brown bat		SC
Myotis septentrionalis	Northern long-eared bat	LT	SC
Notropis dorsalis	Bigmouth shiner		SC
Pandion haliaetus	Osprey		SC
Perimyotis subflavus	Eastern pipistrelle		SC
Pleurobema sintoxia	Round pigtoe		SC
Pomatiopsis cincinnatiensis	Brown walker		SC
Prunus umbellate	Alleghany/Sloe plum		SC
Sistrurus catenatus	Eastern massasauga	LT	SC
Terrapene carolina carolina	Eastern box turtle		SC
Acipenser fulvescens	Lake sturgeon		T
Buteo lineatus	Red-shouldered hawk		T
Cirsium pitcher	Pitcher's thistle	LT	T
Clemmys guttata	Spotted turtle		T
Coregonus artedi	Lake herring or Cisco		T
Cygnus buccinator	Trumpeter swan		T
Gavia immer	Common loon		T
Ixobrychus exilis	Least bittern		T
Orobanche fasciculata	Broomrape		T
Panax quinquefolius	Ginseng		T
Parkesia motacilla	Louisiana waterthrush		T
Setophaga cerulea	Cerulean warbler		T
Trimerotropis huroniana	Lake Huron locust		T
Zizania aquatica	Wild rice		T

SOURCE: MNFI-MSUE, Watershed Element Data for Watershed ID 4060104 20L 2.

Legend: SC – Special Concern, T – Threatened, E – Endangered, LE – Listed Endangered, LT – Listed Threatened

While the specific locations of these species are not publicly disclosed in order to protect the species, the MDNR uses the information to evaluate state or federal permits required for land or water uses. The threatened species and species of concern in Manistee County and their habitat requirements are described briefly in **APPENDIX B: ENDANGERED, THREATENED, AND SPECIES OF CONCERN DESCRIPTIONS**.

INVASIVE SPECIES

Aquatic Nuisance Organisms

Portage Lake is particularly vulnerable to the introduction of exotic species. The open channel to Lake Michigan allows any exotic species in the Great Lakes to eventually find its way into Portage Lake and establish a population if appropriate habitat exists. Because it is a destination harbor for many Great Lakes anglers, boats from throughout Michigan, and even nearby states, routinely launch in Portage Lake and, as a result, potentially transport to Portage Lake exotic species that have attached to their boats or trailers.

Four exotic species are of particular concern in Portage Lake due to their known presence and their potential impact on existing uses. All four, zebra mussels (*Dreissena polymorpha*), Eurasian milfoil (*Myriophyllum spicatum L.*), purple loosestrife (*Lythrum salicaria L.*) and non-native varieties of the common reed (*Phragmites australis),* are highly invasive and in other lakes have caused significant changes in fish and wildlife populations and other surface water uses. A few other aquatic invasive species found in Portage Lake are Curly-Leaf Pondweed (*Potamogeton crispus*), Narrow leaf cattails (*Typha angustifolia*) and Yellow Iris. A brief overview of these invaders is provided below.

Because of its direct access to the Great Lakes, Portage Lake is also vulnerable to other exotic, invasive species like quagga mussels (*Dreissena rostriformis bugensis*, similar to the zebra mussel) and round gobies (*Neogobius melanostomus*), along with several other exotic plant and animal species now found in Lake Michigan. However, the presence and abundance of these species in Portage Lake has not been documented, nor are their potential effects on inland lakes well understood.

EURASIAN WATERMILFOIL (*MYRIOPHYLLUM SPICATUM*)

Eurasian watermilfoil (*Myriophyllum spicatum*) was accidentally introduced to North America from Europe. Spread westward into inland lakes primarily by boats and also by water birds, it reached Midwestern states between the 1950s and 1980s. In nutrient-rich lakes it can form thick underwater stands of tangled stems and vast mats of vegetation at the water's surface. In shallow areas the plant can interfere with water recreation such as boating, fishing and swimming. The plant's floating canopy can also crowd out important native water plants.

Figure 69. *Eurasian watermilfoil*
Photo from Wisconsin DNR

A key factor in the plant's success is its ability to reproduce through stem fragmentation and underground runners. A single segment of stem and leaves can take root and form a new colony. Milfoil may become entangled in boat propellers and may wrap around other external parts of the boat. Stems can become lodged among any watercraft apparatus or sports equipment that moves through the water, including boat trailers. Fragments clinging to boats and trailers can spread the plant from lake to lake.

The mechanical clearing of weed beds for beaches, docks, and landings creates thousands of new stem fragments. Removing native vegetation creates perfect habitat for invading Eurasian watermilfoil. This plant has difficulty becoming established in lakes with healthy populations of native plants. In some lakes it appears to coexist with native flora and has little impact on fish and other aquatic animals. In some situations, physical removal of small areas of milfoil has been effective. Once it becomes well established, however, more aggressive chemical or biological controls may be the only effective means to reduce its abundance in order to restore impaired surface uses. Chemical control through the use of selective herbicides has been used in many Michigan lakes under permits from the EGLE. Concerns with the application of chemicals and the potential impacts on other aquatic organisms have pushed research into the use of a small aquatic weevil (*Euhrychiopsis lecontei*) that feeds directly on milfoil, causing subsequent bacterial infection that can kill the plant. The effectiveness of this type of biological control is still undergoing investigation (Minnesota Sea Grant, 2006). Current research has shown that milfoil populations change over time and as the genetics change, management techniques may need to be altered as well.

THE COMMON REED (*PHRAGMITES*)

While the common reed, *Phragmites*, is a plant native to Michigan, it is relatively uncommon. A European variant of this species, though, has become established in Michigan and elsewhere in the United States. This variety of reed is very aggressive and, like purple loosestrife, has spread to many wetlands in the Great Lakes and inland waters. The native and non-native variants are difficult to distinguish from one another.

Figure 70. *Phragmites*
Photo from EGLE

Phragmites plants range from six to 15 feet in height with nearly 80 percent of the plant mass contained in the root mass below ground up to six feet in depth. In the summer its flat gray-green leaves are two to 2.5 inches wide and eight to 15 inches long in an alternate pattern on the stem. It has distinctive purple-brown seed heads that appear in late July. These feathery plumes form at the end of the stalks and are up to 20 inches long. While each plant can produce up to 2,000 seeds each year, it normally spreads by rhizome fragments. Left unchecked, the aggressive variant of

Phragmites can spread rapidly, pushing out native wetlands species and reducing available fish and wildlife habitat in nearshore wetlands. The deep root system makes control of *Phragmites* difficult. Only chemical control has been successful, followed by cutting, mowing, and/or controlled burning. No biological control is currently available. The application of chemical control agents requires a state permit. Mowing and burning are likely to require state and/or local permits as well (MDEQ, 2007c).

YELLOW IRIS (IRIS PSEUDACORUS)

The Yellow Iris is a perennial aquatic herbaceous plant that grows two-three feet tall along shores in shallow water. The leaves are broad and flat with two-three deep yellow flowers per stalk. *Iris pseudacorus* is a fast-growing and fast-spreading invasive plant that can outcompete other wetland plants, forming almost impenetrable thickets, in much the same way as cattails (*Typha*) do.

Figure 71. *Yellow iris*
Photo from Jay Rendall, Minnesota DNR

PURPLE LOOSESTRIFE (*LYTHRUM SALICARIA L.*)

Purple loosestrife (*Lythrum salicaria L.*) is a plant native to Europe and was most likely introduced in North America from ballast materials used in ships during the early1800s. Viable seeds in the ballast deposited on the shoreline of eastern North America established the species on the Eastern Seaboard of the United States, where enterprising horticulturalists began distributing the plant for its flowers in perennial gardens. It eventually spread to 34 states by 1985 and is found throughout Michigan.

Figure 72. *Purple loosestrife*
Photo from USEPA Great Lakes National Program Office

Due to its aggressive growth in wetland ecosystems, purple loosestrife can quickly convert areas to virtual monocultures displacing native plant species and associated wildlife populations that depend upon diverse wetlands habitats. Because of the concerns related to this exotic species and its apparent increasing abundance throughout the state, Michigan has passed laws that prohibit the sale and distribution of this species.

Various means have been attempted to control the abundance of purple loosestrife, including hand pulling, periodic flooding, fire, chemical treatment, and biological controls. Because of the expense and habitat disruption associated with other control mechanisms, biological controls were researched resulting in United States Department of Agriculture (USDA) approval of three insects for introduction to control purple loosestrife. The MDNR began the first releases of leaf beetles and root weevils to control purple loosestrife in 1994 in Saginaw Bay. Since that time numerous locations in the state have received similar introductions and evaluations are under way to determine the effectiveness of biological controls of purple loosestrife (Michigan Sea Grant, 1997).

ZEBRA MUSSELS (DREISSENA POLYMORPHA)

Figure 73. *Zebra mussels*
Photo from Minnesota DNR

Zebra mussels were introduced to the Great Lakes and first observed in the mid-1980s in Lake St. Clair. They are a European mollusk most likely transported to North America in ballast water from transoceanic ships. By 2000, zebra mussels had spread throughout the Great Lakes basin, the Mississippi drainage, and many of the lakes and streams in the eastern United States. This species continues to move south and westward; it is now found in 20 states and two Canadian provinces, as it is easily transported on recreational boats and trailers that have been largely responsible for its wide distribution since the species was first observed in the Great Lakes.

In addition to serious water intake fouling, zebra mussels have caused significant ecosystem changes in the Great Lakes and in inland lakes where they have become abundant. Zebra mussels feed on phytoplankton (free-floating algae), and in massive numbers deplete this important food source of native invertebrate species, disrupting the flow of nutrient energy required to support forage and predator fish species higher in the food chain. Zebra mussel abundance has been so great in many areas that the clarity of the water has been noticeably increased by their removal of phytoplankton and rooted aquatic plant species have increased in abundance due to increased light penetration. Some of the increased clarity measured in Portage Lake beginning in 2003 may in fact be due to the invasion and colonization of this species. While zebra mussels are present in large number in Portage Lake, the impact of this species on resident fish populations is not known. Although some native species, and some exotic fish species introduced into the Great Lakes, have been found to feed on zebra mussels, the abundance of zebra mussels does not appear to be controlled by this predation. There are no effective means to control the abundance of zebra mussels once they become established in a lake system. Strategies to prevent their transport from one lake to another on boats and trailers have had only limited success. Recent information collected in Lake Michigan and elsewhere in the Great Lakes indicates that zebra mussels are being replaced in some areas by another invasive aquatic mollusk, the quagga mussel, which is similar in size and shape to the zebra mussel. Adults of both species are between one quarter and one-half inch long and have D-shaped shells. These are the only freshwater mussels that can attach to objects (Wisconsin Sea Grant 2005).

CURLY- LEAF PONDWEED (*POTAMOGETON CRISPUS*)

Figure 74. *Curly-leaf pondweed*
Photo from Michigan Invasive Species

Curly-leaf pondweed is a rooted, submersed aquatic plant. Its coloration varies from olive-green to reddish-brown. Curly-leaf pondweed is native to Eurasia, Africa, and Australia. It was likely introduced when common carp were intentionally introduced into Midwest waters as a game fish in the 1880s. The species was likely spread through the movement of watercraft and water-related equipment. It was first noted in Minnesota around 1910. Curly-leaf pondweed generally grows from the shore to water depths of 15 feet and can grow up to 15 feet tall. It tolerates low water clarity and will readily invade disturbed areas. Curly-leaf can be distinguished from native pondweeds by its unique life cycle. Turions sprout in the fall, and it is generally the first pondweed to come up in the spring. It typically flowers, fruits, and produces turions in June before dying back in mid-summer. Management of invasive aquatic plants involving either mechanical removal of plants or application of herbicides to public waters requires a permit from the DNR.

NARROW LEAF CATTAILS (*TYPHA ANGUSTIFOLIA*)

Figure 75. *Narrow leaf cattails*
Photo from ArcheWild

Scientists are not yet sure whether narrow-leaf cattail was introduced from Europe, or whether it was already present in the US along the Eastern seaboard, from which it would have moved westward with European settlers along newly developed corridors like railroads and roadways. It was first recorded in Michigan in 1837. Narrow-leaf cattail's leaves are about ½ inch wide, roughly half the width of the native broadleaf cattail (*Typha latifolia*). There is also a gap of one to three inches between the male and female flowering parts.

<u>*Terrestrial*</u>

The following terrestrial species have been identified as invasive to the Portage Lake Watershed: Autumn Olive, Oriental Bittersweet, Glossy Buckthorn, Periwinkle, Black Locust Honeysuckle, *Phragmites*, Japanese Barberry, Purple Loosestrife, Japanese Knotweed, Reed Canary Grass, Cow Vetch, Spotted Knapweed, Crown Vetch, Leafy Spurge, White Sweet Clover, Cypress Spurge, Motherwort, Wild Parsnip, European Swamp Thistle, Mullein, Forget Me Nots, Multiflora Rose, Garlic Mustard and the Yellow Iris. It should be noted that the above inventory is based on public reports and targeted areas surveys by the Northwest Michigan Invasive Species Information Network. Of the identified terrestrial invasive species, the following have been determined a significant concern with a brief description of each below: *Phragmites* (description included above), Japanese Knotweed, Garlic Mustard, Yellow Iris (description included above) and Japanese Barberry.

GARLIC MUSTARD (ALLIARIA PETIOLATA)

Garlic mustard was likely introduced to North America for medicinal and herbal uses as well as erosion control. It was first recorded in 1868 at Long Island, NY. It is an herbaceous, flowering plant that smells like garlic when crushed with heart-shaped leaves and white flowers which bloom in the early spring. Garlic mustard thrives in wooded areas and can tolerate deep shade, partly because it emerges and blooms before trees develop leaves in spring. This invasive species produces allelopathic compounds that can limit seed germination in other species. Garlic mustard within the Portage Lake Watershed is hand pulled as the method of control.

Figure 76. *Garlic mustard*
Photo from Michigan Invasive Species, State of Michigan

JAPANESE KNOTWEED (*FALLOPIA JAPONICA*)

Japanese knotweed is a perennial, herbaceous shrub that can grow from three-ten feet high with hollow stalks and stems with a fine white coating. Their flowers are arranged in spikes near the end of the stem are small, numerous and creamy white in color. Japanese knotweed can be found along roadsides, wetlands, wet depression, woodland edges, and stream or riverbanks. Full sun conditions are preferable, although this plant can tolerate some shade and a wide range of soil and moisture conditions.

Figure 77. *Japanese knotweed*
Photo from Michigan Invasive Species, State of Michigan.

JAPANESE BARBERRY (*BERBERIS THUNBERGII*)

The Japanese Barberry is a spiny, deciduous shrub that is usually one-two feet but can grow up to six feet in height with small, oval green leaves with smooth edges. It has small, pale yellow flowers with six petals that hang from stems. The Japanese Barberry has fruits that are small, bright red, egg-shaped berries that persist into the winter. They tolerate a wide range of soils and moisture conditions and can thrive in the sun or the shade. Japanese Barberry is often found in forests, pastures and old fields and along woodland edges, roadsides and disturbed areas.

Figure 78. *Japanese barberry*
Photo from Michigan Invasive Species, State of Michigan

RECREATION

Portage Lake is very popular for fishing, sailing, cruising, water skiing, and swimming. The watershed is also located at the beginning of the M-22 Scenic Drive. Its Great Lakes access and protected harbor provide the opportunity for larger recreational boat owners to sail, cruise, or fish in the Great Lakes. Several Great Lakes salmon and trout charter-fishing businesses operate from a base on Portage Lake. There are two public boat launch sites on the lake, shown below in **Figure 79**; one is operated by the state and one by the Village of Onekama. During peak fishing periods in the fall, the launch facilities are used to capacity. A large number of permanent and seasonal residences on and near the lake dock or moor their fishing and recreation boats on the lake during the open water season. In the winter months the lake supports an intensive ice fishery for a variety of species. The boat launch areas are used as winter access to the lake by the public.

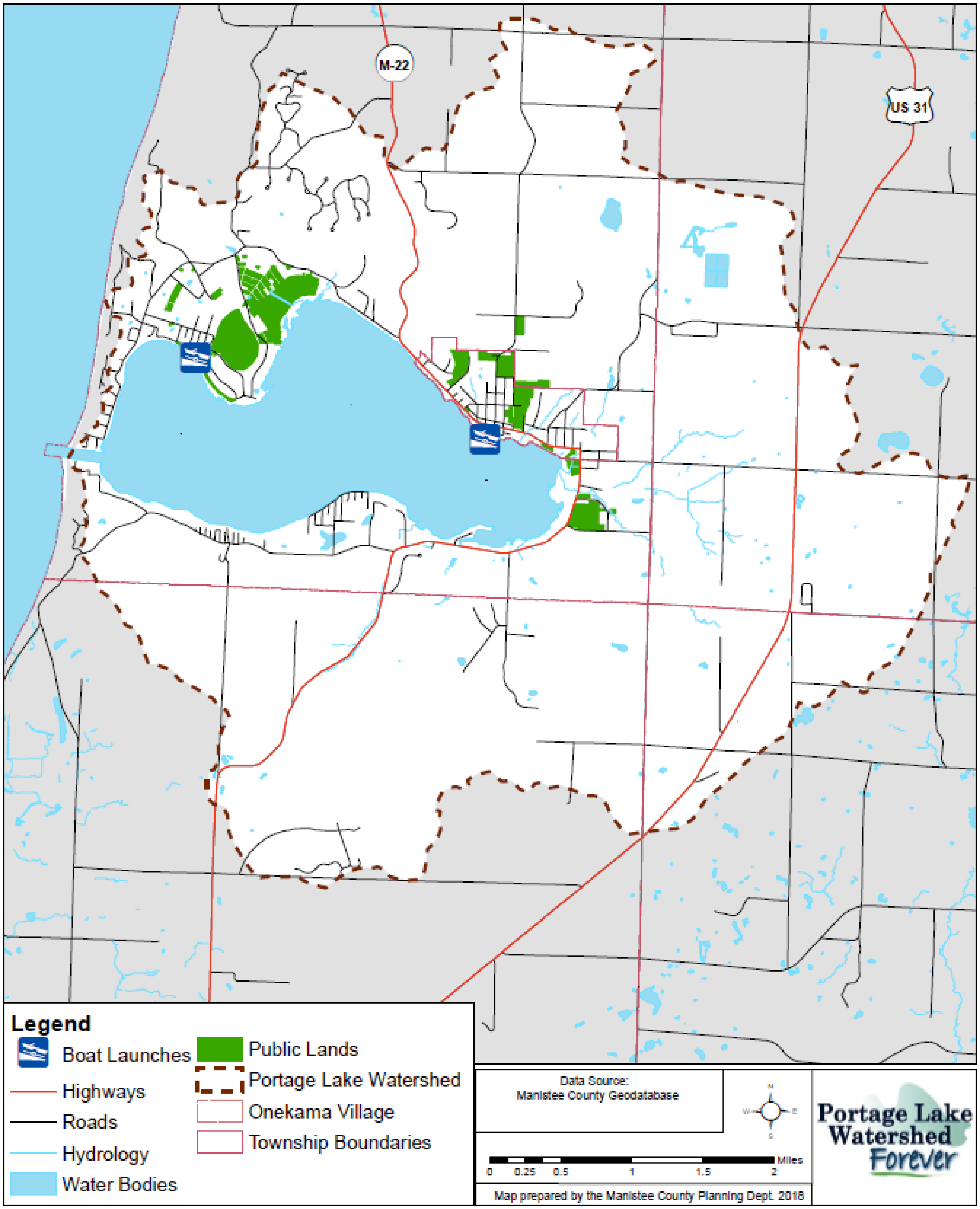


Figure 79. *Portage Lake Watershed public lands & public boat access*

SOURCE: Manistee County Geodatabase. Map prepared by the Manistee County Planning Dept. 2018.

DEMOGRAPHICS

Because the Portage Lake Watershed boundary does not directly correspond to established census boundaries, it is difficult to analyze demographic characteristics of the population situated within the Watershed boundary. Geographic Information System (GIS) software and data from the 2000 and 2010 U.S. Census (U.S. Census Bureau, 2010) were used to develop approximate boundaries to allow for estimated demographic information. This was done by inputting the Watershed boundary into ArcMap GIS software and then comparing it to the Census 2000 and 2010 block boundaries. Census blocks within the Watershed boundary or immediately bordering the watershed boundary were isolated and demographic information was gathered based on this boundary.

Table 17, below, reveals the demographic information for the watershed using this approach. The approximate population of the Portage Lake Watershed according to the 2010 Census Data is 1,791, with the most densely populated areas around Portage Lake, see **Figure 80**. This approximate population of the Watershed is a decrease from 2000 Census Data population of 2,059. Of the 2000 Census Data population, 449 people (22%) were over 65 years of age. There were approximately 1,351 housing units reported in the 2000 Census Data: 809 occupied housing units and 542 vacant units (among the vacant units, 474 were classified for occasional, seasonal, or recreational use). There are approximately 1,478 total housing units as reported in the 2010 Census Data Bureau, an increase from the 2000 Census. There were 809 households in the Watershed reported in the 2000 Census Data.

Table 17. *2000 & 2010 Demographic information for Portage Lake Watershed*

Characteristic	2000 Census	2010 Census
Population	2,059	1,791
Population over 65 years of age	449	Not available
Total housing units	1,351	1,478
Occupied housing units	809	Not available
Vacant housing units (not seasonal)	68	Not available
Seasonal housing units	474	Not available
Number of households	809	Not available

SOURCE: U.S. Census Bureau, 2000 and 2010.

To get a sense for demographic trends in the Watershed, the indicators mentioned above were compared from 1990 to 2000 to 2010. Unfortunately, census block data was not available for certain demographic characteristics in the 2000 census and 2010 census and was not available for any demographic characteristics in the 1990 census. Therefore, the census-friendly geographic boundary of Onekama Township (including the Village of Onekama) was used to determine trend information. This area comprises much of the most densely populated areas of the Watershed as shown in **Figure 81**.

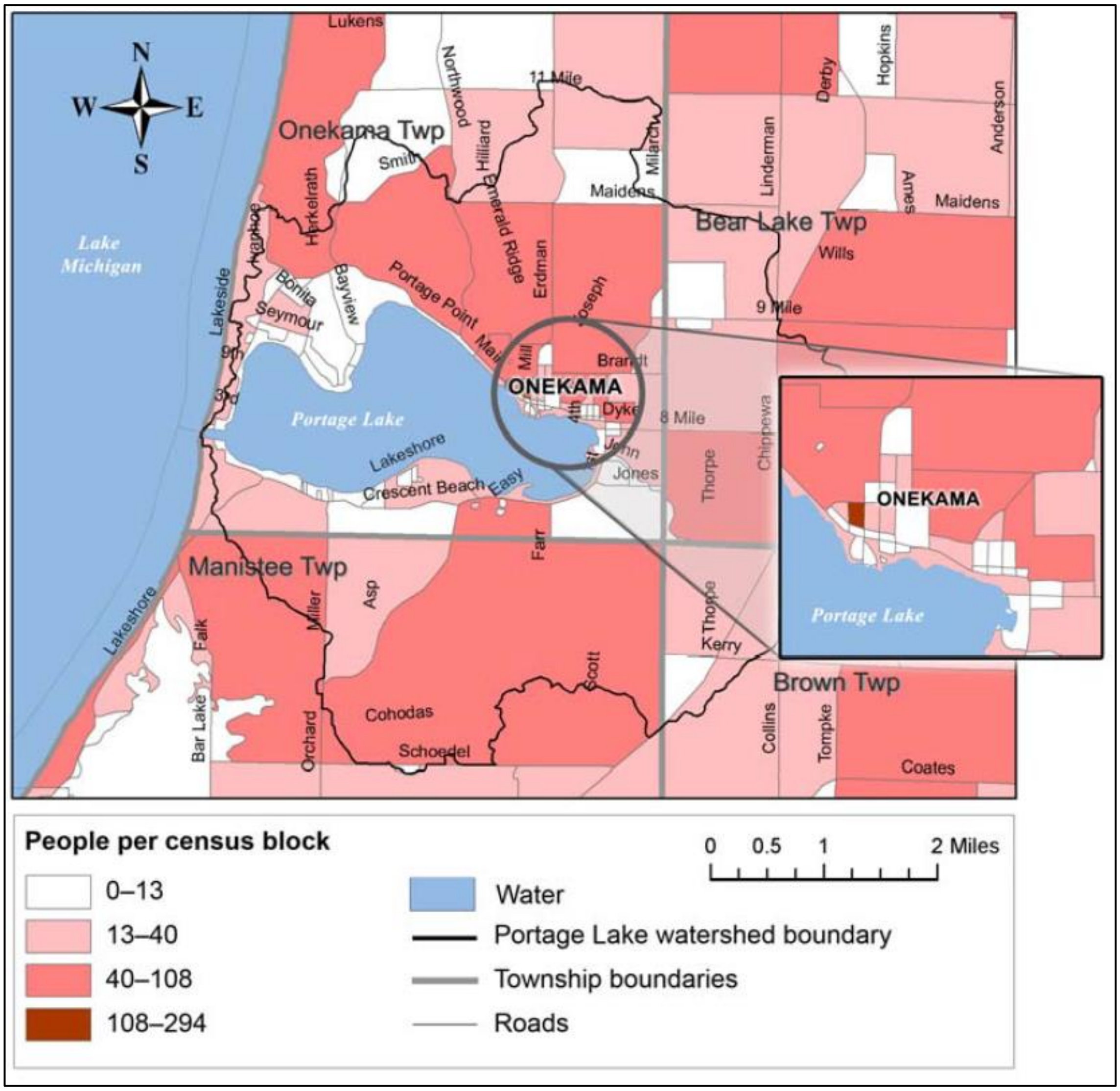


Figure 80. *Population density (people per census block group) for Portage Lake Watershed and surrounding areas, 2000*

SOURCE: Public Sector Consultants Inc., 2007, using data from U.S. Census Bureau, 2000 (TIGER/Line data (Manistee County, Michigan).

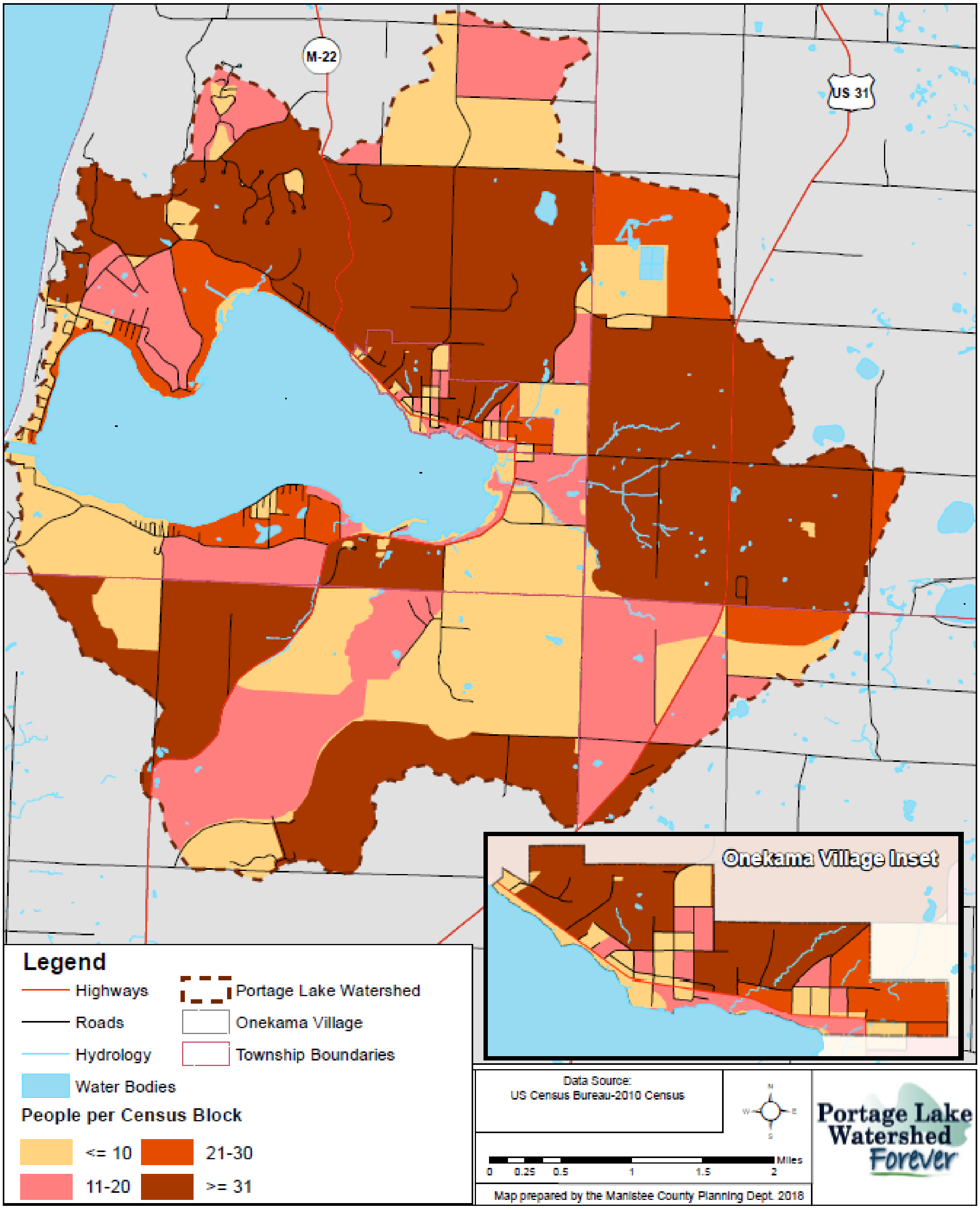


Figure 81. *Population density (people per census block group) for Portage Lake Watershed, 2010*

SOURCE: US Census Bureau-2010 Census. Map prepared by the Manistee County Planning Dept. 2018.

Between 1990 and 2000, the population in Manistee County increased by 3,262 to a total of 24,527 based upon U.S. Census information. This represents a growth rate of 15.3 percent during this ten-year period, more than double the state's growth rate of 6.9 percent during the same period. Between 2000 and 2010, the population in Manistee County increased by 206 to a total of 24,733 based upon the U.S. Census information. This represents a growth rate of only 0.8 percent during this ten-year period.

Table 18, below, illustrates the significant changes that occurred in Onekama Township between 1990 and 2000 and 2000 and 2010. The total population of the Township increased by nearly 20 percent within the 1990 to 2000 timeframe, and the number of residents 65 years of age and older increased by 25.3 percent. This population growth rate is slightly greater than growth in Manistee County and much greater than the state increase. During the timeframe of 2000 to 2010, the total population decreased by 12 percent and the number of residents 65 years of age and older increased by 8.5 percent.

The total number of housing units in the township increased slightly between 1990 to 2000, as did the number of seasonal housing units. Although this represented only a 2.9 percent increase in total housing units over the ten-year period, there was a 58.9 percent decrease over the ten years in the number of vacant housing units. The average household size for both owner occupied, and rental housing decreased slightly. During the timeframe of 2000-2010, the total number of housing units in the township increased 15.4 percent with a dramatic increase from 46 *vacant* housing units in 2000 to 103 units in 2010. Also, during the timeframe of 2000 to 2010, the average household size for both owner occupied, and rental housing decreased.

The proportion of seasonal housing units in the township is very high and represented approximately 42 and 43 percent of all housing units in 2000 and 2010, respectively. This is consistent with the outstanding quality of the area's water and related outdoor summer activities. It is likely that in the period from Memorial Day through Labor Day of each year the number of people living in the township, and in the Watershed, increases significantly. During peak summer weekends the overnight population in the Watershed is likely to be two to three times that of the permanent winter population.

Economic indicators in the township are remarkable. Median and per capita income nearly doubled from 1990 to 2000 while the number of impoverished families decreased by 19.4 percent. During the timeframe of 2000 to 2010, median family income increased 12.3 percent, per capita income increased 49.2 percent and the number of impoverished families decreased by 64 percent.

Table 18. *Demographic information for Onekama Township (including the Village of Onekama), Manistee County, 1990, 2000, and 2010*

Characteristic	1990 Census	2000 Census	1990-2000 % Increase/ Decrease	2010 Census	2000-2010 % Increase/Decrease
Population	1,266	1,514	19.6	1,329	-12.2
Population over 65 years of age	292	366	25.3	397	8.5
Total housing units	1,086	1,117	2.9	1,289	15.4
Occupied housing units	519	603	16.2	634	5.1
Vacant housing units (not seasonal)	112	46	-58.9	103	123.9
Seasonal housing units	455	468	2.9	552	17.9
Average household size (owner occupied)	2.4	2.3	-4.2	2.1	-7.8
Average household size (renters)	2.3	2.1	-8.7	1.9	-8.6
Median family income	$26,406	$51,042	93.3	$57,344[1]; $64,583[2]	12.3[1]; 26.5[2]
Per capita income	$10,601	$20,919	97.3	$31,208[1]; $29,522[2]	49.2[1]; 41.1[2]
Families below poverty level	31	25	-19.4	9[1]; 25[2]	-64.0[1]; 0.0[2]

SOURCE: U.S. Census Bureau, 1990, 2000 and 2010.

[1] *U.S. Census Bureau, 2006-2010 American Community Survey,*

[2] *2012-2016 American Community Survey 5-Year Estimates*

CHAPTER 4: IMPACT OF THE 2008 WATERSHED MANAGEMENT PLAN

The Portage Lake Watershed Forever Watershed Management Plan is truly a community-driven effort, as evidenced by the number and diversity of stakeholders that have been engaged throughout the 12-year process. Beginning in 2006, more than 50 individuals, organizations, agencies, and businesses signed the *Portage Lake Watershed Forever Partnership Agreement*. This agreement contained principles to guide the original Watershed Management Plan published in 2008, as well as expected outcomes of the process.

The 2008 Watershed Management Plan's lifespan was ten years. During the last decade, the plan provided the framework that outlined community actions necessary for the attainment of plan goals and objectives. The annual fund serves to provide funds for operating expenses and the wetland fund was established as a special fund for wetlands preservation. Plan implementation costs have exceeded $1.3 million since 2008, which includes staff and volunteer time. Listed below are the goals from the 2008 plan, amount spent on each (excluding the cost of staff/ volunteer time), and the actions that were taken in order to reach each of the five goals within the last ten years. Many of these projects will remain implemented for the next 10 years in order to keep meeting plan goals and preserving the Portage Lake Watershed.

GOALS FROM 2008 PORTAGE LAKE WATERSHED FOREVER PLAN

- **Goal 1 – Public Health ($139,000):** Ensure that participants in the water-based recreation are not exposed to pathogens or toxic chemicals, and are not consuming water, wild fish, or wildlife with contaminants in excess of advisories.
- **Goal 2 – Aquatic Ecosystem ($694,000):** Protect the quality of water resources in the Portage Lake Watershed, as well as other essential habitats, to maintain the integrity and functions of the aquatic ecosystem.
- **Goal 3 – Water-Based Recreation ($20,000):** Protect and enhance the quality of and access to water-based recreational opportunities within the Portage Lake Watershed for people of all ages and abilities.
- **Goal 4 – Natural Resource and Cultural Assets ($40,000):** Invest in protection and enhancement of land-based natural resources and related cultural assets that provide recreational and educational benefits unique to the Watershed and contribute to the quality of life and economic well-being of local residents while expanding the vacation experience of visitors.

- **Goal 5 – Local Management and Implementation Institutions ($90,000):** Establish mechanisms to provide sustained local leadership, community engagement, and fundraising needed to assure implementation and updating of the Portage Lake Watershed Forever Plan.

GOAL ONE – PUBLIC HEALTH

Ensure that participants in water-based recreation are not exposed to pathogens or toxic chemicals, and are not consuming water, wild fish, or wildlife with contaminants in excess of advisories.

Escherichia coli (E. coli) Monitoring (2008 – Present)

E. coli is a species of bacteria found in the gut of mammals and birds that is an indicator of fecal contamination in waterways. While *E. coli* itself typically does not cause illness, its presence at elevated levels is indicative that other pathogens that can cause illness are present.

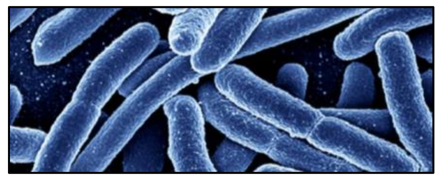


Figure 82. *E. coli bacteria under scanning electron microscope*
Photo from BBC, 2011

As part of its annual lake management plans, *E. coli* monitoring has been conducted for the last ten years to ensure that Portage Lake and its tributary streams do not pose a health risk to area recreationalists. Additionally, weekly testing at the Village Park and Langland Park during peak swimming times has been conducted by the Village of Onekama and District Health Department #10 and is frequently updated on the Department of Environment, Great Lakes, and Energy's (EGLE) BeachGuard website. Beginning in spring 2018, the Portage Lake Watershed Forever (PLWF) committee worked with Onekama Township and District Health Department #10 to expand *E. coli* sampling to ten sites around the lake. In the last decade, two creeks had instances of elevated levels of *E. coli,* which could be attributed to a variety of causes, including wildlife, failing septic systems, and illicit connections of sanitary sewer to surface water. Currently, follow up work on both streams is being done to locate the source of *E. coli*.

Septic System Point-of-Sale Ordinance (2010 – Present)

The PLWF committee played a significant role in the update to the District Health Department #10's Uniform Sanitary Code that was adopted in 2008. This includes the "Point-of-Sale Evaluation of On-site Water and Sewage Disposal Systems" chapter that was adopted by Manistee County. This section requires that a septic system is inspected during the time of sale of a property, thus failing septic systems may be addressed at this time. Without the point-of-sale inspection, failing systems would be more likely to be unaddressed. The PLWF committee supports the development of additional ordinances by Onekama Township for ongoing inspections and maintenance of a septic system after installation.

<u>Two Lakes Collaborative Sewer Initiative Project (2016 – Present)</u>

The Two Lakes Collaborative Sewer Initiative Project would create a collaborative sanitary sewer system between four area government entities, including Bear Lake Township, Onekama Township, Pleasanton Township, and the Village of Bear Lake. The wastewater generated by those serviced by the sewer would be processed in a wastewater treatment plant. Currently, many of the residences around Portage Lake rely on an on-site septic system to process wastewater. Over time, these systems fail, and have the potential to contaminate area waterways with bacteria, excess nutrients, and other contaminants. A sewer system would eliminate the need for septic systems, thus proactively preserving Portage Lake's high level of water quality. Additionally, the sewer system would allow for business development in areas that require municipal wastewater capacity. The PLWF committee supports the future expansion of a sanitary sewer around Portage Lake in order to protect water quality. At this time, an application has been submitted to the United States Department of Agriculture (USDA) and two proposals are being considered for the creation of a sewer system by the Township to connect with the existing village sewer.

***Figure 83**. Areas in Portage Lake watershed to be serviced by proposed sewer system (shown in hatched blue)*
Photo by Wade Trim, 2017

<u>Swimmer's Itch Study Involvement and Monitoring (2016)</u>

Swimmer's itch is an itchy rash caused by the infective cercaria stage of avian schistosomes, flatworm that parasitizes birds, primarily waterfowl. During the summer of 2016, an Oakland University research project was conducted on Portage and other area lakes to determine the risk for swimmers' itch and why some lakes have a higher risk than others. Ultimately, the study's results showed that Portage Lake is at a low risk for swimmer's itch, and currently does not have a problem. However, swimmer's itch is prevalent in several nearby lakes, and the PLWF committee's involvement in the Michigan Swimmer's Itch Partners (MISIP) steering committee will continue.

GOAL TWO – AQUATIC ECOSYSTEM

Protect the quality of water resources in the Portage Lake Watershed, as well as other essential habitats, to maintain the integrity and functions of the aquatic ecosystem.

Invasive Species Management (2009 – Present)

In 2009, Onekama Township passed a Special Assessment District (SAD) to fund a five-year program to control invasive species. At that time the Township appointed an Invasive Species Committee. Each year they are responsible for writing a monthly report to the Township board regarding the status of the treatment, surveys, costs, and available grants. Between 2009 and 2013, a total of 124 acres of *phragmites* and 540 acres of Eurasian watermilfoil (EWM) were treated. The *phragmites* are currently under control, and the EWM is being managed. The success of the first SAD triggered approval of a second, five-year SAD in the spring of 2014. In recent years, a hybrid form of invasive milfoil has become prominent on the lake. In response to this, a three-year study was conducted with Michigan Technological University to determine the most effective treatment for Portage Lake's specific hybrid milfoil. Based off a recommendation to the Onekama Township board, another SAD was passed in 2019 for a 10-year period to continue monitoring and controlling aquatic and emergent invasive plant species. The assessment will be based only upon the amount spent each year because of the unknown status of future invasive species treatments.

Figure 84. *Invasive species control on phragmites*
Photo from PLWF, 2018

Water Quality Data (2009 – Present)

Since 2009, a report defining the environmental status of Portage Lake and its tributaries has been published annually. Data collected in Portage Lake, its tributaries, and storm drains typically includes dissolved oxygen concentration, water temperature, phosphorus and nitrogen levels, *E. coli*, aquatic vegetative species populations, among other parameters. From these and other historical water quality reports, a "State of the Lake" report summarizing 39 years of Portage Lake water monitoring data and its trends was produced in 2013 by Dr. Herb Lenon, PhD Fisheries Biologist. When

Figure 85. *Old Faceful artesian spring, a*bundant groundwater recharges Portage Lake
Photo from PLWF, 2018

treatment of invasive species began in 2009, water quality monitoring was expanded to ensure that the treatment was not having a negative effect on water quality and the aquatic environment.

Shoreline Survey (2009)

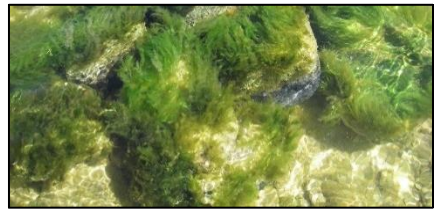


Figure 86. *Cladophora attached to rocks*
Photo by Kevin Wyatt, Lake Scientist 2014

Cladophora, a genus of green algae, is typically found growing and attached to sub-surface, solid substrate and is long, flowing, and green in appearance. Presence of *Cladophora* may indicate excess nutrients in surface water and may be used as rudimentary evidence of leaking septic fields contaminating nearby surface water. In 2009, 50 trained volunteers completed a *Cladophora* survey of the entire Portage Lake shoreline. The *Cladophora* survey was conducted once prior to 2009, and it is anticipated that the training and survey will repeat at least once every ten years. As with all types of monitoring, *Cladophora* monitoring helps to keep a pulse on the waterway's environmental quality and helps to prevent irreversible environmental degradation.

PLWF Wetland Committee (2012 – Present)

Figure 87. *Eagle View Wetland Preserve*
Photo from PLWF, 2018

The success of 2012 Wetland Purchase project and the awareness it raised in the community about the value of wetlands prompted the PLWF to form a Wetlands Committee. The committee has since developed a strategy to identify wetlands whose preservation and protection can be directly linked to safeguarding Portage Lake's environmental quality. Extensive maps of properties considered were provided by the Manistee County Planning Department. These wetlands have been, and continue to be, considered for purchase. Discussion with the Grand Traverse Regional Land Conservancy (GTRLC) provided advice on the various methods and process of acquiring land for conservation purposes. To further wetland conservation goals, a Wetlands Fund was established in 2012 at the Manistee County Conservation Foundation.

Wetland Purchase (2010-2012)

In 2010, Onekama Township purchased 196 wetland lots and a portion of Outlot 4 from the Michigan Department of Natural Resources in Sections 21 and 27, now known as

Portage Wetland Park. In the summer of 2012, the PLWF was able to raise over $40,000 to purchase 2.4 acres of wetland property with 342 feet of Portage Lake frontage to preserve the property. After purchase, the property was donated to Onekama Township with deed restrictions that ensure protection and preservation forever.

Riparian Overlay (2014)

The Onekama Township Planning Commission requested that the Watershed council review a sample riparian ordinance and make recommendations to the commission. There was no recommendation made as the committee did not agree on an ordinance. The riparian ordinance will again be discussed by the council and with the goal of presenting a riparian ordinance to recommend to the Planning Commission.

Figure 88. *View of Portage Lake and its wetlands from M-22 hilltop*
Photo from PLWF, 2018

Raingarden Installation (2016)

A raingarden is an engineered "best management practice" that collects stormwater runoff, slows down its flow, and uses native plants to remove any contamination it may be conveying before it reaches the lake. In 2016, PLWF received a grant from the Manistee County Community Foundation (MCCF) to build a community raingarden. Partnerships with the Portage Lake Garden Club (PLGC), Manistee Conservation District, and the Manistee County Planning Department helped to make this project possible. Following the installation of the raingarden, an educational program was held for the community by PLWF and the PLGC to provide information about the value of raingardens and how they protect the water quality of Portage Lake.

Figure 89. *Village of Onekama raingarden display*
Photo from PLWF, 2018

Boat Washing (2016 – Present)

Portage Lake has long been a destination for anglers from all over Michigan and their trailered boats pose the potential for introducing new aquatic invasive species to the water. Several times during the past three summers, PLWF has used portable boat washers from the Manistee County Planning Department and the Benzie Conservation District to wash boats, distribute educational materials, and alert anglers to the threat of invasives.

Shoreline Stewardship Program (2018)

Importance and impact of what riparians do to the shoreline has been promoted by various means, including outreach by Julie Kirkwood of EGLE. A program for the community was held in July of 2018 with the PLGC. The goal of this program is to promote natural shorelines and to recognize those people who maintain them.

Figure 90. *Michigan shoreland steward sign*
Photo from Michigan Shoreland Steward, 2018

GOAL THREE—WATER BASED RECREATION

Protect and enhance the quality of and access to water-based recreational opportunities within the Portage Lake Watershed for people of all ages and abilities.

Universal Access (2012 – 2019)

A grant from the Michigan Coastal Management Program permitted Onekama Township to receive funds from the Michigan Department of Natural Resources Trust Fund, total of $366,300. These funds were used to develop universally accessible facilities, trails, exhibits, signage, and landscaping at two to three community parks, the Onekama Village Park on Portage Lake, and John Langland Park on Lake Michigan. An additional grant was awarded in 2017 for a universally accessible kayak launch at the DNR boat launch on the northern shore of Portage Lake. Anticipated completion of the launch is 2020. Other grants for providing universal access to recreational areas have been applied for since.

Figure 91. *Plaque at John Langland Park*
Photo from Michigan Water Trails, 2018

Road Ends Study (Present)

Road ends that abut Portage Lake are commonly used as areas of recreation by local residents and visitors. Currently, they are being reviewed by Onekama Parks & Recreation Committee and are being considered for enhancement. These road ends are owned by Onekama Township, Onekama Village, and the Manistee County Road Commission; recreational enhancement to these areas would be coordinated with the respective entity.

GOAL FOUR – NATURAL RESOURCES AND CULTURAL ASSETS

Invest in protection and enhancement of land-based natural resources and related cultural assets that provide recreational and educational benefits unique to the Watershed and contribute to the quality of life and economic well-being of local residents while expanding the vacation experiences of visitors.

Historical Preservation within Watershed (2011 – Present)

The 1930 pierhead light from the south wall of the Portage Lake channel was restored and placed at the Michigan Department of Natural Resources (MDNR) boat launch in 2011. The project was a joint effort between the Harbor Commission, Onekama Township and the Onekama Parks and Recreation Committee and was supported by the PLWF.

Figure 92. *Recreation on Portage Lake, 1914*
Photo from PLWF, 2018

In 2015, Glen Park, located off 4th Avenue in Onekama, was designated as a Historical Site. The park is home to Glen Springs, a natural mineral water spring. In 1880, lumberman A.W. Farr purchased the site. A hotel was later constructed, where guests enjoyed the "healing powers" of the property's mineral water springs. The land was later deeded back to Onekama Township for public access and is now designated as a historic site and park.

The summer of 2018 saw the completion of a project to refurbish the 130-year-old cast iron fountain in the Village of Onekama Park. The fountain needed major structural work and improvements to the surrounding area in order to preserve and protect the feature for future generations to enjoy. In 2019 the process to have the fountain listed on the historical register will begin. The work was spearheaded by the Portage Lake Garden Club and supported by the PLWF.

Local and County-wide Trails (2016)

Through the collaborative efforts of 20 government entities, a county wide Parks and Recreation Plan was completed in 2016 and received official MDNR approval for parks and recreation plans. Additional trail plans within the Watershed include the development of a nature trail through the aforementioned PLWF-purchased wetlands parcel

Figure 93. *Trail at Glen Park*
Photo from PLWF, 2018

adjacent to the east end of Portage Lake (Eagles View).

Portage Lake Access Channel to Lake Michigan *(2017)*

The PLWF has been actively involved in enlisting necessary support to ensure the future stability of this waterway that is vital to the community. In 2017, a $6.6 million-dollar grant was awarded to the Portage Lake Harbor Commission by the U.S. Army Corps of Engineers. Funds have been, and continue to be, used for improvements to the harbor and access channel from Lake Michigan to Portage Lake. Once complete, the project will have improved the south wall of the channel, dredged the channel to the original dredge depth of 16 to 18 feet, installed a safety light on the north wall, and improved pedestrian access on both the north and south walls of the channel for recreational purposes.

Figure 94. *Portage Lake channel*
Photo from PLWF, 2018

GOAL FIVE – LOCAL MANAGEMENT AND IMPLEMENTATION INSTITUTIONS

Establish mechanisms to provide sustained local leadership, community engagement, and fundraising needed to assure implementation and updating of the Portage Lake Watershed Forever Plan.

Fiscal Sustainability (2006 – Present)

The earliest fund established by PLWF was the Endowment Fund in 2006 to provide a source of ongoing support to help reach Watershed goals. The PLWF's Annual Fund, established in 2008, covers yearly operating expenses and other projects, such as the 2018 Watershed Plan Update. The Wetland Fund, established in 2012, is intended specifically for the protection of wetlands. As of June 2018, the total dollar amount for the three funds was $234,316. Efforts to raise money to assure future progress is ongoing.

Fundraisers to Supplement Portage Lake Watershed Forever (2007 – Present)

Since 2007, the PLWF has held annual fundraisers. The funds raised from these events provide the Annual Fund operating expenses. In addition to raising money, the events serve as occasions to inform supporters about the status of various projects, elicit ideas and suggestions, build stewardship, and increase awareness about protecting the watershed. A unique fundraiser held in 2007 was the Fish out of Water Auction, where artists decorated large fish sculptures that were auctioned off in order to support the Portage Lake Watershed Forever Endowment Fund.

Collaboration with Local Organizations (2008 – Present)

Many PLWF projects have been made possible thanks to collaboration and partnership with various community groups. Several PLWF members provide representation on or are involved in these groups, including the Portage Lake Garden Club, Onekama Parks and Recreation, Onekama Planning Commission, Portage Lake Association, Harbor Commission, Manistee Conservation District, Plant It Wild, Northwest Michigan Invasive Species Information Network, Stewardship Network, Great Lake Clean Communities Network, Benzie Watershed Coalition, and GTRLC.

Grants Awarded (2013 – Present)

In order to fund projects within the watershed in the last decade, various grants were applied for and awarded. These grants include those from the following: Manistee County Community Foundation, Michigan Department of Natural Resources Trust Fund, Michigan Coastal Management Program, 100 Women Who Care, and Department of Environment, Great Lakes, and Energy's Stormwater Asset Management and Wastewater Grant for Onekama Township. Each of these grants has helped to improve the Watershed and ensure its preservation for many years to come.

Manistee Watersheds Partnership (2017 – Present)

Formed in 2017, the Manistee Watersheds Partnership is a collaboration among the Manistee Conservation District, local watershed groups, and other partners that aim to enhance area water resources. Local watershed groups involved include the Greater Bear Watershed, Bear Creek Watershed, Little Manistee Watershed Conservation Council, Arcadia-Pierport Watershed, and Portage Lake Watershed Forever. The group strives to encourage environmental stewardship and raise public awareness regarding water quality, holds quarterly meetings, and publishes the annual newsletter "Water Wise."

Figure 95. *Fish Out of Water event, 2007*

Photo from PLWF, 2018

INFORMATION AND EDUCATION

In the 2008 Portage Lake Watershed Management Plan, information and education goals and objectives were folded into the five main goals previously listed. New to the 2018 plan is a separate goal for information and education, Goal Six. In order to maintain consistency between the two plans, the education and outreach actions completed between 2008 and 2018 are listed below.

Program Presentations (2008 – Present)

There have been numerous programs presented to the community with common themes of water quality, watershed preservation, invasive species, and environmental health. Audience and presentation style have varied depending on the event. Listed below are various educational events coordinated and presented by the PLWF:

- *H_2O Expo* – Full day of scheduled presentations and exhibits held at the Village Park.
- *Tuesdays with Water* – The event, which took place in 2014, was a well-attended, six-week series featuring various topics related to water quality and stewardship.
- *Water Wise* – Similar to Tuesdays with Water, Water Wise took place in 2015, and provided a series of educational forums presented by staff from the MDNR, EGLE, Fisheries, District Health Department #10, and others.
- *Invasive Species Star Wars Play* – Play developed and presented to several clubs, which provided valuable information on invasive species.

Figure 96. *Star Wars themed invasive species play*
PLWF, 2018

- *Protecting and Preserving our Shoreline* – EGLE presenter in July of 2018 for a community program on the Shoreline Stewardship program**.**
- *Raingarden Presentation* – Presentation to the community and at the garden expo explaining their purpose, importance, and design.

Onekama Schools Educational Programs (2008 – Present)

In cooperation with Onekama Public Schools, the PLWF has provided a variety of unique educational opportunities to students that help to spark environmental stewardship. Programs within the last decade include:

- *Salmon in the Classroom* – Funds were granted to Onekama School's third grade classroom to purchase equipment, raise, and ultimately release salmon.
- *Sooper Yooper Program* – The author and illustrator of the book travel across the Great Lakes Region telling Billy's story and educate students on the importance of preserving natural resources. The program also has a state-wide environmental art competition component where students submit their work and have an opportunity to win a prize.
- *What is a Watershed? Program* – Program PowerPoint presentation to the community.
- *Water Pledge Cards* – Water Pledge Cards are signed by students, watershed buttons and bags are distributed, and each student is given a tree to plant after the program.

<u>*Community Outreach Programs (2008 – Present)*</u>

Various programs have been introduced to the community during the last decade. Listed below are some of the programs and community events that took place:

- *Citizen Scientists* – Programs designed to engage local participation in Watershed activities.
- *Only Rain Down the Drain (2015)* – Labeling of area storm drains with signage that reads "Only Rain Down the Drain." The program is intended to prevent disposal of pollutants into drains, and to raise awareness that whatever is put into a storm drain will go directly into a river, stream, or lake.

Figure 97. *Storm drain example signage*
Photo from Only Rain Down the Drain, 2018

- *Crowd Hydrology (2013 – Present)* – Project informs area residents and visitors on how to use smartphones to monitor water levels in five Portage Lake tributary streams, including Stream #4, Onekama Creek, Stream #7, Schimke Creek, and Hansen Creek. Measurements are used to create a historical record of the streams. Beginning in 2018, the Watershed is starting a program with the University of Buffalo and the USGS to gather data on 5 area streams. Monitoring stations are to have signage to inform individuals what the stations are.
- *ciBioBase (2014 – 2015)* – The PLWF purchased equipment that allowed volunteers to survey and produce detailed aquatic plant density maps of Portage Lake. The data is GPS-referenced. Two years of survey, 2014 and 2015, were completed with this equipment.

- *Midwest Invasive Species Information Network (MISIN) Smartphone App* – MISIN has developed a smartphone app that allows for the identification and reporting of 300+ invasive plant and animal species, and the capture and submittal of invasive species observation in the field. PLWF was supportive of utilization of this tool to help better control emerging and existing invasive species in the Watershed.
- *Shoreline Stewardship Program* – Education and promotion for riparians to rate their shoreline.

<u>*Miscellaneous Outreach Endeavors (2008 – Present)*</u>

- *Homeowner's Packets* – Hand-delivered packets of watershed, water quality, and environmental information to all the homes in the Watershed.
- *Public Informational Displays* – Watershed information distributed and displayed at the Manistee County Fair, Lion's Club breakfasts and dinners, Onekama School, Portage Lake Garden Club, Onekama Days, Onekama Days parade, and Arbor Days.

Figure 98. *Display set up at the Manistee County fair, 2013*
Photo from PLWF, 2018

- *Watershed Website and Facebook Page Development (2014 – Present)* – In the last decade, PLWF has developed a Facebook page and website (portagelakewatershed.com). Both forms of media are utilized to share studies, events, workshops, projects, and other relevant information with area residents and visitors.
- *Newsletters (2008 – Present)* – A variety of newsletters are published and distributed. Newsletters include quarterly updates in the Portage Lake Association newsletter, Manistee Watersheds Partnership Annual Newsletter, a Spring Newsletter by the lake manager that is sent with taxes, and monthly reports to the Onekama Township Board.

Figure 99. *Parade float displaying information about aquatic invasive species*
Photo from PLWF, 2018

- *Newspaper Articles (2008 – Present)* – A variety of newspaper articles have been published exhibiting the activities, events, and projects that PLWF has been involved in in the last decade. These publications further educate the public about the Watershed and how to be an environmental steward.

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CHAPTER 5: PLAN DEVELOPMENT

2008 PLAN DEVELOPMENT

The Portage Lake Watershed Forever Plan began in 2006 as a local initiative by residents, public officials, nonprofit organizations, and business leaders aided by the Manistee County Community Foundation and Manistee Economic Development Office, all of whom recognize the importance of protecting and enhancing this natural resource for the future quality of life and economic well-being of the area. At the beginning of the planning process, more than 50 individuals, organizations, agencies, and businesses signed the Portage Lake Watershed Forever Partnership Agreement, which contained principles that helped guide the development as well as the expected outcomes of the plan. Using funds provided under a grant from the Michigan Department of Environment, Great Lakes, and Energy's Costal Management Program and local resources, the initial plan development began. The Portage Lake Watershed Forever Committee, its Executive Committee, and Steering Committee organizational structure and roles are shown below, **Figure 100**.

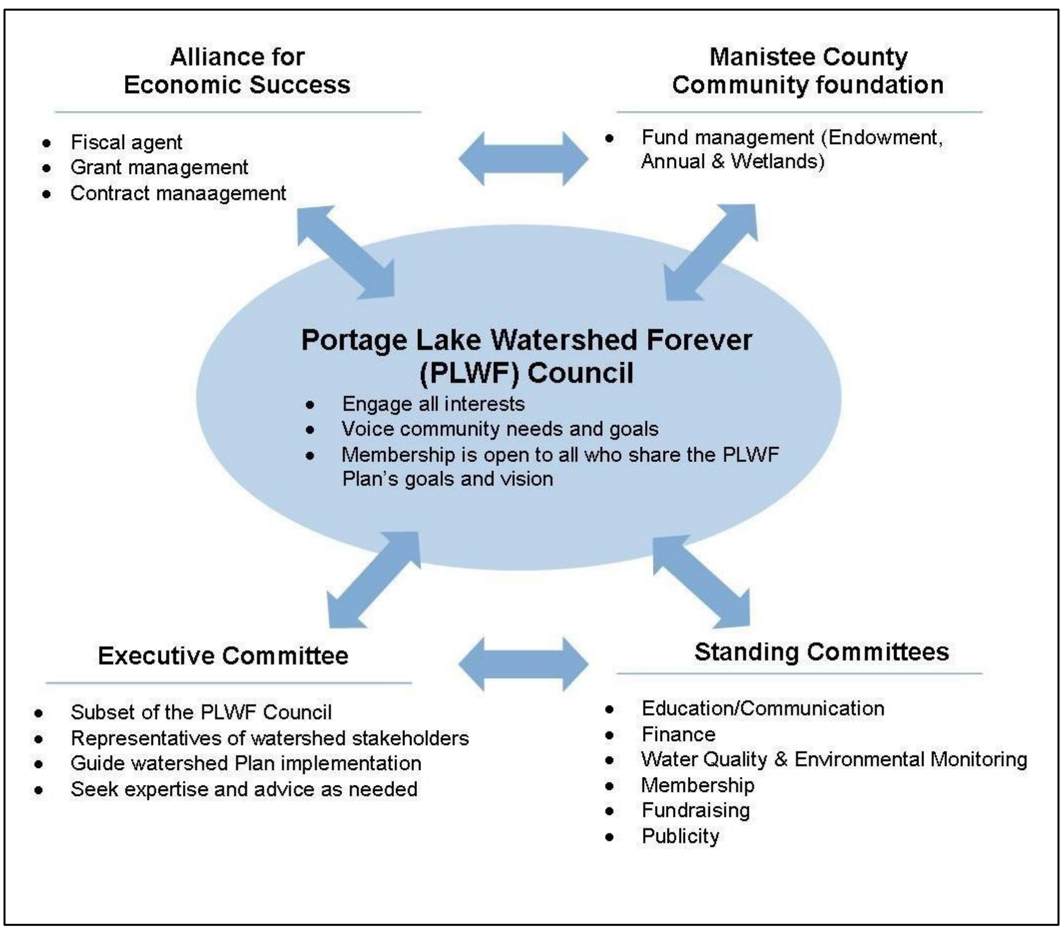

Figure 100. *Portage Lake Watershed Forever (PLWF) council organization*

In 2006, one of the first steps in the early development of the 2008 Watershed Management Plan involved identifying and convening stakeholders in the Watershed through community conversations. Stakeholders were defined as individuals, groups, agencies, and organizations that make and carry out decisions, are affected by decisions, or have the ability to impede or affect decisions that impact the Watershed. Their participation was considered critically important to ensure the development of a community-driven Watershed Management Plan (WMP) and local commitment toward achieving goals through implementation of the plan.

The purpose of the community conversations was to:

- Educate participants about the Watershed, the history, and status of the Portage Lake Watershed, the development of Watershed Management Plans and how a plan can benefit the local community.
- Solicit information from all interests about water quality concerns and desired uses to provide a foundation for the development of the Watershed Management Plan and gather qualitative information that would help inform the development of a watershed household survey.
- Build community ownership of and engagement in the plan.

Prior to the completion of the 2008 Watershed Management Plan, Public Sector Consultants engaged nearly 150 people through eight community conversations organized by stakeholder groups (see **Appendix C**, **Table 1**). These conversations were conducted between March and June of 2007. Additionally, a community forum aimed at engaging the general public was held in May of 2007. A series of eight questions were asked during each facilitated meeting and responses were recorded (see **Appendix C**, **Table 2**). The information collected through the community conversations, community forum, and additional stakeholder meetings provided a valuable foundation for the development of the first Portage Lake Watershed Management Plan with the guidance of Public Sector Consultants. In order to provide support for the 2008 plan and its long-term implementation, community citizens established a Portage Lake Watershed Forever Endowment Fund at the Manistee County Community Foundation *(www.manisteefoundation.org*).

PORTAGE LAKE WATERSHED FOREVER COUNCIL

The Watershed Bylaws were revised and approved by the council in December of 2015. There are now twelve council members who serve varying terms of office and meet monthly (with the exception of December). Elections are held each year at the annual meeting in November. Committee chairs are appointed and applications for membership are sent out annually. Members are encouraged to be active members and serve on one of the committees. Meetings for the

Executive Committee, Steering Committee, and Standing Committees are scheduled on an as needed basis. To date there are approximately 130 paid members of Portage Lake Watershed Forever. The funds received for membership costs along with any additional donations go into the PLWF annual fund that is used for yearly operating expenses along with other projects, including this 2018 Watershed Management Plan update.

Executive Committee

The Executive Committee is responsible for providing historical perspective, leadership, and project management for the development of the updated Portage Lake Watershed Forever Plan. Executive Committee members will also participate in the Steering Committee meetings and activities. The Executive Committee will:

- Create the timeline, process, and work plan for the project
- Determine levels of engagement and create committee descriptions
- Assemble the Steering Committee and Advisory Group
- Coordinate a review and analysis of existing Watershed conditions, including information and data that has been collected since 2008
- Create a Conditions Summary Document
- Create online surveys to solicit input from the public
- Manage meeting facilities, materials, and refreshments
- Manage project files
- Manage the consultant contract
- Submit the updated plan to the Department of Environment, Great Lakes, and Energy (EGLE) for approval

Steering Committee

The Steering Committee will provide guidance and perspective for the development of the updated Portage Lake Watershed Forever Management Plan. Steering Committee members will work closely with the Executive Committee, Advisory Group, and other stakeholders, and will likely form subcommittees with interest or expertise in specific parts of the WMP. The Steering Committee will help the Executive Committee:

- Host a community forum to energize the community for the WMP update and solicit feedback on Watershed conditions

- Analyze community input
- Update long-term goals to protect and restore designated and desired uses in the Watershed
- Update prioritization of pollutants, sources and causes to identify critical and priority areas
- Update measurable objectives and management measures
- Create an education and outreach plan
- Create a fund development plan
- Create an updated Watershed Management Plan
- Gather community feedback on the draft update
- Revise the updated plan

Advisory Group

The Advisory Group will support the work of the Steering Committee, providing expertise and guidance for specific portions of the Watershed Management Plan update. The Advisory Group will meet as needed to inform specific activities throughout the WMP update. There will not likely be meetings of the entire group, but there will be meetings with specific individuals from this group to answer questions or provide input. Advisory Group members will also be invited to attend other events if they are interested. This group is composed of a wide variety of individuals with backgrounds in local government, engineering, lake management, invasive species, conservation, parks & recreation, education, and local businesses.

PLWF Standing Committees

The Portage Lake Watershed Forever Standing Committees have areas of expertise related to the Watershed Management Plan update. Current Standing Committees include: Education & Communication, Finance, Membership, Water Quality & Environmental Monitoring, Publicity & Fundraising, and Wetlands & Critical Land Preservation. The Standing Committees will be kept informed of events and activities that they may be interested in. They may also be asked for input or assistance with specific tasks as the updated WMP is developed.

Invested Stakeholders

Invested Stakeholders are individuals or groups with specific interests or influence related to the Watershed Management Plan update. This group could be subdivided into those with interests in water quality, education, shoreline protection, government, etc. Invested Stakeholders will not specifically meet as a group, but will be kept informed of events and activities that they may be interested in. This includes, but is not limited to, the following individuals and groups:

- Alliance for Economic Success
- Concerned Citizens of Portage Lake
- Covenant Church Camp
- Junior Clio Club
- Little Eden Camp
- Little River Band of Ottawa Indians
- Onekama Lions Club
- Onekama Marine
- Onekama Township
- Onekama Village
- Portage Lake Association
- Portage Lake Garden Club
- Portage Lake Watershed Forever
- Portage Lake Yacht Club
- Portage Point Inn
- Portage Point Summer Resort Corp

Committee Involvement

During the last ten years, the Portage Lake Watershed Forever members have been involved with multiple organizations in the Watershed and have continued to educate and gather input from these groups and the general public. Council members are also active members of the Parks and Recreation Committee, the Planning Commission, Portage Lake Association, Portage Lake Resort Corporation, Junior Clio, and other community organizations. The Steering Committee is composed of members from the Onekama Township Board, EGLE, Onekama Consolidated School Board, Portage Lake Garden Club, Plant it Wild, and the Manistee County Sport Fishing Association.

2018 PLAN DEVELOPMENT

Utilizing the structure of the 2008 plan as a foundation, work started on the update for the 2018 Portage Lake Watershed Management Plan. The process started in 2015 with submitting for a grant from the EGLE to complete the WMP update. After not being awarded the grant, the Portage Lake Watershed Forever Council decided to self-fund the update with the goal to again develop a state and federal approvable plan. Since the groundwork for the PLWF was already in place, the main focus of the update was on gaining input from stakeholders and updating the plan to reflect the changes the community had seen in the past ten years. NorthSky Nonprofit Network (NorthSky) was contracted in 2017 to assist with the update of the WMP. They began by reviewing the current plan and looked at other plan updates from around the state along with EGLE and United States Environmental Protection Agency (USEPA) requirements. Along with hiring a consultant, a Watershed Steering Committee was created, and a chair was appointed. Other people in the community were involved as advisors to the committee.

In February of 2017, a Steering Committee was formed, and a committee chair was selected in order to assist with the WMP update process. The Steering Committee was composed of nine members plus the Executive Committee. A Watershed Open House was held on August 1, 2017. The goal of the Watershed Open House was to kick off the update of the Portage Lake Watershed Forever Plan. There was a brief presentation providing an introduction of the Portage Lake Watershed, an overview of the 2008 Watershed Management Plan, a highlight of the accomplishments, and the watershed plan update process. In addition to gathering input from local organizations, NorthSky created and assisted the Watershed in conducting an online survey in September 2017 that gathered area visitors and residents' opinions on the Watershed. Water quality, public access, septic system, and other topics concerning the Watershed were included in the survey and the results of this survey are summarized in **CHAPTER 6: HOUSEHOLD SURVEY**. Watershed Coffee Hours began in the fall of 2017 for the public to share ideas for the update and Monthly Watershed group meetings for public participation to share ideas were also held.

In December 2017 the contract with NorthSky was discontinued and a contract was signed with Spicer Group, Inc. to finish updating the plan to meet the criteria in place by the EGLE and the USEPA. Due to the resignation of the Steering Committee Chair, the committee was inactive in 2019. Therefore, Spicer Group worked with the PLWF Executive Committee to revise the plan to better fit the priorities of the Watershed today based off of the stakeholder input. The majority of the map updates needed for the plan were contracted out to the Manistee County Planning Department; any additional maps needed were created by Spicer Group. The input received from EGLE and the structure of other accepted WMP updates was also used to aid in the process. A Public Forum was held on August 2, 2018. The goals of the public forum were to increase public involvement, review current and upcoming updates, have the availability for discussion, and provide opportunities to have the public more involved. A slideshow was presented detailing the highlights of the Watershed Management Plan update and copies of the plan were available for those interested to review before initial submittal to EGLE.

After receiving initial comments from EGLE, changes were made and new drafts of the WMP were shared with the community at Watershed parties, which served as small informal gathering to obtain input on the plan. In total there were four gatherings held which were successful in gaining feedback on the draft. The plan was also sent to those listed in the **PARTNERSHIP AGREEMENT** and other local organizations and potential partners. Social media, primarily Facebook, along with the PLWF website were used as another method for distributing the plan to the community and to gain public input.

Furthermore, during the Watershed Management Plan update process, two Stormwater, Asset Management, and Wastewater (SAW) grants were received; one by Onekama Township and the other by the Village of Onekama. This has helped the community develop a better understanding of the stormwater network currently in place and new information has since been incorporated into the WMP. A portion of this grant will be used to create a Stormwater Management Plan that will target stormwater quality and quantity within Onekama Township in an effort to protect the watershed. This Watershed Management Plan also aligns with the Onekama Community 2010 Master Plan, Onekama Community 2012 Park Access Plan, and the 2014 Portage Lake Community Five-Year Plan for Parks and Recreation.

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CHAPTER 6: HOUSEHOLD SURVEY

The development of the 2008 Watershed Management Plan included a survey of 250 households in the watershed. This survey was conducted in August of 2007 by Public Sector Consultants. The survey was designed to learn how residents used the Watershed, how they want it to look in the future, their perceptions of and priorities for improving water quality and to provide general information about the households that could impact the Watershed. A complete report containing the survey instrument and results can be found at https://publicsectorconsultants.com/2008/05/01/portage-lake-watershed-forever-plan/.

In the spring of 2017, the Portage Lake Watershed Forever posted a survey on Survey Monkey on the Onekama social media page in addition to sending it to 1,400 e-mails. Hard copies were also made available at the Village library, Onekama schools and at the post office. Responders were asked to answer 45 questions/issues and were invited to offer any comments and/or suggestions. In all, 395 people responded including 12 hard copy returns; **Table 19**, below, depicts the number of responses received for each stakeholder group.

Table 19. *Stakeholder groups and responses from 2017 Watershed survey*

Stakeholder Group	Responses
All Residents	201
Full Time Residents	108
Seasonal Residents	109
Visitors	74
Property Owners	109
Shoreline Property Owners	118
Portage Lake Watershed Forever Members	65
Full Time Resident Landowners	226
Part Time Resident Landowners	215
Age 65+	120
Age 45 - 64	146
Age 25 - 44	46
Total Responses	**395**

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

Both the 2007 and 2017 surveys helped shape the information and education section of the plan by shedding light on the perceived use and trustworthiness of different sources of information, uncovering false perceptions, identifying targets for outreach efforts and establishing a baseline of information that can be used to evaluate the success of watershed activities. Efforts for the 2017 survey were made to reach as diverse a cross section as possible in the Watershed including, but not limited to, the following: land owners, seasonal residents, shoreline residents, renters, church camp visitors, business owners, sports fishing and other recreational interests, federal, state, local and tribal governments, educational institutions, service organizations, agricultural interests, and natural resource interests. Stakeholder responses are shown below in **Figure 101**.

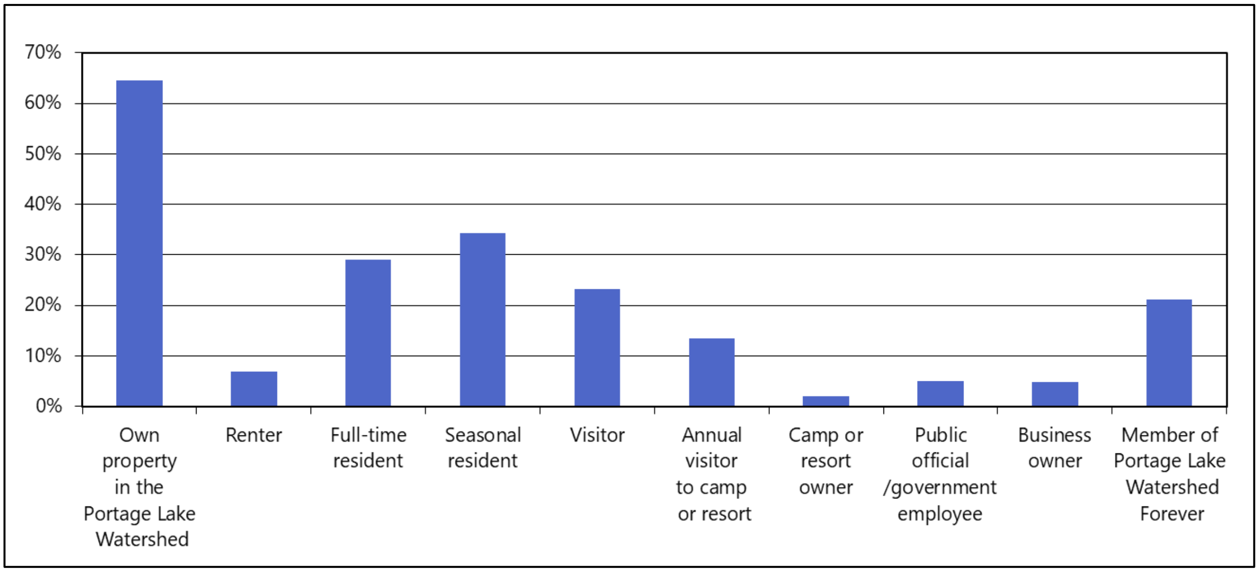
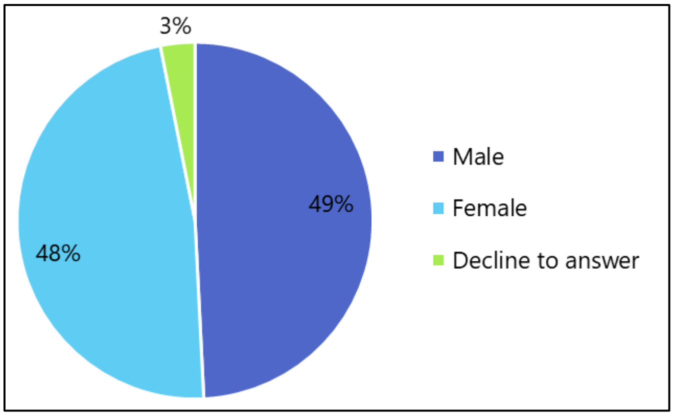


Figure 101. *Stakeholder groups and responses from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

GENDER, AGE AND EDUCATION

Because of the diversity of the population and the variety of interests, respondents' ages, gender and education levels were also collected (if applicable) for the 2017 survey to better direct information and outreach efforts. 120 of the respondents were 65 years or older, 146 were between 45 and 64 years, and 42 were between 24 and 44. The gender of those who responded was 49 percent male and 48 percent female; three percent declined to answer the question, **Figure 102**. The education level, depicted in **Figure 103**, below, went from 'some high school' (2%) to 'post-graduate' (38%). A total of 59 percent had either some college (11%), two years of college (9%), or had completed four years of higher education (39%).



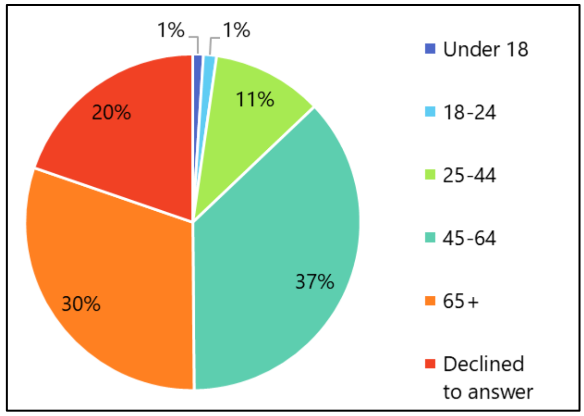


Figure 102. *Gender and age of respondents from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

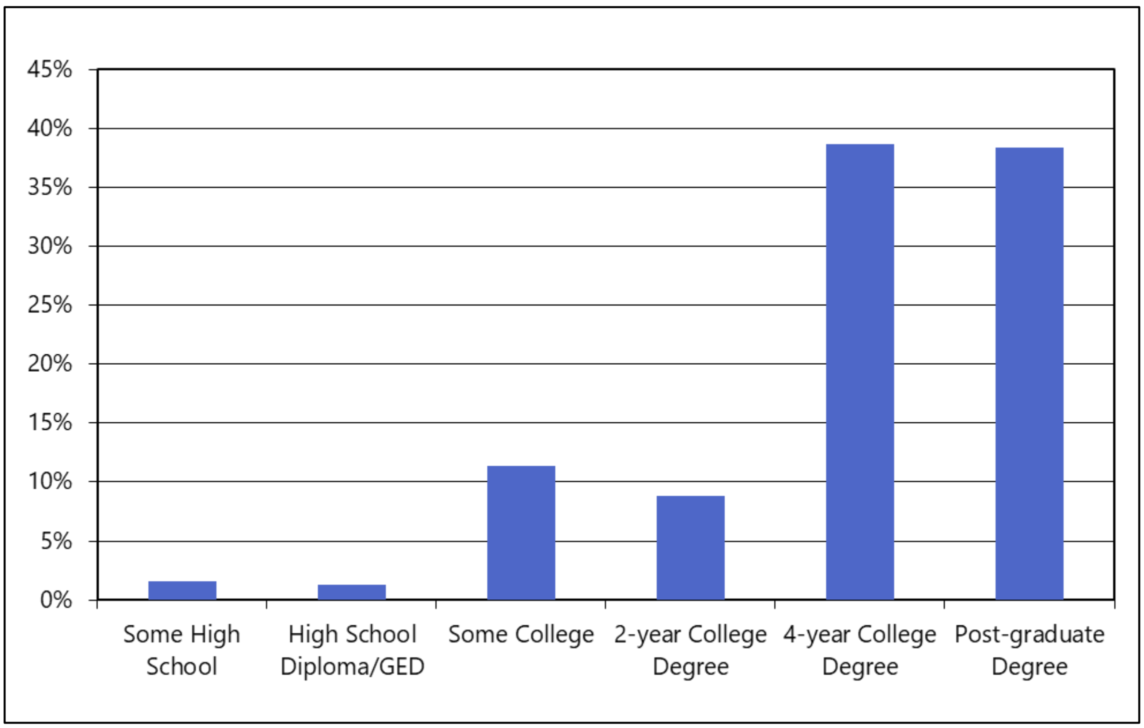


Figure 103. *Respondents' highest education level from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

ACTIVITIES

When creating and implementing a watershed management plan, it is important to understand how residents use the watershed and how they want it to look. This information is important because it helps guide and prioritize protection and restoration efforts. To identify how residents in the Portage Lake area use the Watershed, in the 2007 survey respondents were asked to report how frequently they participate in certain activities, weather permitting. The activities that respondents most frequently engaged in were:

- Boating: 45 percent participate once a week or more often
- Swimming, snorkeling, or scuba diving: 42 percent participate once a week or more often
- Fishing: 37 percent participate once a week or more often

In the 2017 survey, respondents were asked which activities were most important to them. The following **Figure 104** below depicts respondents' responses. Not surprisingly, the importance of the activities seems to depend on the age of the respondents. For example, while beauty from the land received high marks across the board, 73 percent of those aged 45 to 65 and older indicated it as a primary value. However, only eight percent of that cohort chose canoeing/kayaking. Residents and property owners were keen on beauty from the water (33% and 35% respectively), but that percentage dropped to single digits in every other stakeholder category.

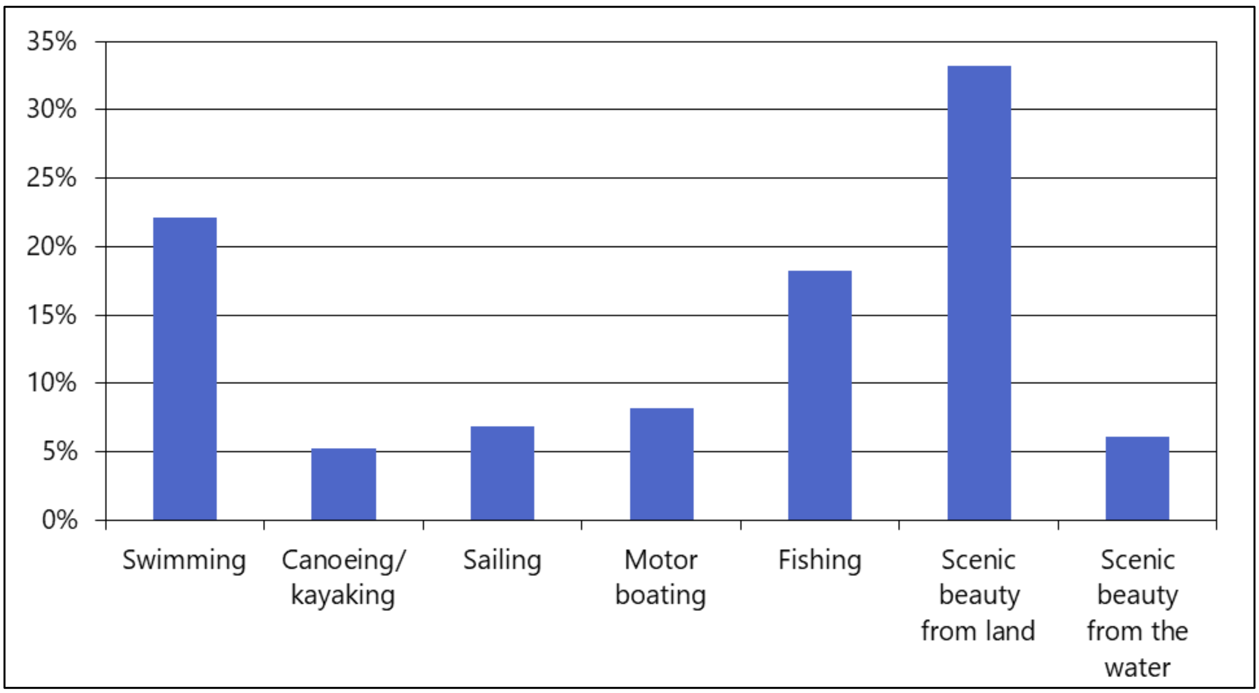


Figure 104. *Activities most frequently engaged in within Portage Lake Watershed from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

In addition, survey participants were asked to rate the quality of the water for the following: swimming, canoeing/kayaking, sailing, motor boating, fish habitat, eating locally caught fish, scenic beauty from land, and scenic beauty from the water. According to the results that can be seen below in **Figure 105**, the water quality for the scenic beauty from land was the highest at 95 percent and the lowest for eating locally caught fish at 47 percent.

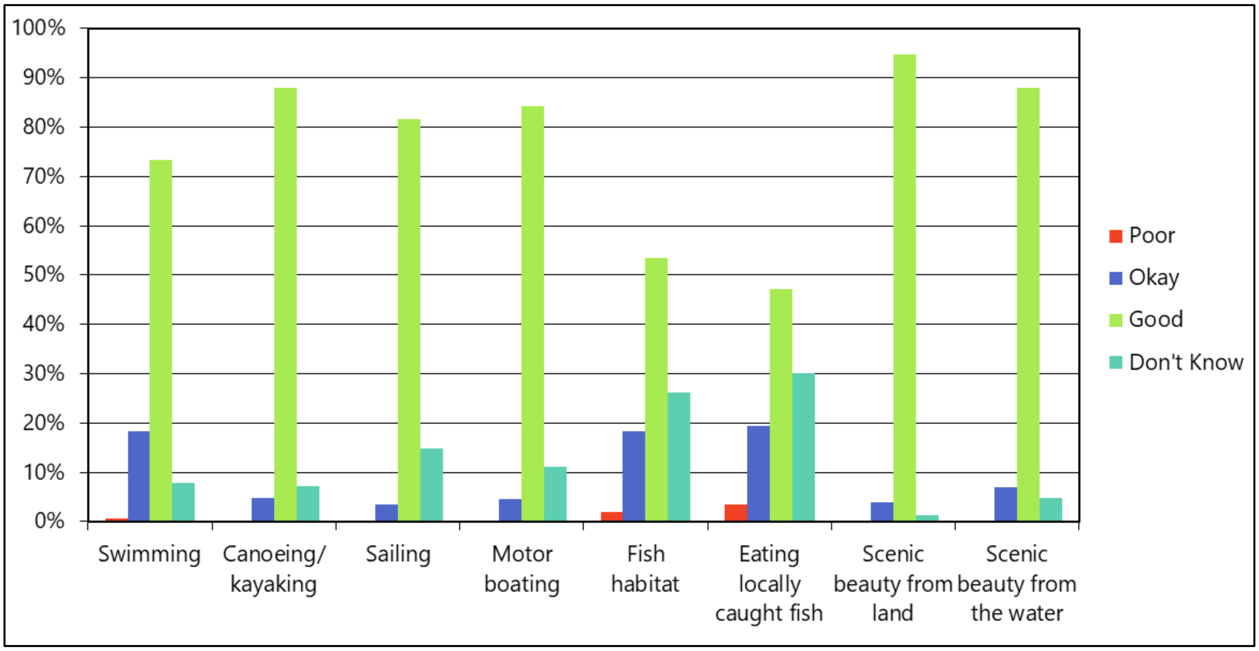


Figure 105. *Water quality per activity responses from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

According to the 2007 survey, residents in the Watershed used different boating access points to Portage Lake in fairly equal proportions. One-third (33%) of respondents who report boating access Portage Lake by a dock, mooring, or launch from their own property; 31 percent from a Michigan Department of Natural Resources (MDNR) state public access site; and 23 percent from Village Park.

According to the 2017 survey results, 66 percent of the respondents reported that they accessed Portage Lake via public beaches and parks while 59 percent reported that they accessed Portage Lake from private beaches. Furthermore, when respondents were asked if they would like to see increased access to Portage Lake, 44 percent were in favor for more access with public beaches and parks with a substantial amount of the “other” responses being no more access is needed and that current access provided is sufficient, see **Figure 106**.

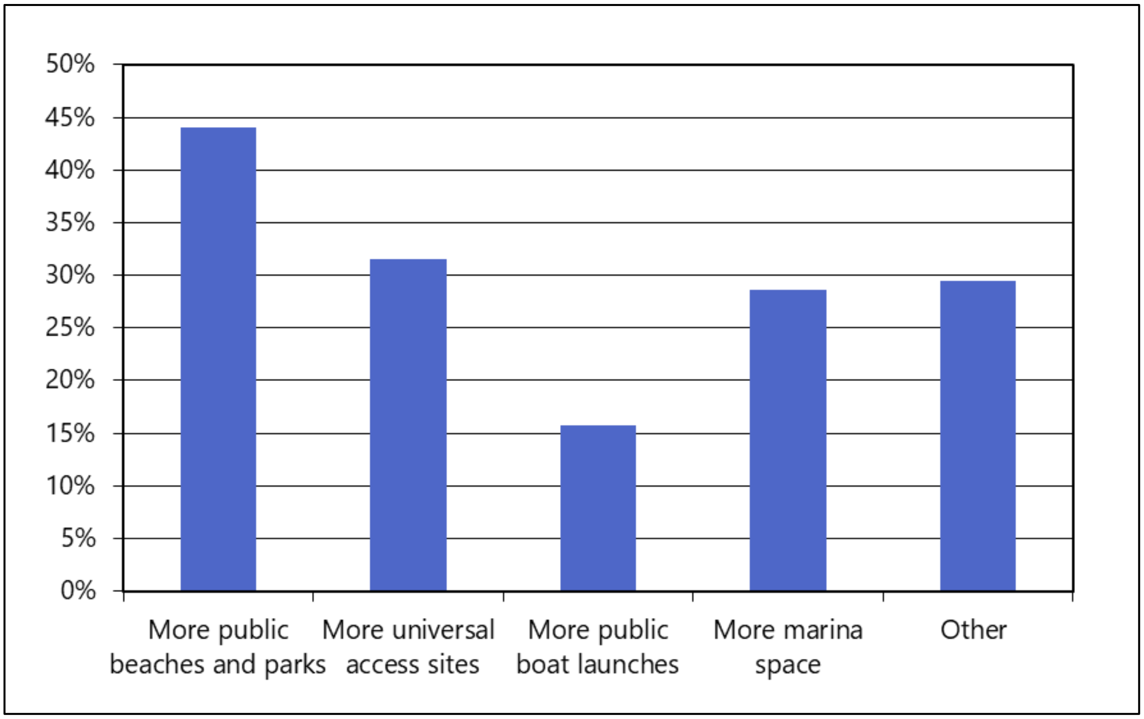


Figure 106. *Increased access to Portage Lake with the following options from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

Fishing

Anglers have long enjoyed the variety of fish species found (and caught) in Portage Lake. Their appreciation for the resource is reflected in 2017 survey results as more than 50 percent indicated that they fished in the lake as do 47 percent of visitors. The 2007 survey respondents who reported fishing as being one of the most frequent activities that they participated in, 66 percent rated the fishing as either excellent or good (13% and 53% respectively). Nearly half (46%) reported that the fishing had stayed about the same over the past few years. In the 2017 survey, 17 percent of the respondents rated the fishing in Portage Lake as excellent and 54 percent of the respondents rated the fishing in Portage Lake as good. More than half (60%) reported that the fishing had stayed about the same over the past few years, **Table 20**.

Table 20. *Fishing quality rating by area visitors, residents* from 2017 Watershed survey

Fishing Rating	2007 Survey Respondents	2017 Survey Respondents
Excellent	13 %	17 %
Good	53 %	54 %
About the Same	46 %	60 %

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

Agriculture/Lawn & Garden

Results from the 2017 survey showed that 96 percent of respondents do not own agricultural property in the Portage Lake Watershed. Respondents were asked their level of agreement or disagreement with a few statements pertaining to agricultural practices (only 12 respondents answered these statements). Of the series of statements, 75 percent of the respondents stated the following: using recommended management practices on farms improves water quality, they would be willing to change their management practices to improve water quality, and they limit the use of pesticides/herbicides.

According to the results from the 2017 survey, 87 percent of all respondents believed that the way they cared for their lawn and garden could influence the quality of water in local lakes and streams and 78 percent would be willing to change the way that they cared for their lawn and garden to improve the water quality. The following questions below in **Figure 107** were asked to respondents pertaining to their lawn and garden; 339 respondents answered these statements.

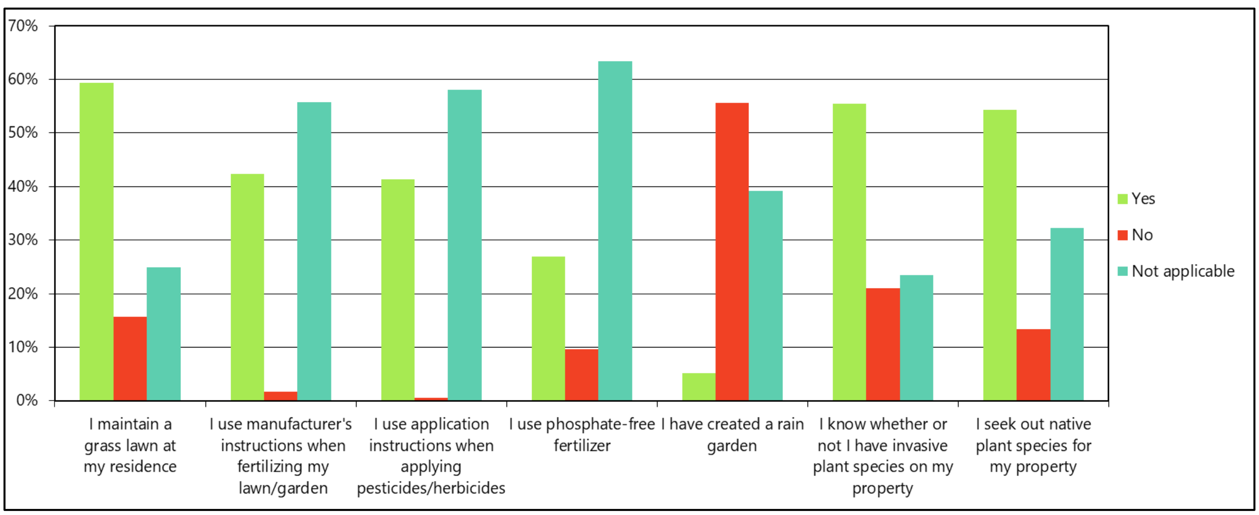


Figure 107. *Lawn and Garden related responses from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

Recreational Conflict

For watershed planning purposes, it is important to know if any of the ways in which residents use the watershed are in conflict. To answer this question, respondents were asked if they had personally observed any conflicts between users of Portage Lake, such as personal watercraft interfering with fishing. According to results from the 2007 survey, about two-thirds (67%) of respondents said that they had not seen conflicts between various users of Portage Lake. Respondents who had personally observed conflicts most frequently mentioned personal watercraft being involved (39%), even though personal watercraft represented just six percent of boating reported on Portage Lake by those surveyed. Other conflicts included issues involving access to the lake (19%), conflicts between those fishing and those boating on the lake (14%), and among boaters on the lake (10%). 2017 survey results showed the following in **Figure 108**, below. Per the responses received, the most responses received were "no", meaning there were no concerns, or conflicts related to access or shared recreation use of Portage Lake.

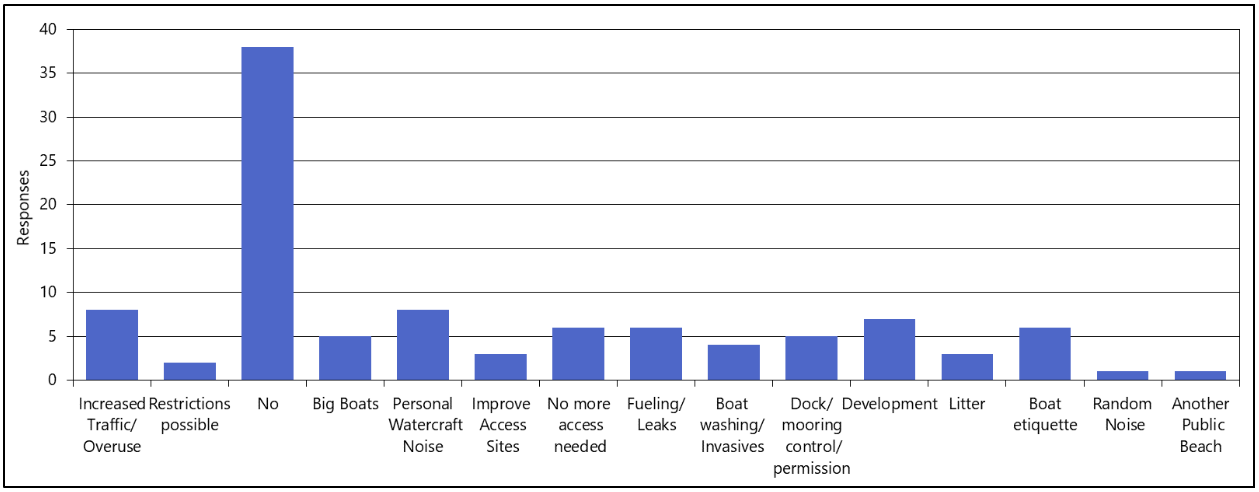


Figure 108. *Concerns related to access or shared recreation use of Portage Lake from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

SEPTIC SYSTEMS/SEWER

To build a sewer system around Portage Lake or not to build a sewer system around Portage Lake has been a contentious topic for years. The Portage Lake Watershed Forever organization supports such a project despite arguments that water quality does not justify the effort and asked questions in the survey to determine the present state of affairs regarding septic systems. 84 percent of the "all resident" respondents who answered said they owned property with a septic tank; 16 percent said they do not. **Figure 109** shows a breakdown of stakeholder groups and whether they own a septic system. As shown in **Table 21**, 25 percent of these septic systems are less than ten years old. Regardless of the age of the septic system, the vast majority of respondents (82%) indicated that they have had their system inspected and/or pumped out in the last five years. This response stayed consistent with the 2007 survey results where 85 percent indicated that they had their system inspected and/or pumped out in the last five years.

Of the 35 people who responded (360 respondents did not answer this question), 51 percent did not know that their septic system needed to be maintained (i.e. inspected, cleaned) every five years or less. Other comments were that the respondents were only seasonal users, so they did not see the need to have the tank pumped regularly. Here, too, is a clear example of the need for education and information about the importance of maintaining a septic system and the threats untreated waste poses to the Watershed.

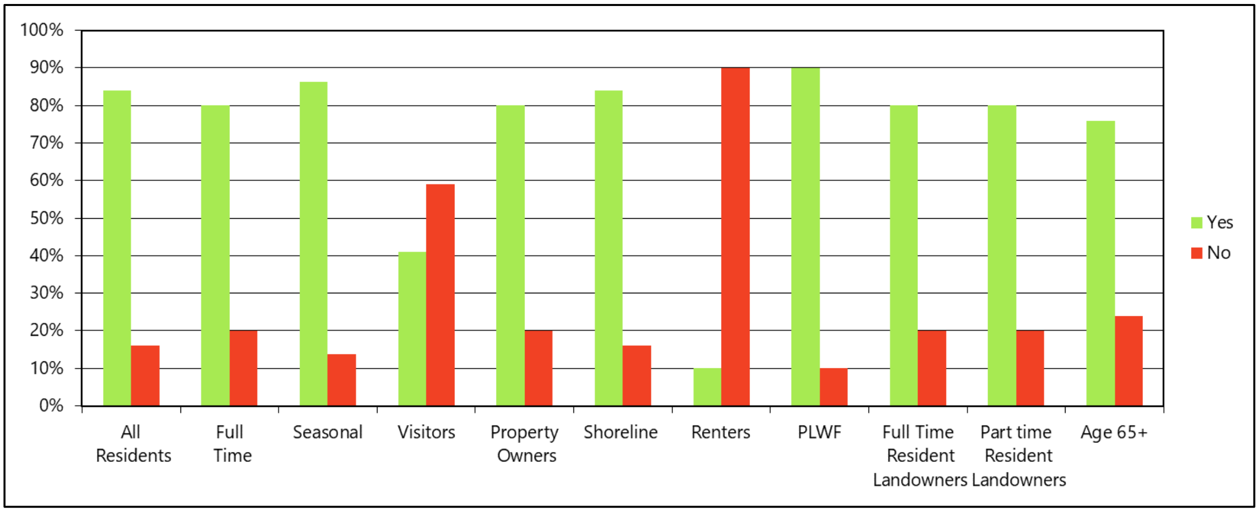


Figure 109. *Septic system ownership from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

Table 21. *Septic system age and maintenance from 2017 Watershed survey*

Septic System Installed	% of Respondents	Septic System Inspected or Cleaned	% of Respondents
Less than 10 years ago	25	0-5 years ago	82
10-20 years ago	32	6-10 years ago	8
More than 20 years ago	34	More than 10 years ago	5
I don't know	9	Never	5

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

In view of the public discussion about septic systems, the 2017 survey incorporated a question about the possible policies that could be passed; **Table 22**, below, depicts the results. The majority of the "no action related to septic systems" responses were from those of the age of 25-44.

Table 22. *Septic system policy options from 2017 Watershed survey*

Option	# of Respondents
No action related to septic systems.	8
Educational outreach to inform citizens of the importance of inspecting and maintaining their septic tanks.	68

Table 22 cont. *Septic system policy options from 2017 Watershed survey*

Option	# of Respondents
Time of Transfer Inspection Ordinances - Requiring inspection of septic tanks to be completed at the time of sale or transfer of property. If issues are found during inspections, this approach usually requires a plan for remediation and a future inspection to ensure compliance.	63
Mandatory Pumping or Inspection Ordinances - Requiring septic tanks to be pumped or inspected at regular, specific time periods. Property owners submit proof of compliance and follow recommendations specific to them after inspection.	33
Transition from septic systems to a community sewer system.	53

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

WATER QUALITY PERCEPTIONS AND IMPROVEMENT ACTIONS

To begin to understand potential water quality problems in the Watershed, 2007 and 2017 survey respondents were asked about their perceptions of the water quality of Portage Lake. Overall, respondents gave the water quality of the Portage Lake high marks, **Table 23**.

Table 23. *Public perception of Portage Lake water quality*

Water Quality Rating	2007 Survey Respondents	2017 Survey Respondents
Excellent	25 %	-
Good	57%	78%
About the Same	55%	51%

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

2007 survey results showed the following:

- 82 percent of respondents rated the overall water quality of Portage Lake as excellent (25%) or good (57%).
- The majority (64%) felt that the water quality of Portage Lake is somewhat (39%) or significantly (25%) better than the water in other inland lakes.
- About half (55%) stated that the water quality stayed about the same over the past few years; another 18 percent say that it is either somewhat (16%) or much (2%) better.

2017 survey results showed the following:

- 78 percent of all the respondents rated the overall water quality of Portage Lake as good.
- About half (51%) of all the respondents stated that the water quality stayed about the same over the last ten years.
- 37 percent of all the respondents stated that the water quality of Portage Lake increased.

The 2017 survey also asked respondents a question to determine to what degree they considered a list of issues to be a problem threatening the quality of the Watershed. Over a quarter (27%) of those who answered the question didn't know if the issues were a problem or not. This finding could well become a focus of the plan's information and education efforts. **Figure 110**, below, lists the type of issues along with the respondents' level of concern (not a problem, slight problem, moderate problem, severe problem, or don't know).

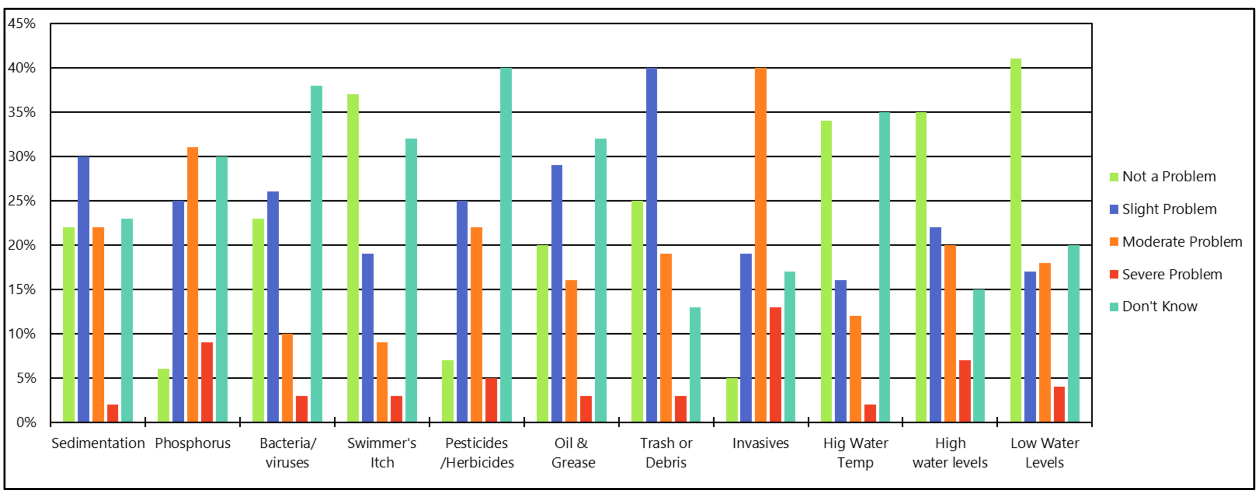


Figure 110. *Watershed issues from 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

Although the 2017 survey showed that nearly 100 percent of responders indicated that they had not had any problems with swimmer's itch, the fact that nearby lakes have had serious outbreaks with it indicates an awareness of, and concern about, the possibility that Portage Lake, too, could be vulnerable. The same could be said about the 40 percent who indicated some concern about invasive plants and animals and the use of phosphates, pesticides and herbicides.

When stakeholders were asked what the first word was that came to mind when they thought about the Portage Lake Watershed, many referred to the condition of the lake as being clean, healthy, pristine, and natural. Respondents love the lake, but also believe that it is vulnerable, precious, and irreplaceable. As a result, many have also expressed a willingness to change personal habits to protect it and even a willingness to pay additional taxes if necessary. Unexpectedly, 67 percent of the seasonal and visitor respondents answered that they agree or strongly agree with their willingness to pay more to improve water quality (i.e. local taxes, fees); their support was somewhat higher than all residents (61%) and full time (62%) residents.

SOURCES OF INFORMATION

The next decade we spend implementing the Portage Lake Watershed Forever plan will rely largely on our ability to convince our stakeholders that they do, indeed, have a stake in our success. The electronic and social media tools we have available now, as opposed to ten years ago, must be used efficiently and effectively to educate, inform, and engage the stakeholders.

Presently, 41 percent of 201 "all resident" responders said they get information about water quality issues from newspapers, brochures and fact sheets, 28 percent from the internet, only one-half percent from the radio, and six percent from newspapers. The remaining 22 percent rely on workshops, meetings, or conversations with others. A scant three percent reported none of the above. Given the choices available, we also asked who was most trusted in terms of the accuracy of the information received; **Figure 111**.

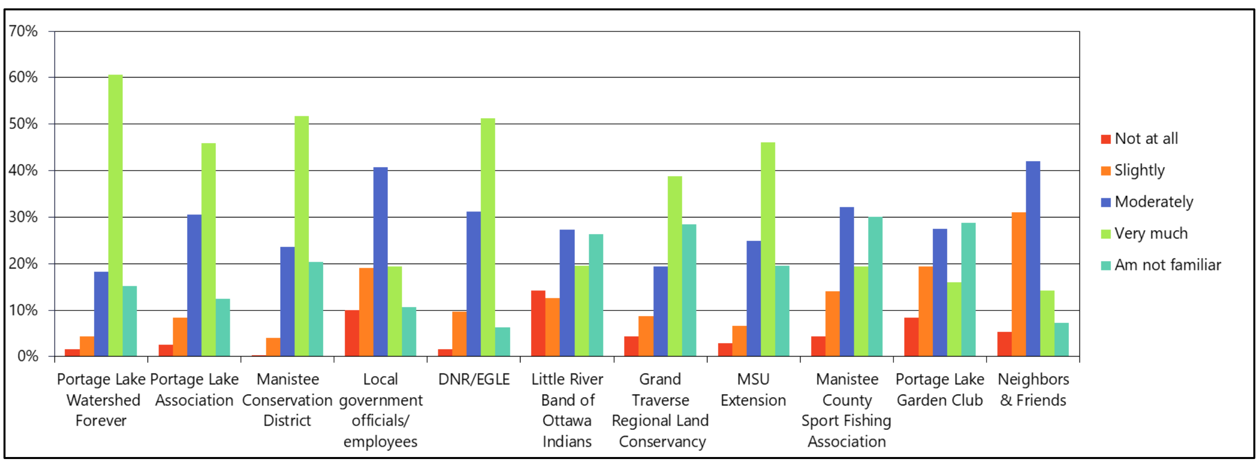


Figure 111. *Trusted sources of information based on 2017 Watershed survey*

SOURCE: Portage Lake Watershed Forever, 2017 Community Survey.

CONCLUSION AND RECOMMENDATIONS

Based on survey results, it is unanimous that everyone loves Portage Lake and values the importance of water quality. Fishing, swimming, and scenic beauty from the land are most important to respondents; it was found that the importance of activities depended on the age of the respondents. The perception from the survey is that respondents are dedicated to water quality and are willing to do things differently to improve Portage Lake for the future.

Respondents have a favorable opinion of the current water quality in the Portage Lake Watershed and feel that it compares favorably to other inland lakes. There is a clear lack of knowledge about what to do to protect water quality given the number of “don’t know” responses that were received throughout the entirety of the survey. Furthermore, when asking respondents to what degree they considered a list of issues to be a problem threatening the quality of the Watershed, over a quarter of those who answered the question didn’t know if the issues were a problem or not. These results indicate the need for education and coordinated dissemination of information to residents and other users.

One of the biggest concerns identified during the survey is pollution from failing or poorly maintained septic systems. While 82 percent of respondents with septic systems reported having their tanks serviced in the last five years, a significant 51 percent of the respondents did not know that their septic system needed to be maintained (i.e. inspected, cleaned) every five years or less when asked. Based on this response, there is the need for education and information about the importance of maintaining a septic system and the threats untreated waste poses to the Watershed.

Respondents trust information from the Portage Lake Watershed Forever Committee, the Portage Lake Association, the Manistee Conservation District, the Michigan Department of Environment, Great Lakes, and Energy, Michigan Department of Natural Resources, and the Michigan State University Extension more than local government officials/employees, the Portage Lake Garden Club, or neighbors and friends.

The 2018 Watershed Plan must significantly strengthen its education, information, and outreach strategy to reach short and long-term goals. The watershed organization must find ways to engage stakeholders to actively participate in its efforts and, more importantly, to ensure its future.

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CHAPTER 7: USES, THREATS, SOURCES, CAUSES

A comprehensive watershed plan examines whether or not waterbodies in the watershed meet designated, protected uses specifically identified in water pollution control statutes and promulgated rules, and evaluates compliance with water quality standards adopted to protect those uses. It also identifies desired uses within the watershed.

DESIGNATED PROTECTED USES

Under the Michigan water pollution control statute (Natural Resources and Environmental Protection Act, Public Act 451 of 1994), discharges to surface waters are unlawful if they may become injurious to:

- public health, safety, or welfare;
- domestic, commercial, industrial, agricultural, recreational, or other uses that are being made or may be made of such waters;
- the value or utility of riparian lands;
- livestock, wild animals, birds, fish, aquatic life, or plants, or to their growth or propagation; or
- the value of fish and game.

Promulgated Michigan water quality rules based on this state law and the federal Clean Water Act establish, as a minimum, that all waters of the state are designated and protected for the following uses:

- Agriculture
- Navigation
- Industrial water supply
- Warmwater fishery
- Other indigenous aquatic life and wildlife
- Fish consumption
- Partial body contact recreation
- Total body contact recreation from May 1st to October 31st

Under state rules, both numerical and narrative water quality standards are established for designated and protected uses. In all cases where waters are designated for more than one of these protected uses, the most restrictive water quality standards apply.

In addition to the above protected uses, additional protected uses include the following if identified by the state:

- Coldwater lakes, trout lakes, and trout streams
- Migratory routes for anadromous salmonids (a family of soft-rayed fishes including the trouts, salmons, whitefishes, and graylings, that live in lake environments but spawn in rivers and streams)
- Public water supply intakes

In the case of the Portage Lake, watershed migratory routes for anadromous salmonids and designated trout streams would apply as additional protected uses. Portage Lake is not a designated cold water or trout lake, and there are no surface water public water supply intakes in the Watershed.

Groundwater is also protected under Michigan law and rules. Under state regulations groundwater discharges must essentially meet a non-degradation standard to protect existing or potential uses such as domestic water supplies, irrigation, stock watering, etc. Groundwater flow to trout streams tributary to Portage Lake and to Portage Lake itself is critical to maintaining existing protected uses. New water withdrawal laws in Michigan provide significant measures to regulate groundwater and surface water uses intended to protect groundwater quantity, particularly where such withdrawals may impact trout streams.

EXISTING CONDITIONS COMPARED TO STATE STANDARDS

In many watershed plans in Michigan, and elsewhere in the country, there is a focus on restoration of protected use impairments due to water pollution sources, as indicated by non-attainment of water quality standards. In the Portage Lake Watershed, according to the most recent Integrated Report (2016), water quality standards are being met for many of the designated uses assessed for McGowans Creek, Schimke Creek, and Portage Lake, **Table 24**. Fish consumption in Portage Lake is currently the only unsupported use due to mercury and PCB found in the fish tissue. A total maximum daily load (TMDL) schedule has been established for both of these pollutants for 2022. Fish consumption was not assessed for McGowans Creek or Schimke Creek.

Table 24. *Designated use support for Portage Lake Watershed from 2016 Integrated Report*

Designated Use	McGowans Creek	Schimke Creek	Portage Lake
Navigation	Fully Supporting	Fully Supporting	Fully Supporting
Industrial Water Supply	Fully Supporting	Fully Supporting	Fully Supporting
Agriculture	Fully Supporting	Fully Supporting	Fully Supporting
Other Indigenous Aquatic Life and Wildlife	Fully Supporting	Fully Supporting	Fully Supporting
Fish Consumption	Not Assessed	Not Assessed	Not Supporting
Cold Water Fishery	Not Assessed	Not Assessed	Not Assessed
Warm Water Fishery	Not Assessed	Not Assessed	Not Assessed
Total Body Contact Recreation	Not Assessed	Not Assessed	Not Assessed
Partial Body Contact Recreation	Not Assessed	Not Assessed	Not Assessed

SOURCE: EGLE Integrated Report 2016.

The Clean Water Act requires Michigan to prepare a biennial report on the quality of its water resources. This report, called the Section 303(d) list, constitutes the principal means of conveying water quality protection/monitoring information to the United States Protection Agency (USEPA) and the U.S. Congress. The Section 303(d) list includes Michigan waterbodies that are not attaining one or more designated use and require the establishment of TMDLs to meet and maintain water quality standards. The Portage Lake Watershed is attaining its designated uses currently. A summary of this information can be found in **Table 25** and **Table 26**.

Table 25 details (1) existing activities and uses; (2) the categories of designated, protected uses under statute and regulations; (3) the water quality standards that apply to each designated, protected use; and (4) the existing conditions compared to the water quality standard, including the date for the latest information available. **Table 26** details potential future activities and uses; the categories of designated, protected uses under statute and regulations; and existing conditions.

The surface waters of the state shall not have any of the following physical properties in unnatural quantities which are or may become injurious to any designated use (e.g. turbidity, color, oil films, floating solids, foams, settleable solids, suspended solids, and deposits). There are multiple parameters that can impact these designated/ desired uses, for which the State of Michigan has defined narrative standards for water quality, **Table 27**.

Table 25. *Portage Lake Watershed state designated existing uses, applicable water quality standards, and existing conditions*

Designated, protected uses (Part 31 of Act 451, §324.3109)	Water quality standards (MDEQ, 2006)	Existing activities and uses[1]	Existing condition compared to standard[2] (year of most recent data collection)
Total body contact recreation	Counts of 130 or less for *Escherichia coli (E. coli)* per 100 mL monthly average and 300 or less for *E. coli* per 100 mL at any time.	Swimming, SCUBA, tubing, snorkeling, water skiing, wake boarding, knee boarding, and related total body contact activities	▪ Not assessed, Integrated Report (2016). ▪ Meets standard based on historical data and tests at major beach areas (2017).
Partial body contact recreation	Counts of 1,000 or less for *E. coli* counts per 100 mL.	Canoeing, kayaking, cruising, sailing, and related boating activities	▪ Not assessed, Integrated Report (2016). ▪ Meets standard based on historical data and tests at major beach areas (2017).
Fish consumption	Fish consumption advisory trigger levels for toxic heavy metals and organic compounds.	Fishing	▪ Not supporting in Portage Lake and not assessed for McGowans Creek and Schimke Creek, Integrated Report (2016). ▪ Fish consumption warnings for Portage Lake are limited to PCBs and mercury in certain species due to sources outside of watershed (2007).[3]
Warmwater fishery and seasonal migratory pathways for anadromous salmonids (Portage Lake)	Dissolved oxygen (DO) not less than 5.0 mg/L during summer stratification in the epilimnion (uppermost layer of the lake). Not less than 5.0 mg/L for the rest of the year in entire lake area.		▪ Not assessed, Integrated Report (2016). ▪ Meets standard based upon historical data and recent summer testing for dissolved oxygen during summer stratification (2017).

Table 25 cont. *Portage Lake Watershed state designated existing uses, applicable water quality standards, and existing conditions*

Designated, protected uses (Part 31 of Act 451, §324.3109)	Water quality standards (MDEQ, 2006)	Existing activities and uses[1]	Existing condition compared to standard[2] (year of most recent data collection)
Coldwater fishery (tributary streams)	DO no less than 6.0 mg/L in any 24-hour period during summer minimum flow period and not less than 7.0 mg/L rest of the time.	Fishing	▪ Not assessed, Integrated Report (2016). ▪ Benthos sampling indicates diverse, stable coldwater bottom organisms (2003)[4]. Presence of trout and salmon in tributary streams would indirectly indicate that standard is being met (2007). Meets standard based upon historical data and recent summer testing for dissolved oxygen during summer stratification (2017).
Other indigenous aquatic life and wildlife	Numerous numeric chemical limits such as pH, ammonia, toxic metals, and organic compounds, as well as narrative limits for nutrients (nuisance algal growths) and physical properties (color, temperature, clarity, etc.). See **Table 27** for narrative state water quality standards	Hunting, wildlife observation, ecosystem protection, plant and animal diversity	▪ Fully supporting, Integrated Report (2016). ▪ pH (2017), phosphorus (2017), physical properties all within acceptable ranges for mesotrophic lakes (1992). No toxic substances reported above levels of concern (1992). No nuisance algae blooms reported, some concerns over excessive weed growth and invasive species (1992– 2007).

Table 25 cont. *Portage Lake Watershed state designated existing uses, applicable water quality standards, and existing conditions*

Designated, protected uses (Part 31 of Act 451, §324.3109)	Water quality standards (MDEQ 2006)	Existing activities and uses[1]	Existing condition compared to standard[2] (year of most recent data collection)
Navigation	No interference or increased cost to navigation.	Access to and from Lake Michigan through Portage Lake Channel	▪ Water quality standards for other protected uses sufficient to protect this designated use.

SOURCE: Public Sector Consultants Inc., 2007, EGLE Integrated Report 2016, updated 2018 Spicer Group, Inc.

[1] From cited, previous studies, and focus groups, public meetings, and telephone surveys conducted during 2007.

[2] From cited previous studies and information recently provided by Onekama Township and MDNR Fisheries Division.

[3] See Fish Consumption Advisory section (pgs. 93-94) for species and sizes covered by recommended fish consumption advisories for Portage Lake

[4] From cited, previous studies from MDEQ Water Bureau, 2007d.

Table 26. *Portage Lake Watershed state designated uses for potential future use, likelihood of future use, and existing condition*

Designated, protected uses (Part 31 of Act 451, §324.3109)	Potential future use	Likelihood that designated/surface water use may be made in the future	Ability of existing water quality to support use
Public Water Supply	New public water supplies from surface waters.	Adequate quality and quantity of groundwater in watershed for expected domestic water demand. Surface water sources other than Portage Lake are small. Municipal supply, if from surface water, most likely would be taken from Lake Michigan.	▪ Not assessed, Integrated Report (2016). ▪ Drinking water quality standards higher than existing water quality and further treatment would be required to meet state drinking water requirements.
Industrial Water Supply	New industrial / commercial surface water supplies.	Future demand unknown, but likely major industrial use would be either from groundwater or Lake Michigan.	▪ Fully supporting, Integrated Report (2016). ▪ Most industrial/commercial uses could be accommodated by existing water quality.
Agriculture	New agricultural surface water uses (possible existing, small quantities used for lawn and garden watering by riparians).	Tributary streams too small to support significant agricultural withdrawal and there are no expected significant agricultural uses riparian to Portage Lake.	▪ Fully supporting, Integrated Report (2016). ▪ Agricultural uses could be supported by existing water quality.

SOURCE: Public Sector Consultants Inc., 2007., EGLE Integrated Report 2016.

Table 27. *Narrative state water quality standards*

Parameter	Standard	Impacted Uses
pH	Within range 6.5 to 9.0 S.U.	
Taste and Odor Producing Substances	None should be present	▪ Public Water Supply ▪ Industrial Water Supply ▪ Agricultural Water Supply ▪ Fish Consumption
Toxic Substances	Shall not be present in the surface waters of the state at levels that are or may become injurious to the public health, safety, or welfare, plant and animal life, or the designated uses of the waters.	▪ All but navigation
Plant Nutrients	Nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the surface waters of the state.	▪ All
Temperature * Note that these are standards for point source discharges and general guidelines for ambient waters in northern Michigan	Monthly Average for Inland Lakes: J F M A M J J A S O N D 45 45 50 60 70 75 80 85 80 70 60 50	▪ Cold water fishery ▪ Other indigenous aquatic life and wildlife
	Monthly Average for Coldwater Inland Streams: J F M A M J J A S O N D 38 38 43 54 65 68 68 68 63 56 48 40	▪ Cold water fishery ▪ Other indigenous aquatic life and wildlife
	Monthly Average for Warmwater Inland Streams: J F M A M J J A S O N D 38 38 41 56 70 80 83 81 74 64 49 39	▪ Warmwater fishery ▪ Other indigenous aquatic life and wildlife

SOURCE: Sections 3103 and 3106 of 1994 PA 451, MCL 324.3103 and 324.3106.

Total and Partial Body Contact Recreation

Five popular swimming areas on Portage Lake were sampled on two occasions during 2007 to verify that bacteria levels as measured by the presence of *E. coli* still meet state standards for both total and partial body contact recreation. All results indicated that water quality standards are being met. Historical sampling in Portage Lake has on occasion shown that the bacteria levels have at times exceeded state standards. Many of the problem areas were addressed, however, when the sanitary sewer system was constructed and operated for homes and businesses within the Village of Onekama in the early 1990s. Further testing for *E. coli* should continue to assure that the water quality standards for bacteria associated with human and animal waste are being met throughout the year and in locations where potential sources are concentrated near the shoreline of Portage Lake and tributary streams.

<u>Fish Consumption Advisories</u>

According to testing conducted by the state, only polychlorinated biphenyls (PCBs) and mercury (Hg) are being detected at levels of concern for human consumption of fish from the lake (MDEQ, 2007e). PCB levels in fish from Portage Lake are declining, consistent with similar trends elsewhere in the state following controls on the use and disposal of this chlorinated hydrocarbon. Mercury levels in Portage Lake fish are lower than those commonly found in inland lakes within Michigan. The source of mercury and PCB contamination is likely atmospheric deposition from sources outside of the Watershed or the result of Lake Michigan fish that had accumulated contaminants from other locations entering Portage Lake. (For more detail on fish contaminants in Portage Lake, please see pages 93-97 of this report.)

<u>All Other Numerical and Narrative Water Quality Standards</u>

Historical and recent test results from Portage Lake and tributary streams do not indicate that there are current exceedances of state water quality numeric or narrative standards intended to protect designated uses for most parameters. Ammonia levels in the deepest basins have exceeded the Final Chronic Value (FCV) once. The FCV concentration (0.47 mg/L) is dependent on the pH and temperature of the lake and is the concentration where long-term exposure will lead to negative impacts on aquatic organisms. This exceedance occurred in September of 2016 in Basin 1 where ammonia concentrations were measured to be 0.54 mg/L.

Data collected in 2006 and 2007 by Onekama High School for dissolved oxygen, chlorophyll *a*, water transparency and phosphorus show no significant change in the productivity level of Portage Lake, and the information collected is consistent with a mesotrophic lake. Additional testing of DO may be warranted to determine whether the state standard is being met throughout a 24-hour period and whether oxygen depletion at the deeper portions of the lake during stratification are existing for a longer period of time. Continual monitoring of both exotic plant species and algae may be appropriate to determine whether further actions are needed to protect existing uses of the lake.

MOST LIKELY THREATS TO PROTECTED USES IN THE FUTURE

The focus of this Watershed Plan is thus to protect the existing high-water quality of the lake and associated protected uses by closely monitoring priority threats to address sources of detected problems before they cause significant impairments. Recent data from sources other than the Integrated Report support the findings presented above and results of recent data collection can be found in **Table 28**. The last column of **Table 28** identifies such potential threats based on the review of available information both for the Portage Lake Watershed and through the examination of information from other watersheds that have experienced water quality problems and impairment of protected uses. The Portage Lake stakeholders have the opportunity to prevent major impacts on existing uses rather than having to confront the often difficult and costly efforts to restore the quality of the environment after it has been degraded. Not all preventive measures are inexpensive, and a case must be established for any costly prevention activities. This Watershed Plan is intended to identify actions that are justified based on current information and building a database so that any future recommendations can be established based on information that clearly demonstrates what further actions are needed to protect the uses valued by the Watershed stakeholders.

Table 28. *Portage Lake Watershed existing uses and associated designated protected uses, existing conditions, sources/ causes of threat*

Designated, protected uses (Part 31 of Act 451, §324.3109)	Most likely source and cause of threat to meeting standard in the future[2]
Total body contact recreation	Pathogens coming from failed septic systems, uncontrolled runoff from farm-raised animals, household pets, and waterfowl.
Partial body contact recreation	Same as above.
Fish consumption	Air deposition of toxic, bioaccumulative heavy metals and persistent organic compounds; potential, but undocumented, historical industrial releases contained in Portage Lake sediments.
Warmwater fishery and seasonal migratory pathways for anadromous salmonids (Portage Lake)	Over-enrichment due to septic tile field leachate, riparian lawn fertilization, stormwater discharges, agricultural practices and resulting excessive plant and algal growth, decomposition, and oxygen consumption.

Table 28 cont. *Portage Lake Watershed existing uses and associated designated protected uses, existing conditions, sources/ causes of threat*

Designated, protected uses (Part 31 of Act 451, §324.3109)	Most likely source and cause of threat to meeting standard in the future[2]
Coldwater fishery (tributary streams)	Streamside development that would remove natural vegetative cover, large land use changes creating direct, polluted runoff to coldwater trout streams, bank erosion due to stream crossings and adjacent upland uses, riparian agricultural food and animal production.
Other indigenous aquatic life and wildlife	There are no known continuous, direct or indirect, discharges resulting in violations of water quality standards designed to protect aquatic life and wildlife in Portage Lake and tributaries. However, accidental spills of hazardous substances related to improper storage or use, and/or inadequate contingency plans related to transportation, storage, and use do pose a threat through storm drainage systems.
Navigation	Unlikely, but potential increase in cost of Portage Lake Channel dredging due to presence of contaminants.

SOURCE: Public Sector Consultants Inc., 2007, updated by Spicer Group, Inc., 2018.

[1] From cited previous studies, information recently provided by Onekama Township and MDNR Fisheries Division.

[2] Conclusions of this study by Public Sector Consultants Inc. endorsed by the Portage Lake Watershed Forever Technical Advisory Committee.

Additionally, an overall Watershed runoff analysis was completed using the Long-Term Hydrologic Impact Assessment (L-THIA) model to determine future threats to the Watershed as land use changes over time. The model was designed by Purdue University with cooperation from the USEPA. Based on average annual runoff, soil conditions, land use type, and impervious cover, the L-THIA model was used to estimate expected nonpoint source pollution loadings to waterbodies in the Portage Lake Watershed. The model was also used to determine the pollutant loading if predicted future land use trends come to fruition. To determine runoff and pollutant loading for current conditions, the Watershed from the National Land Cover Database (MRLCC, 2001 and 2006), and the Natural Resources Conservation Service 2016 data were used. To estimate potential future loads, a land transformation model developed by the Computational Ecology and Visualization Lab and Michigan State University Land Policy Institute was used for the year 2040. Outputs for fecal coliform, nitrogen, phosphorus, runoff volume, and total suspended solids are included below and all other outputs are summarized in **APPENDIX D: L-THIA RESULTS**.

Public Health

PATHOGENS

While there are many potential sources of pathogens (bacteria, viruses, and other disease-causing microorganisms) in the Portage Lake Watershed, including stormwater runoff and waterfowl, septic systems (on-site disposal systems, or OSDSs) pose the largest threat. OSDSs provide a means of treating household waste in areas that do not have access to public sewers or where sewering is not feasible. They typically consist of two components: a septic tank designed to intercept and hold partially treated solids and a drainfield that disperses wastewater to surrounding soils, see **Figure 112**. OSDS effluent is the substance that passes through the tank to the drainfield and eventually filters through the soils. This effluent has the potential to contain pathogens and high levels of nutrients (nitrogen and phosphorus), both of which are harmful to groundwater and surface waters when found in excessive amounts.

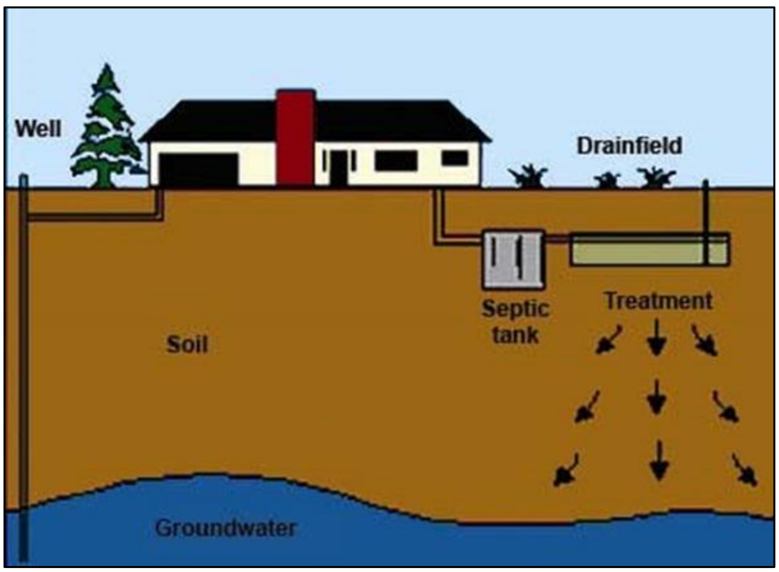

Figure 112. *Typical septic system*

SOURCE: MSU, Institute for Water Research, 2007.

When properly designed, sited, constructed, and maintained, a conventional on-site septic system effectively reduces or eliminates most human health or environmental threats posed by pathogens, nutrients, and other contaminants during the course of its design life (typically 30 years). Previous studies cite that approximately 99 percent to 99.99 percent of fecal coliforms that pass through conventional septic systems are removed (USEPA, 2002).

OSDSs fail to meet human health and water quality objectives for many reasons, including improper siting (too close to drinking water supply or water table), outdated and underperforming technologies, inadequate maintenance, and systems exceeding design life[8] (USEPA, 2002). Surface water may eventually be affected as groundwater seeps into adjacent streams, lakes, rivers and wetlands. Surface waterbodies may also be directly affected if a nearby system fails and the effluent ponds on or just below the soil surface.

The definition of septic system failure has been debated for years. As of October 2014, a workgroup consisting of members from the Michigan Association of Local Health Administrators and from EGLE came to an agreement on what septic system failure means. The definition of a septic system and of system failure were determined to be, "A system consists of a tank or tanks, an adsorption system and associated appurtenances.
The following classifies when a system is considered to have failed:

- sewage backs up into the home or structure,
- discharges to the ground surface, contaminates surface water or drinking water supplies,
- any part of the system is bypassed,
- the system is the source of an illicit connection,
- there is an absence of absorption system,
- or there is a structural failure of septic tank or other associated appurtenances."

The new definition of failure was used by local health departments starting in January 2015.
According to a 2002 USEPA study, septic systems fail at a rate that ranges between 10 and 20 percent each year. According to 2008 Watershed data, there were 570 homes with septic systems in the Watershed, meaning that at the time, about 144 systems could have been failing. Since that time, the threat of septic system failure has only increased. There have been more recent studies conducted by the EGLE in regard to septic system failure.

Starting in 2009, failed system data collection by local health departments began and continued for at least five years. The data was submitted to the EGLE, who processed the data in order to understand the rate of failure in Michigan. According to the Michigan Statewide Failed Sewage System Evaluation Summary Reports from 2013, 2014 and 2015, there were 328 reported failing septic systems within the District Health Department #10's jurisdiction, in which the Portage Lake Watershed is a part of. The actual number of failing septic systems is likely much higher than the reported. Of the reported, residential, failing septic systems, 99.4% were at single-family

[8] Tanks and pipes buried in the ground can be expected to last 20 to 30 years before they begin to deteriorate and require repair or replacement. The soil itself does not "wear out," but its capacity to absorb and assimilate pollutants can become inadequate.

residences. The failing systems tended to have smaller tanks, where 50.9% of the failed systems had tanks with a capacity between 1,000 – 1,500 gallons, and 25.0% had a capacity of <1,000 gallons, **Figure 113**.

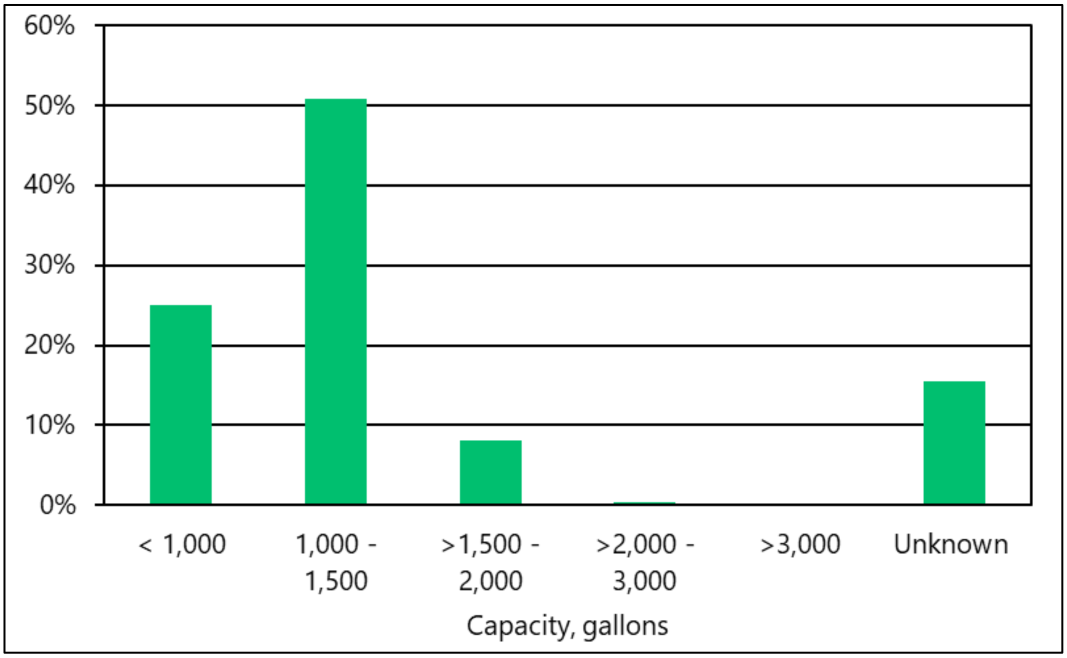

Figure 113. *Septic tank capacity of failed systems 2013 - 2015*

SOURCE: Michigan Statewide Failed Sewage System Evaluation Summary Reports from 2013 - 2015, MDEQ.

The EGLE study also looked into the age, seasonal high-water table, and probable causes of system failure. **Figure 114** shows the majority of failed systems were either 31 years and older, or their age was unknown. The failed systems also tended to be in areas with deeper seasonal high-water marks, where 64.0% of the faulty systems had a seasonal high-water mark either 48 inches below grade or deeper, **Figure 115**. The probable causes for system failure are noted below in **Figure 116**. According to the EGLE data, systems most often failed due to soil clogging, root intrusion, hydraulic overload, or an undersized system.

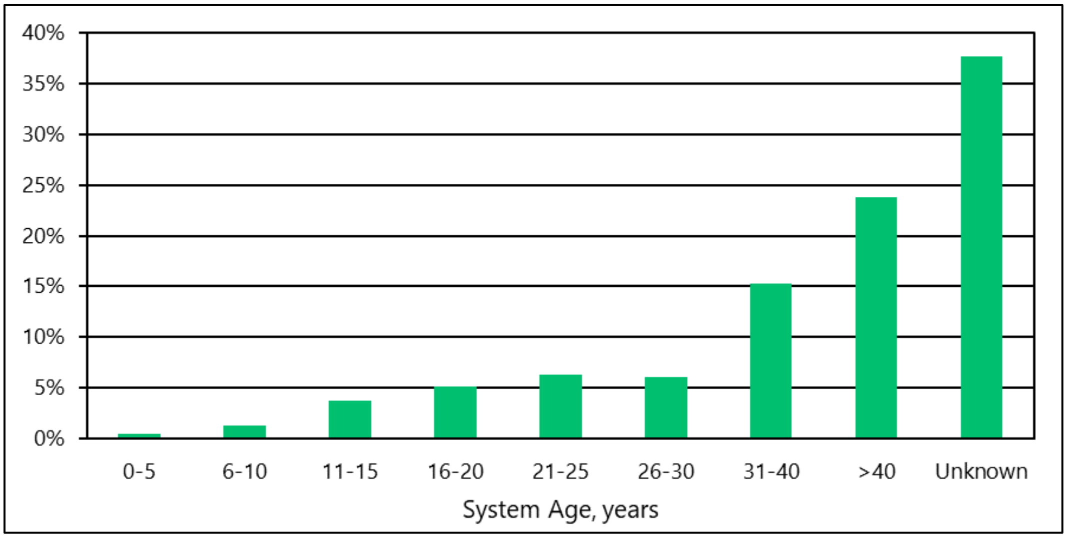

Figure 114. *Septic system age of failed systems 2013 - 2015*

SOURCE: Michigan Statewide Failed Sewage System Evaluation Summary Reports from 2013, 2014 and 2015, MDEQ.

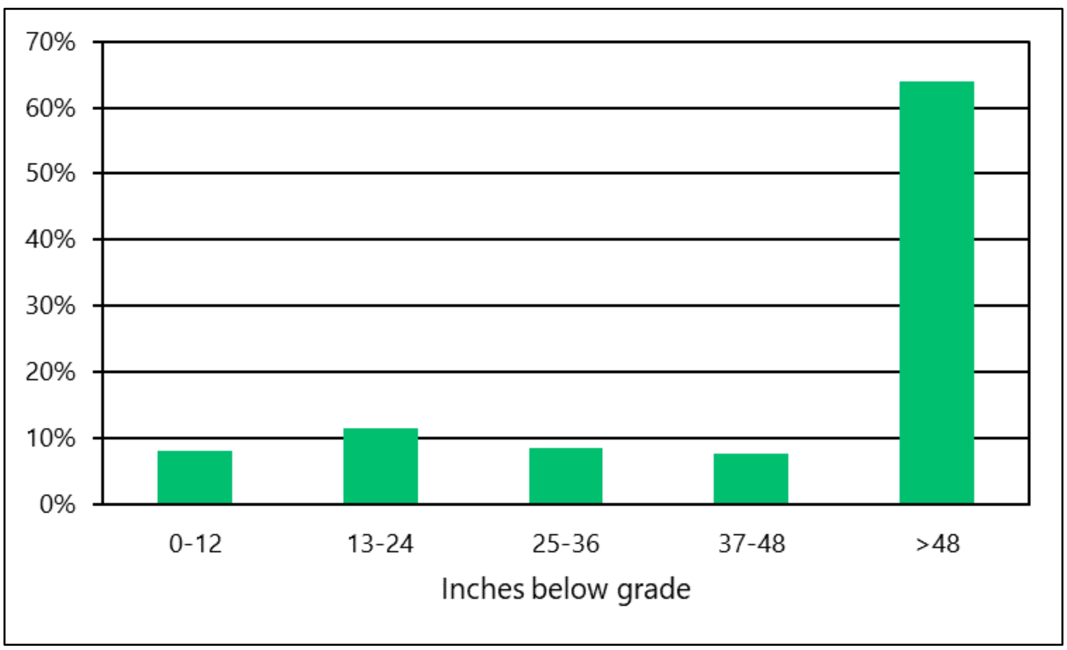

Figure 115. *Seasonal high-water table of failed systems 2013 - 2015*

SOURCE: Michigan Statewide Failed Sewage System Evaluation Summary Reports from 2013 - 2015, MDEQ.

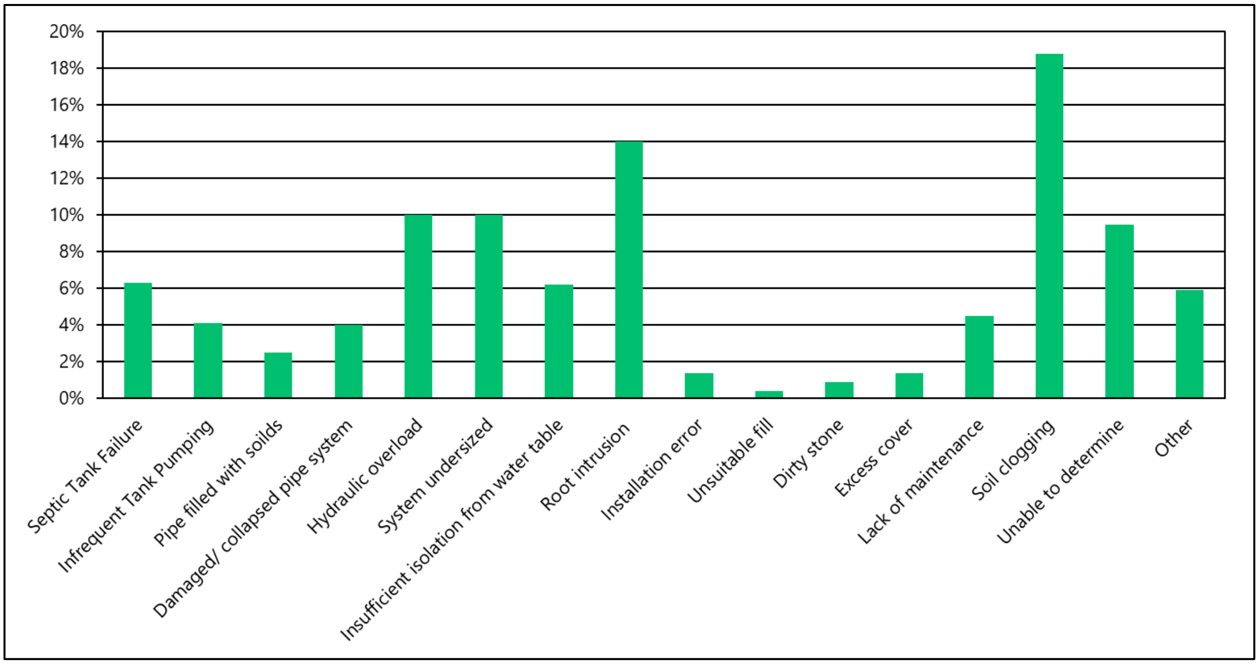

Figure 116. *Probable cause(s) of failure of failed systems 2013 - 2015*

SOURCE: Michigan Statewide Failed Sewage System Evaluation Summary Reports from 2013 - 2015, MDEQ.

As the land use projection maps in the Watershed Description section suggest, demand to build homes along Portage Lake and other waterways in the Watershed will continue to increase. Residents will also continue the trend of converting existing waterfront part-time dwellings to permanent residences. Many of these homes were built with septic tanks/tile fields that were adequate for limited summer use but not for year-round residence. Small waterfront lots with a high-water table and/or poorly draining soil conditions are not well suited to septic systems in any case. When a cottage once used only a few weeks a year becomes a permanent home, the addition or increased use of automatic dishwashers, garbage disposals, and washing machines can overload the system. Systems will also age, exceeding their design life and increasing the failure rate.

Identifying and eliminating these possible failing septic systems will help control pathogenic bacterial contamination of groundwater and surface water supplies in the Watershed from untreated wastewater discharges. The highest priority for protecting water users from potential human disease threats associated with human or animal waste is monitoring of the areas with relatively high-density development around the lake and adjacent to streams that are not currently served by a sanitary sewer system. This includes virtually all of the Portage Lake Watershed, as well as the near lake outlets of significant tributary streams, with the exception of the area served by the Village of Onekama sanitary sewer system. As noted in the EGLE Statewide Failed Sewage System Evaluation reports, density, age, number of people served, size of the drainage field, soil type, depth of groundwater and the waste streams entering septic tank/tile fields are all factors in determining the effectiveness of existing systems to prevent pathogens from entering surface waters.

The capacity of existing OSDSs to treat increased waste loads to control both pathogens and nutrients, particularly phosphorus, is limited. The 2008 plan called for a series of iterative steps, including providing better information to property owners on the maintenance and use of OSDSs, systematic monitoring of *E. coli*, phosphorus, nearshore algal growth and an advocacy for time-of-sale OSDS inspections. These steps provided the information necessary to determine if a sanitary sewer system is needed for the more densely developed areas adjacent to Portage Lake and its tributary streams in order to ensure the protection of public health and reduce pollutant loading to surface and groundwater.

E. coli monitoring has taken place on Portage Lake since 2004 and has been consistently monitored through 2017. Data has been collected by various entities for different reasons. Data has been collected by the District Health Department #10 at the Onekama Township Beach since 2004 through 2017 in the months June to September. Additional *E. coli* data has been analyzed by the Great Lakes Water Quality Lab at the Village Park Beach from 2010 – 2016, except for 2012, typically in the months of June, July and August. During annual lake monitoring for the State of the Lake Reports, *E. coli* samples have also been periodically sampled and analyzed at the following locations: Schimke Creek, Covenant Camp, the marina, Portage Point Inn, Little Eden Camp, and the Village Park and beach. Traditionally, *E. coli* results have been very low, and well under the total body contact limit of 300 CFU/100 mL of sample. For a compilation of *E. coli* results, please refer to the water quality section of the Watershed Management Plan.

The L-THIA model is able to estimate the annual loading of fecal coliform, which only comes from human and animal fecal waste, based off of land use within the Watershed; results are shown in **Table 29**. Units of millions of coliform/yr (M coliform/yr) indicate the average bacterial count distributed throughout the total amount of annual runoff during the year. The annual runoff values can be found in **Table 33**. For perspective, for the total fecal coliform loading from all sources and the associated runoff for the 2040 data, for each cubic foot of water there are only 5,300 coliforms. The average annual fecal coliform loading is expected to increase by 179 percent from 96,031 millions of coliform/yr in 2016 to 267,851 millions of coliform/yr by 2040. As a general trend, the average loading between sources is decreasing. However, high density residential and low density will be increasing by around 2,365 and 451 percent respectively.

Table 29. *Average annual fecal coliform loading (millions of coliform/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006 NLCD)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (M coliform / yr)	Acres	Loading (M coliform / yr)	Acres	Loading (M coliform / yr)	Acres	Loading (M coliform / yr)
Commercial	59	3,046	131	6,775	NA	NA	193	9,967
High Density Residential	672	45,280	58	3,910	89	5,996	2,194	147,832
Low Density Residential	1,043	13,172	1,664	21,002	618	7,802	3,403	42,967
Forestland	5,494	112	5,667	116	5,292	108	3,408	69
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	82	2,694	113	1,802	75	1,532	63
Agricultural	3,593	89,065	2,729	67,642	3,310	82,050	2,701	66,953
Total	**15,745**	**150,757**	**15,793**	**99,558**	**11,781**	**96,031**	**15,745**	**267,851**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD 2006, Natural Resources Conservation Service 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: M denotes millions of coliform, Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

The second priority noted in the 2008 plan was to begin to monitor land uses that could contribute human or animal waste, such as stormwater discharges from the Village of Onekama and runoff from agricultural animal operations. In order to assist with the identification of areas of concern, a Stormwater, Asset Management, and Wastewater (SAW) Grant was obtained by the Township of Onekama in November 2017 and work will be completed in November 2020. The SAW grant allows for the analysis of the township's storm infrastructure and may provide insight to problematic areas within the system, which could lead to degraded water quality in Portage Lake. The Village of Onekama also received a SAW grant in 2018 to look specifically at the Village infrastructure.

CONTAMINANTS IN FISH

Based upon state testing of contaminants in fish from Portage Lake in 1990 and again in 2004, air deposition from sources outside of the Watershed represents the greatest threat to increases in contaminants found in Portage Lake fish (MDEQ, 2007e). While PCB contaminant levels in fish have declined statewide following state and federal controls on the use and disposal of this industrial chemical, mercury levels have remained high. Support for regional efforts to control sources of mercury emissions, particularly related to the burning of coal, is important to the Portage Lake Watershed. Historical industrial operations adjacent to Portage Lake may have resulted in the discharge of toxic materials that could result in the contamination of fish and/or direct exposure to recreational users. While no specific information was uncovered during the development of this plan, residents of the area have suggested that the operation of a tannery, railroad spills of hazardous materials, and/or chemicals associated with wood processing facilities need to be investigated using a more thorough examination of historical information.

EMERGING CONCERNS IN SURFACE WATER

Pharmaceutical and Personal Care Products

Pharmaceutical and Personal Care Products (PPCPs) are defined by the EGLE as "any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock." (e.g. prescription and over-the-counter drugs, fragrances, UV-protecting agents, etc.) The EGLE listed this classification of compounds as emerging contaminants of concern, meaning they are "a chemical or material that is characterized by a perceived, potential or real threat to human health or the environment."

No research has been conducted to quantify the presence of PPCPs within the Portage Lake Watershed. Research conducted by the University of Wisconsin has confirmed concentrations of environmental concern 3.2 km off the coast of Milwaukee in Lake Michigan. These results show that the dilution offered by the Great Lakes may not suffice to neutralize this threat to environmental health.

Since these compounds were designed to function in physiochemical processes, it is unknown what aquatic organisms will be affected and in which way it will affect them. The elevated levels (part per trillion), while not lethal to aquatic organisms, may result in unknown behavioral, physiological and morphometric changes over time. This growing issue may have direct effects to Portage Lake due to the channel that connects it to the waters of Lake Michigan.

The process in which these substances enter the environment generally involve household disposal down toilets and drains. There is no current legislation that requires Wastewater Treatment Plants (WWTPs) or septic systems to treat for this broad range of compounds in the State of Michigan. To combat this emerging contaminant, individuals should begin disposing of drugs at designated locations. The closest locations for responsible disposal are as follows:

1. Manistee County Sheriff's Office (24-Hour Access): 1525 Parkdale Ave., Manistee, MI 49660

2. City of Manistee Police Department: 70 Maple St., Manistee, MI 49660

3. Benzie County Sheriff's Office (24-Hour Access): 505 South Michigan Ave., Beulah, MI 49617

Microplastics

Microplastics are a popular topic regarding ocean pollutants, however, they are being found in the Great Lakes and are the most prevalent marine debris according to NOAA. Microplastics are defined as pieces of plastic that are less than five millimeters (mm) in length. These plastics come from a variety of sources including the breakdown of larger plastic pieces discarded in our waters, plastic manufacturing processes, and from health and beauty products (e.g. toothpastes, hand soap, and exfoliating scrubs). In 2015, microplastics were banned within the United States in cosmetic and personal care products, but they still pose a threat to our environment. These small pellets can be mistaken as food for aquatic wildlife and cause a variety of health problems, even death.

Per- and Polyfluoroalkyl Substances (PFAs)

Per- and Polyfluoroalkyl substances, commonly referred to as PFAs, are a manmade compound used in a variety of consumer products such as nonstick cookware, waterproof apparel, and stain repellants. They we also previously used in firefighting foams. Due to their wide use and persistence in the environment, they are appearing at greater concentrations in groundwater and surface water. The United States Environmental Protection Agency set a combined Lifetime Health Advisory level of 70 parts per trillion (ppt) for two specific PFAs in drinking water (perfluorooctanoic acid and perfluorooctane sulfonic acid). These compounds are of concern as they bioaccumulate in wildlife and humans and can cause adverse development and reproductive effects. Michigan is one of several states that has set additional guidelines on concentration in groundwater and or drinking water.

Ecosystem Health

The threats to water quality essential to the protection of existing fish and wildlife populations and related angling and hunting opportunities are primarily related to changes in the trophic status, or productivity level of Portage Lake. Alterations in the remaining natural habitats essential to reproduction, survival and growth of fish and wildlife and related food organisms are also a significant threat in both Portage Lake and its tributaries. Cool, high-quality groundwater is an essential factor in maintaining current protected uses related to coldwater fish species in both Portage Lake and in the coldwater tributaries to the lake. Any significant changes in the quantity or quality of groundwater are a threat to existing uses.

EUTROPHICATION

Phosphorus is the limiting nutrient in Portage Lake. Incremental increases in phosphorus loading over time can significantly alter the productivity level of Portage Lake and result in changes in water chemistry (e.g. decreased dissolved oxygen below acceptable levels) and increased algal and rooted plant growth (i.e. nuisance algal blooms and excessive rooted aquatic plant growth), thus decreasing the quality of fishing, boating, swimming, and other water-related activities. Phosphorus concentrations are monitored in Portage Lake along with annual loading from some of the tributaries, see **Figures 40**, **41**, **42**, **53**, **56**, and **59**. Increases in urbanization and other significant land use changes have been shown to be an important factor in the eutrophication, also known as aging or increased productivity, of other inland lakes. The application of best management practices to control nutrient loadings, as well as sediments and other contaminants in runoff, is an important long-term strategy to reduce this threat. Based on land use change and population growth estimates, phosphorus will continue to be a significant threat that needs to be monitored and for which corrective action must occur as needed.

Table 30, below, shows the estimated phosphorus loading on a watershed-wide scale for each land use data set analyzed using L-THIA. This information was derived from the existing land use types and projected increase in development based on modeling. Common sources of nutrient loading include riparian septic systems, fertilizer use, livestock wastes, and stormwater runoff. The total phosphorus runoff from the Watershed is projected to hit a total of 2,027 lbs/yr by 2040. This is around a 106 percent increase from 2016. While the phosphorus loading from agricultural land use will remain high, an increase in high density and low density residential land use are the two main contributing factors to the rise in phosphorus runoff.

Table 30. *Average phosphorus loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Runoff Volume (lbs/yr)	Acres	Runoff Volume (lbs/yr)	Acres	Runoff Volume (lbs/yr)	Acres	Runoff Volume (lbs/yr)
Commercial	59	29	131	68	NA	NA	193	100
High Density Residential	672	282	58	22	89	35	2,194	925
Low Density Residential	1,043	81	1,664	130	618	47	3,403	267
Forestland	5,494	1	5,667	1	5,292	1	3,408	1
Water/ Wetlands	2,938	0	2,851	0	670	0	2,314	0

Table 30 cont. *Average phosphorus loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Runoff Volume (lbs/yr)	Acres	Runoff Volume (lbs/yr)	Acres	Runoff Volume (lbs/yr)	Acres	Runoff Volume (lbs/yr)
Grass/Pasture	1,946	1	2,694	1	1,802	1	1,532	1
Agricultural	3,593	977	2,729	742	3,310	900	2,701	734
Total	**15,745**	**1,371**	**15,793**	**964**	**11,781**	**984**	**15,745**	**2,027**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Because septic systems are of great concern in the Watershed, an additional loading calculation was made for this particular source. It is difficult to estimate pollutant loading from septic systems. Many factors need to be considered, including soil type, age, condition, use of system, and proximity of system to groundwater and surface water. A rough estimate, however, can be calculated using Census information and data from previous studies.

In the Portage Lake Watershed, 60 percent (570) of the occupied housing units are outside the public sewer "envelope" of the Village of Onekama, and an average of 2.3 people live in each household (U.S. Census Bureau 2000). The USEPA estimates average daily wastewater flows of approximately 50 to 70 gallons per person per day (2002). The USEPA has also documented studies that estimate residential septic effluent pollutant levels (2002). The highest value documented among these studies was used to estimate the maximum estimated phosphorus pollutant load in the Portage Lake Watershed, **Table 31**. If, based on USEPA estimates, 20 percent of the septic systems in the Watershed fail, and the functioning systems are 85 percent effective in removing phosphorus, a maximum of 1,950 pounds could be released from OSDSs annually, **Table 31**. If even half of that amount reaches Portage Lake, septic systems are a significant source of phosphorus in the watershed. As systems age, homes expand, and amenities such as washing machines and dishwashers are added, this source must be addressed in the future.

Table 31. *Residential, conventional septic system pollutant load estimates, phosphorus, 2000*

Variable	Failed septic systems[1]	Functioning septic systems[1]	Total
Households on septic	114	456	570
Residents on septic[1]	262	1,049	1,311

Table 31 cont. *Residential, conventional septic system pollutant load estimates, phosphorus, 2000*

Variable	Failed septic systems[1]	Functioning septic systems[1]	Total
Total effluent generated in watershed[2]	25.4 million L/yr. (6.7 million gal/yr.)	101 million L/yr. (26.8 million gal/yr.)	126 million L/yr. (33.4 million gal/yr.)
Effluent phosphorus concentration	21.8 mg/L	21.8 mg/L	21.8 mg/L
Total phosphorus in effluent	1,220 lbs/yr	4,880 lbs/yr	6,100 lbs/yr
Maximum estimated pollutant load[3]	1,220 lbs/yr	730 lbs/yr	1,950 lbs/yr

SOURCE: Public Sector Consultants Inc., 2007, with data from USEPA (pollutant load, average gallons of wastewater generated/person/day), 2002 and U.S. Census Bureau (number of households, average household size), 2000.

[1]Assumes 20 percent failure rate, USEPA, 2002.

[2]Assumes 70 gallons/person/day (265 L), USEPA, 2002.

[3]Assumes failed systems are 0 percent and functioning are 85 percent effective in reducing phosphorus, USEPA, 2002.

The first priority for nutrient control, as it is for protection of human health, is prevention of increased phosphorus loadings from existing septic tank/tile field onsite disposal systems. The iterative approach outlined in the previous section and in the original Watershed Management Plan works to address public health threats and the threat of nutrient loadings from OSDSs, which only increases over time. A second priority for phosphorus control is reduced use of fertilizers applied to lawns and gardens adjacent to lakes and streams. Education for riparian landowners on the use of low- or zero-phosphorus fertilizers to maintain lawns can result in reduced nutrient loadings. In 2010, the State of Michigan passed a statewide ban on phosphorus. The measure took effect on January 1, 2012. This ban addressed land fertilizers but excluded farms. As shown previously in **Figure 42**, phosphorus concentrations in both deep basins of Portage Lake displayed significant reductions and has maintained low, consistent concentrations since around 2013.

A third priority for phosphorus control is the use of best management practices to reduce nutrient loadings from stormwater in the Village of Onekama and other stormwater systems that discharge directly to the lake or its tributaries. Stormwater runoff has the potential to carry with it a wide range of non-point source pollutants. Finally, previous studies have identified agricultural runoff as a contributor of animal waste and nutrients, including phosphorus, in the lower portion of Schimke Creek, a tributary to Portage Lake. Because of the predominance of permeable sand and gravel glacial deposits, surface water runoff in the Portage Lake Watershed is minimal and the length and size of tributary streams reflect the fact that most water entering Portage Lake and its coldwater tributaries is from groundwater sources rather than from surface water runoff. While significant changes in agricultural practices or other land use changes could pose a threat if stormwater runoff were conveyed directly to surface waters, agricultural sources of nutrients in the Portage Lake Watershed are significantly fewer than those found where agricultural drains are constructed to move water off poorly drained soils for discharge to surface waterways. In the Portage Lake Watershed, agricultural land uses—and for that matter, land use changes that occur significant distances from surface water courses—are not likely to be a significant source of phosphorus loadings to Portage Lake. Nevertheless, it would be good practice to monitor potential agricultural sources of nutrients that are adjacent to waterways.

It is important to understand the changes in loading of nitrogen, as well as phosphorus, over time because it plays in productivity. As estimated by the L-THIA model, the nitrogen loading to the Portage Lake Watershed, shown in **Table 32**, is projected to increase by around 97 percent from 3,467 lbs/yr in 2016 to 6,831 lbs/yr by 2040. Similar to phosphorus, it is estimated that loading will decrease from agricultural sources over time and by 2040, high density residential will be the greatest source of nitrogen loading. Nitrogen concentrations are being monitored in Portage Lake, see **Figures 40** and **41**, to determine if additional loading to the lake is occurring.

Table 32. *Average nitrogen loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Commercial	59	128	131	288	NA	NA	193	424
High Density Residential	672	904	58	76	89	119	2,194	2,958
Low Density Residential	1,043	262	1,664	418	618	155	3,403	858
Forestland	5,494	86	5,667	89	5,292	82	3,408	52
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	62	2,694	87	1,802	58	1,532	48
Agricultural	3,593	3,314	2,729	2,516	3,310	3,053	2,701	2,491
Total	**15,745**	**4,756**	**15,793**	**3,474**	**11,781**	**3,467**	**15,745**	**6,831**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Habitat Degradation

The shoreline of Portage Lake and the downstream sections of some tributaries have been significantly altered since development first occurred in the late 1800s. The remaining undeveloped shoreline and wetlands are critical to maintaining resident, self-sustaining populations of warmwater and coldwater fish populations in the lake, and the trout and salmon in the coldwater tributaries. The number one priority for habitat protection is preservation and enhancement of the remaining wetlands and undeveloped riparian lands that support a diverse habitat for various species and help capture nutrients and sediments from stormwater and snow melt from impervious upland areas. The second priority is protection of the undeveloped areas riparian to Portage Lake and tributaries to preserve to the extent possible the nearshore littoral zone in the lake and a vegetated buffer strip along tributaries.

Invasive plant species within Portage Lake (i.e. Eurasian watermilfoil) and in contiguous wetlands (i.e. purple loosestrife and *Phragmites sp.*) threaten the biological diversity needed to support fish and wildlife populations and surface water recreational uses. Physical, biological, and/or chemical controls may be appropriate if future monitoring indicates that the spread of these species currently present in Portage Lake threatens existing uses. Since 2009, the Township Invasive Species Committee has been overseeing and reporting on the chemical controls being utilized to effectively manage the spread of invasive species on Portage Lake.

Increased stormwater runoff can also pose a threat to the health of the Portage Lake Watershed ecosystem by causing increased stream bank erosion and degradation of instream habitat. An overall watershed runoff analysis was completed using the L-THIA model. **Table 33** depicts estimated runoff amounts for past and future conditions. By 2040, the total runoff volume will almost triple from the 2016 values and double from the 2001 values. The greatest change in runoff over time is due to the significant increase in high and low density residential development, with the predicted runoff from these two land uses combined in 2040 being greater than the total runoff volume in any of the previous years.

Table 33. *Average annual total runoff volume (acre-feet) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Runoff Volume (acre-ft/yr)	Acres	Runoff Volume (acre-ft/yr)	Acres	Runoff Volume (acre-ft/yr)	Acres	Runoff Volume (acre-ft/yr)
Commercial	59	36	131	79	NA	0	193	117
High Density Residential	672	183	58	16	89	24	2,194	597
Low Density Residential	1,043	53	1,664	85	618	31	3,403	173
Forestland	5,494	46	5,667	47	5,292	44	3,408	29
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	34	2,694	46	1,802	31	1,532	26
Agricultural	3,593	277	2,729	210	3,310	255	2,701	208
Total	**15,745**	**628**	**15,793**	**484**	**11,781**	**386**	**15,745**	**1,150**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Acre-ft = volume of water necessary to cover one acre to a depth of one foot (1 acre-ft = 43,560 ft^3).

Sedimentation has not been reported as a major, recurring problem in the lake or in its tributaries. However, lake access areas, bridge crossings, and similar activities that disturb the shoreline have the potential to cause erosion and add sediments and, at least in localized areas, impair benthos habitat. Increases in stormwater runoff volumes can also have an impact. Monitoring of lake access areas, stream road crossings, and other shoreline disturbance activities to detect significant erosion problems and encouraging the application of best management practices by responsible landowners/managers can help to minimize the threat of sedimentation and resulting impairment to aquatic habitats. The L-THIA model was also used to calculate the average annual suspended solids loading, **Table 34**, which is expected to increase by around 104 percent from 2016 to 2040. The two biggest factors contributing to the increase in loading are the high and low density residential land use, which combined, increases loading by almost 80,000 lbs/yr between 2016 and 2040.

Table 34. *Average annual suspended solids loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Commercial	59	5,390	131	11,990	NA	NA	193	17,640
High Density Residential	672	20,420	58	1,762	89	2,704	2,194	66,670
Low Density Residential	1,043	5,940	1,664	9,470	618	3,517	3,403	19,377
Forestland	5,494	123	5,667	128	5,292	119	3,408	76
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	90	2,694	126	1,802	83	1,532	70
Agricultural	3,593	80,637	2,729	61,241	3,310	74,286	2,701	60,618
Total	**15,745**	**112,600**	**15,793**	**84,717**	**11,781**	**80,709**	**15,745**	**164,451**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Groundwater

The greatest threats to groundwater in the Watershed are related to the unlawful releases of contaminants already identified in this Watershed Plan, and to the potential release of contaminants from spills and discharges to the surface that either gain direct access to groundwater or enter otherwise protected groundwater aquifers through improperly plugged and/or abandoned hydrocarbon and mineral wells or domestic water wells. While existing regulations protect groundwater from permitted waste discharges, leaking underground storage tanks, and other nonpoint discharges from land uses, hazardous materials are still a threat the groundwater resources in the Watershed. Groundwater is virtually the only source of potable water in the Watershed and it is a major contributor of cool, clean water to Portage Lake and tributary streams. Groundwater pollution is not only a threat to drinking water, but to protected uses in surface waters. **Figure 117** below shows the location and status of the leaking underground storage tanks (LUST) in the Portage Lake Watershed. Closed LUST sites are potential or past sites of contamination that have been addressed. Active LUST sites are locations where there is at least one tank at the facility that is not closed in place or removed but is not leaking. These active LUST sites still need to be addressed to ensure that discharges to groundwater or surface water do not occur in the future, but do not pose a direct threat at this time.

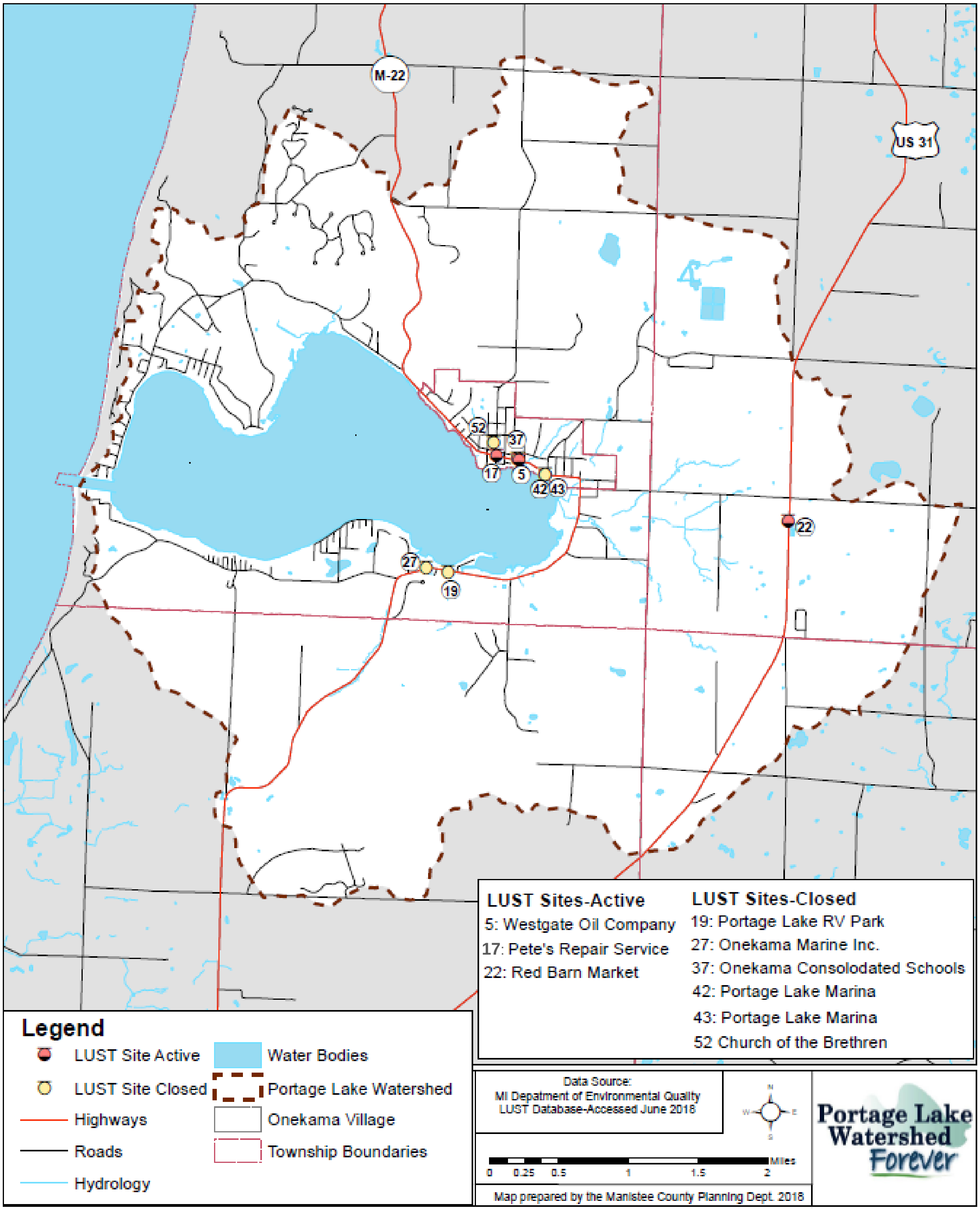

Figure 117. *Portage Lake Watershed leaking underground storage tanks EGLE (LUST) status*

SOURCE: MDEQ LUST Database-Accessed June 2018. Map prepared by the Manistee County Planning Dept. 2018.

Contaminants from spills and discharges to the surface can gain direct access to groundwater or enter otherwise protected groundwater aquifers through improperly plugged and/or abandoned hydrocarbon and mineral wells or domestic water wells. This is a considerable threat, given the fact that Manistee County ranks second in the state in the total production of both oil and natural gas that began in Michigan in 1925. **Figure 118** shows the large number of wells drilled in the Portage Lake Watershed.

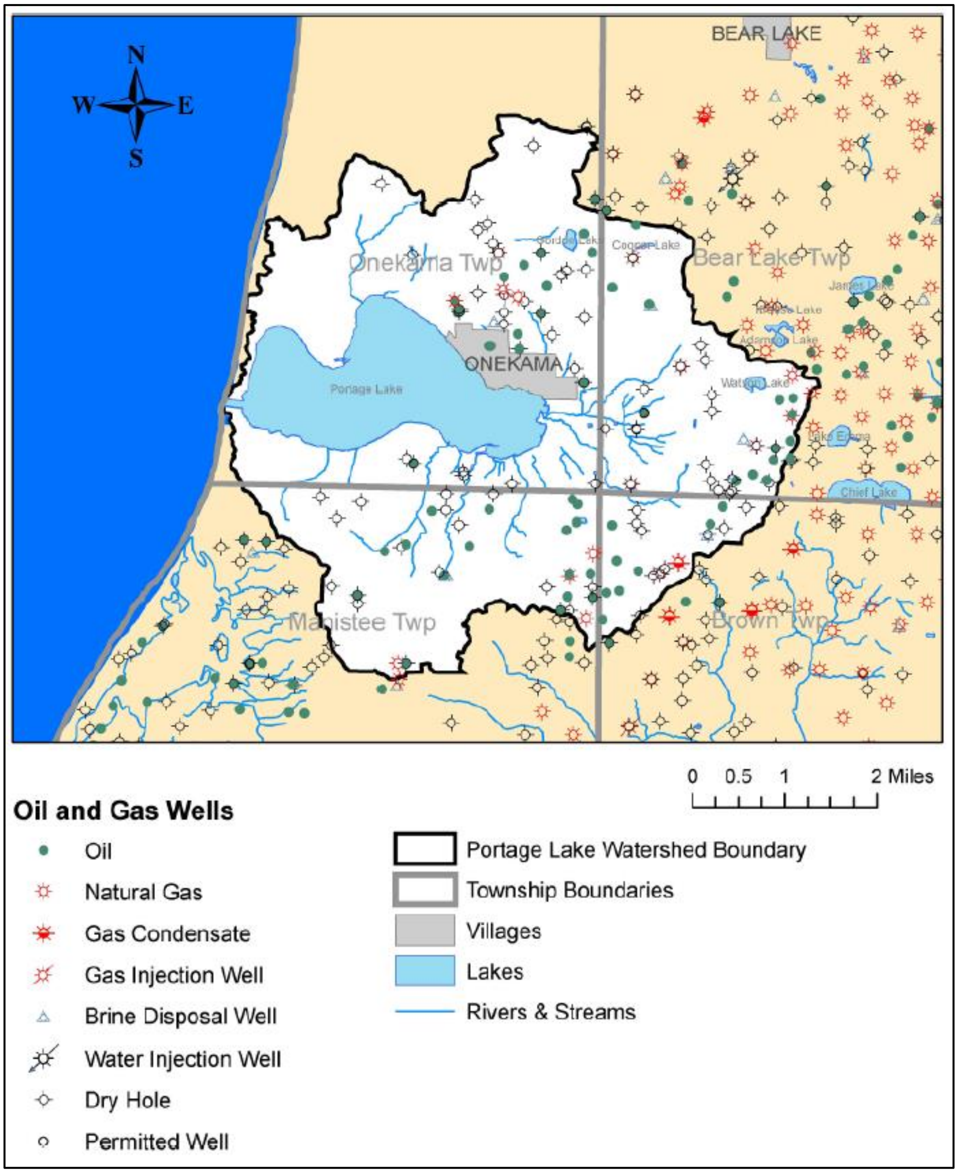

Figure 118. *Location of oil and gas wells drilled in Portage Lake Watershed*

SOURCE: Public Sector Consultants Inc., 2007, with data from MDEQ, 2000, Locations – Oil and gas wells.

Table 35, below, provide details about Part 201 sites in the Watershed, the source of pollution and the pollutants associated with each site. A map of these sites is shown in **Figure 119**. It is important to note that the Part 201 list does not include all of the sites of contamination that are subject to regulation under Part 201 because owners are not required to inform the EGLE about the sites and can pursue cleanup independently. Sites of environmental contamination that are not known to the EGLE are not on the list, nor are sites with releases that resulted in low environmental impact, which includes delisted sites. As stated above, oil and gas extraction are common activities in the Watershed and are the source for over half of the part 201 sites.

Table 35. *Part 201 sites in the Portage Lake Watershed*

Site	Latitude	Longitude	Source	Pollutant
Hadaway 2-2A (PN 30540)	44.33702	-86.2113	Oil & Gas Extraction	Benzene; Toluene; Xylenes
Hansen 1-5 (PN 32203)	44.33887	-86.1573	Oil & Gas Extraction	Benzene; Toluene; Xylenes
Acker #1-24 (PN 33033)	44.38344	-86.184	Oil & Gas Extraction	Benzene; Toluene; Xylenes
Odgers #1-24 (PN 36608)	44.37814	-86.1941	Oil & Gas Extraction	Benzene; Toluene; Xylenes
Res Well Farr Rd Onekama Twp	44.3462	-86.2035	Unknown	Chlorine
Onekama Res Spill Main St	44.36341	-86.2039	Private Households	Fuel oil
Res Well Bear Lake Road	44.37597	-86.1673	Paper and Allied Products	Nitrate
Village of Onekama WWTP	44.33702	-86.2113	Oil & Gas Extraction	Benzene; Toluene; Xylenes

SOURCE: Spicer Group Inc., 2019, EGLE Sites of Contamination Environmental Mapper Part 201 Excel File Accessed June 2019.

Pollution prevention education programs targeted to commercial and public facilities that store, handle and use hazardous materials can be an effective means to protect groundwater. Providing free or subsidized household hazardous waste disposal options for homeowners can reduce unacceptable disposal on the land. Inventorying and the proper closure of abandoned domestic and industrial wells can reduce the potential direct access to groundwater aquifers from contaminated surface runoff. A quick response and cleanup of leaking underground storage tanks and other known groundwater contamination sites can minimize the threat of groundwater pollution. Alerting Watershed property owners of low-cost or free water supply testing for various contaminants can also help detect and address potential threats to groundwater. The community uses the groundwater as their water supply since no public water supply is available making it even more important to address groundwater pollutant issues. **Figure 120** depicts the permitted drinking water wells within Portage Lake Watershed provided by the Michigan Department of Environment, Great Lakes, and Energy.

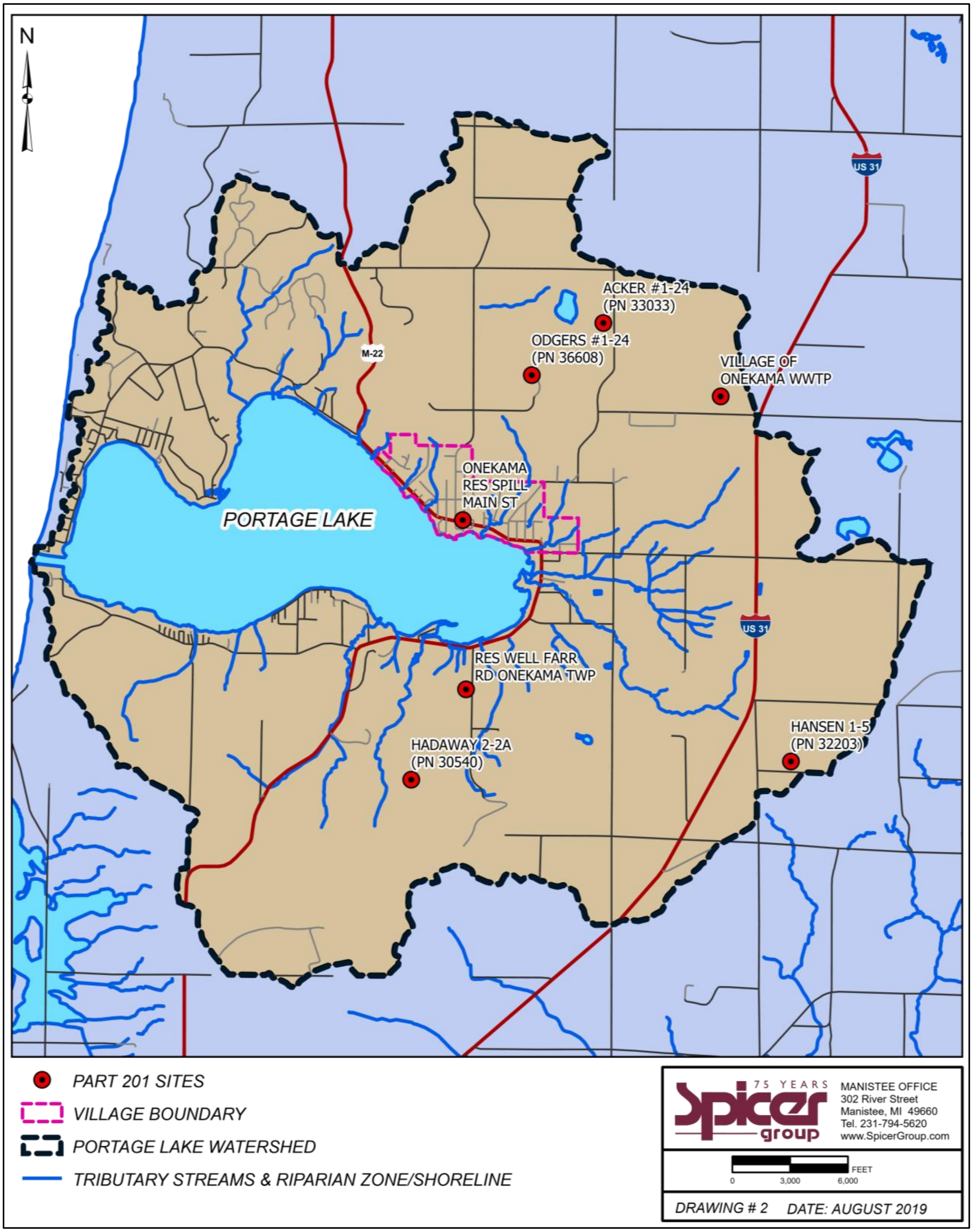

Figure 119. *Part 201 sites within Portage Lake Watershed boundary*

SOURCE: Spicer Group Inc., 2019, EGLE Sites of Contamination Environmental Mapper Part 201 Excel File.

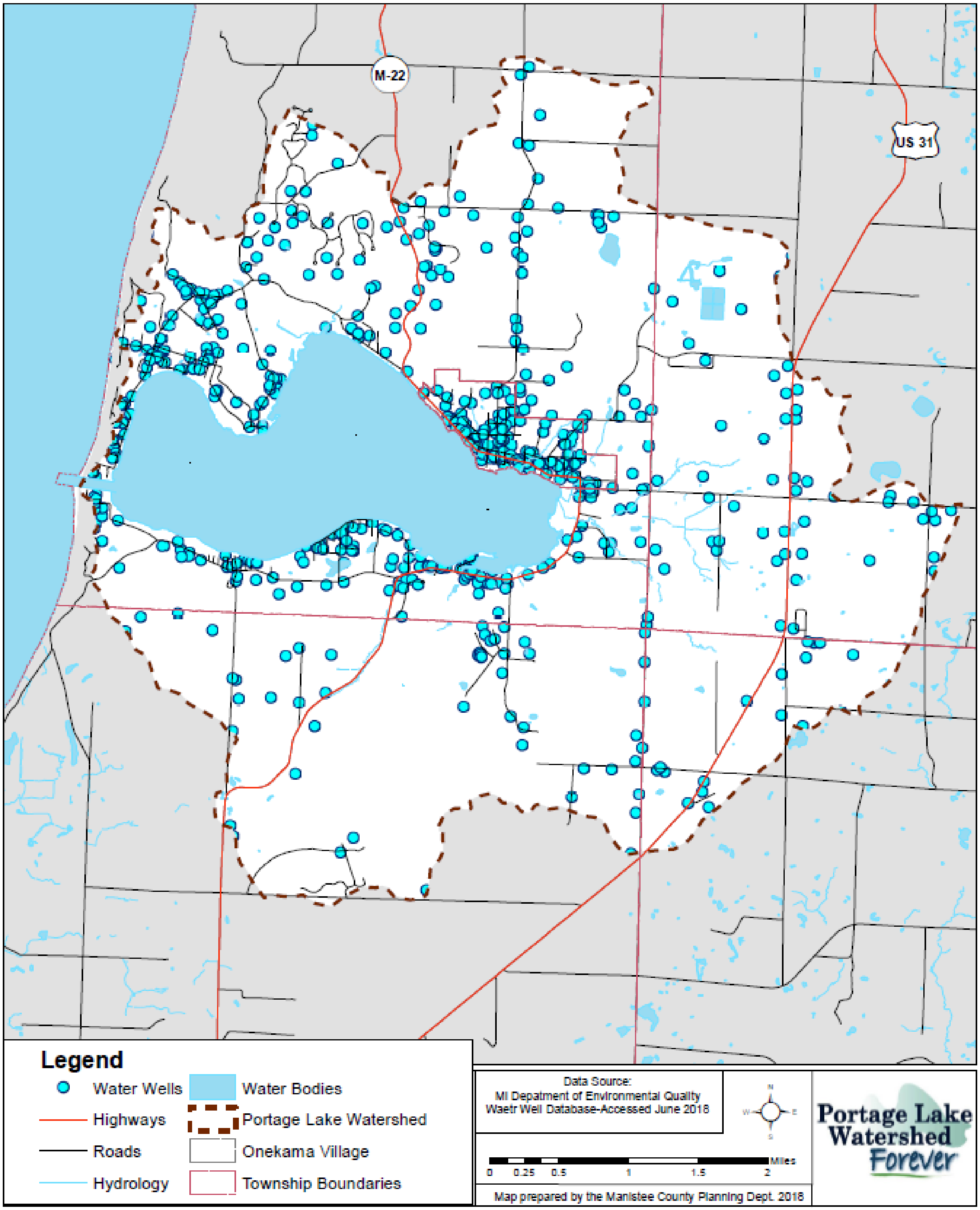

Figure 120. *Portage Lake Watershed EGLE permitted drinking water wells*

SOURCE: MDEQ Water Well Database-Accessed June 2018. Map prepared by the Manistee County Planning Dept. 2018.

Recreational and Fishing Access

The Portage Lake Channel provides a major attraction to residents and visitors who use Portage Lake as an access point to fish and boat on Lake Michigan. Recently a $6.6 million grant was obtained by the community to do major work on the channel structure and to dredge the channel. This work is anticipated to begin in 2019. This work will include any channel/ pier repairs, the dredging of the channel, and improving pedestrian access on both the north and south walls. Since Portage Lake is a "Harbor Refuge" the channel will be dredged to a depth of 16 to 18 feet rather than 12 feet depth for a "Recreational Channel". Once completed, these improvement to the channel will ensure that residents and visitors can take advantage of the many recreational activities provided by the channel in the years to come.

Surface water recreation in Portage Lake is dependent upon adequate and safe boat launching and docking facilities and public swimming and recreational areas. When water levels are at extremes (both low and high), current use of some facilities are limited and new or improved shore-based recreational facilities are needed to support existing and potentially expanded use, even during water level extremes. Contaminated sediments that require special handling and disposal can increase the cost of navigational dredging. There is no evidence, however, of contaminated sediments in the Portage Lake Channel. If actions called for in this plan are implemented to prevent hazardous materials from entering surface waters, there should be no increased costs associated with dredging sediments from the channel.

DESIRED USES

Desired uses of the watershed are those values identified by the community for protection. These uses expand beyond the uses specifically protected under surface water pollution-control laws and regulations that could be incorporated as part of the watershed plan. In the Portage Lake Watershed, the following desired uses were identified by stakeholders through interviews, focus groups and public meetings:

- Maintain existing undeveloped shoreline habitat
- Preserve diverse upland ecotypes
- Maintain scenic vistas
- Preserve examples of historic agricultural practices
- Identify, protect, and preserve culturally and/or historically significant buildings and sites

These uses are listed in **Table 36**, below, along with the location and purpose of the use, existing protections and programs, and potential additional protection and preservation approaches that can be expanded and/or documented with more detail as specific goals, objectives, and actions are identified as priorities.

Table 36. *Additional desired uses not protected under water quality regulations; location, purpose, and additional protections under consideration to preserve and protect these uses*

Desired Use	Location	Purpose	Applicable Laws/ Regulations/ Programs	Potential Additional Protections
Maintain existing undeveloped shoreline habitat	Riparian properties adjacent to Portage Lake and major tributaries	Preserve critical fish habitat, provide filter for land-based stormwater–runoff, maintain biological diversity/stability	State wetlands and inland lakes and streams laws and regulations	Education of owners, fee purchase, acquisition of conservation easements, local ordinance adoption related to new development, control of invasive plant species
Preserve diverse upland ecotypes	Portage Point Woods Preserve, others to be identified	Maintain ecological diversity; habitat for endangered, rare, and threatened species; study sites for understanding natural ecological functions/ processes	State/federal endangered and threatened species laws; state/local property tax exemption status for certain properties and land conservancy acquisitions/ easements	Education of owners, fee purchase, acquisition of conservation easements, local ordinance adopted related to new development
Maintain scenic vistas	Selected areas or zones	Continue to provide aesthetically pleasing landscape views for residents and visitors to the area	State and local highway rest areas, picnic areas and scenic turnouts, local parks, private land conservancies	Public information on scenic road touring, promotion with local and state highway departments, information/ education to landowners

Table 36 cont. *Additional desired uses not protected under water quality regulations; location, purpose, and additional protections under consideration to preserve and protect these uses*

Desired Use	Location	Purpose	Applicable Laws/ Regulations/ Programs	Potential Additional Protections
Preserve examples of historic agricultural practices	Selected areas or zones	Maintain examples of cultural heritage of region for the education/enrichment of residents and visitors	MDARD Centennial Farm Recognition Program, Farmland Preservation Act, land conservancy programs, accommodation of local zoning requirements	Promotion of locally grown agricultural products through markets days, farm roadside products tour information, featuring of locally produced food at nearby restaurants and markets
Identify, protect and preserve culturally and/or historically significant buildings and sites	Selected areas or zones	Increase awareness and understanding of Native American occupation and use of the area in pre-settlement period; maintain and develop historical examples of significant buildings and locations of interest to area residents and visitors	Need to identify	Partnering with Little River Band of Ottawa Indians and local historical groups to identify, interpret, and map sites of significance

SOURCE: Public Sector Consultants Inc., 2007.

PRIORITY AREAS

Priority areas in the Watershed were identified and mapped to help inform the development of goals and objectives and to guide future monitoring, planning, and management efforts. Priority areas are defined as areas that are important to protect and are susceptible to changes that would degrade habitat and water quality within the Watershed, **Table 37** and **Figures 121** and **122**. Priority areas are shown at two levels: general priority areas and specific priority areas. General priority areas represent broader areas where, in general, attention is needed while specific priority areas are the clearly identified priority locations within the Watershed where attention is needed.

Table 37. *Priority areas within the Portage Lake Watershed*

Priority Area	Potential Issues / Importance
General Priority Areas	
Shorelines and Riparian Zones	Loss of shoreline and riparian zones could lead to the loss of water quality improvement ability of these areas as well as habitat. Nonpoint source pollution could be coming from the shorelines in the form of sediment and excess fertilizer application on lawns. 1,000 ft-wide zone around entire lake; 100 ft-wide existing vegetated zone on either side of tributary streams; road lake access, and stream crossings.
Areas with Rates of High Groundwater Recharge	Groundwater is a primary source of water to both the tributary streams of Portage Lake and Portage Lake itself. Areas with highly permeable soils, including sandy soils, will recharge faster. It is important to make sure that the groundwater is not contaminated by leaking storage tanks, failing septic systems, chemical spills, contaminated soils, or application of chemicals for industrial or road maintenance purposes.
Wetland Areas	Wetlands provide aquatic and terrestrial habitat for a wide range of species, provide a base for the food chain, and improves water quality via filtration and contaminant uptake. Wetlands also assist in flood control and protection from erosion.
Potential Future Development	It is important that land within the Watershed that has the potential to be developed in the future is managed appropriately, so there are no adverse impacts on Portage Lake or its Watershed. Best management practices should be employed to minimize adverse impacts.
Steep Slopes	Maintain vegetated slopes in order to protect against erosion. Meaning, if any development is to occur on these slopes, great care is to be taken to prevent erosion. Additionally, managing forest pests and maintaining erosion-preventing vegetation is very important for preservation.

Table 37 cont. *Priority areas within the Portage Lake Watershed*

Priority Area	Potential Issues / Importance
General Priority Areas	
Threatened and Endangered Species Habitat	The Portage Lake Watershed has the capability to support a wide variety of endangered species thanks to the diverse ecosystems within it. Many of the species reside in wetland areas or areas near the water, so it is important that riparian zones and other habitat areas are preserved to support the species.
Forested Areas	Vegetation in a healthy forest is able to stabilize soils and prevent erosion as well as slow down runoff allowing for infiltration and therefore reducing pollutants entering surface waters.
Specific Priority Areas	
Eagle View Wetland Preserve and Portage Lake Wetland	As previously mentioned, wetlands have many benefits, including habitat areas, improvement of water quality, flood, and erosion control. Preserving acreage of wetlands is important for the health of Portage Lake and the Watershed.
Portage Point Wood Preserve	This preserve owned by the Nature Conservancy is a 120 acre preserve that contains a "back-dune" forest that was created from costal dune succession. This is a unique habitat that need to continue to be protected.
Stormwater Management Infrastructure/ Green Infrastructure	Currently, there is one raingarden and a system of detention basins in the Watershed, with funding being sought to install more green infrastructure. These areas should be preserved and maintained in order to prevent contaminated stormwater runoff from entering Portage Lake, its tributaries, or any other body of water within the Watershed (including Gordon and Cooper Lakes).
Historically Relevant Areas	Loss of these historically significant areas could mean a loss of local culture. This includes Portage Point Inn, Glen Park, and the Village of Onekama Park fountain.

SOURCE: Spicer Group Inc., 2019.

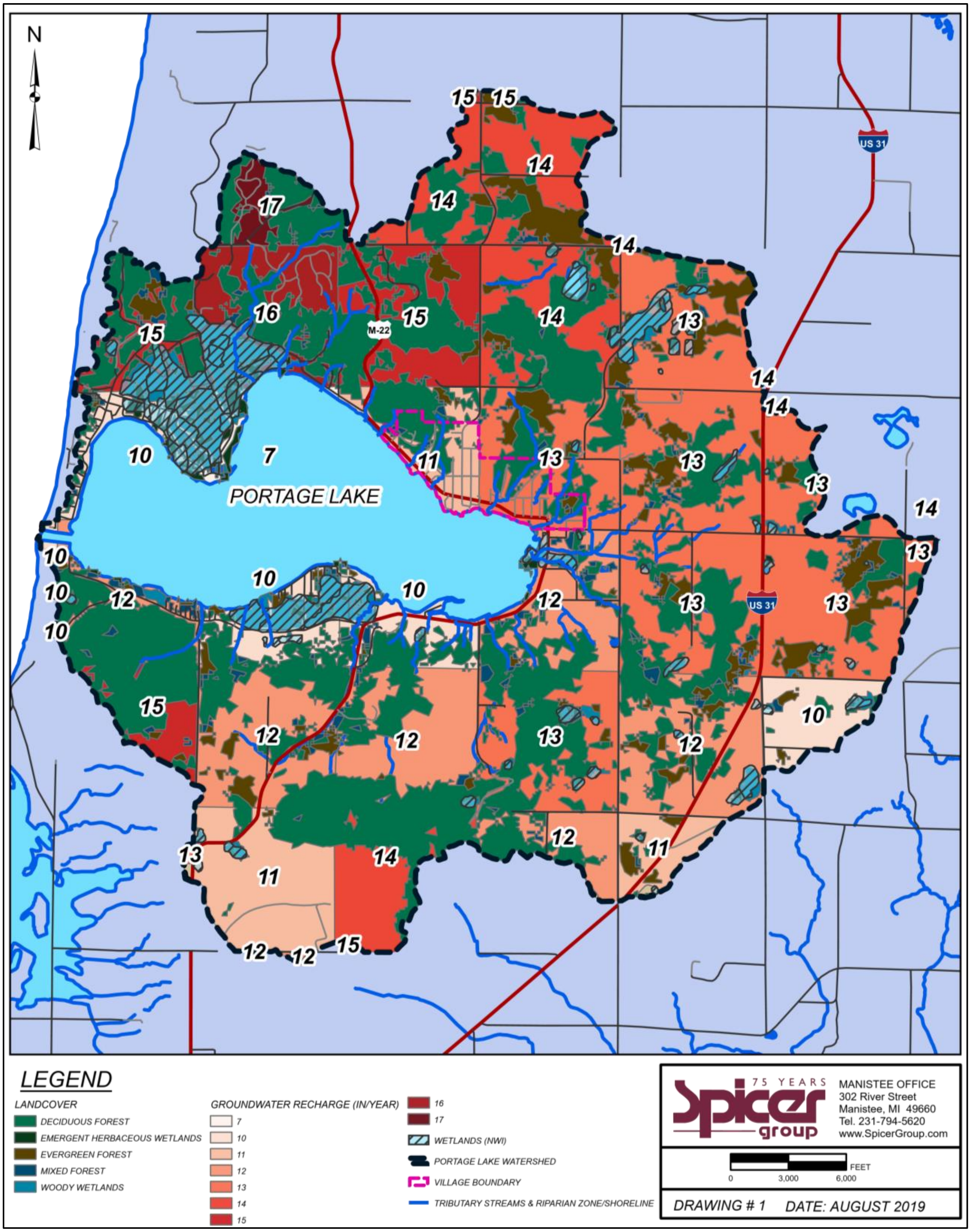

Figure 121. *Priority areas map 1*

SOURCE: 2016 NLCD Land Cover, Michigan GIS Open Data., Spicer Group Inc., 2019.

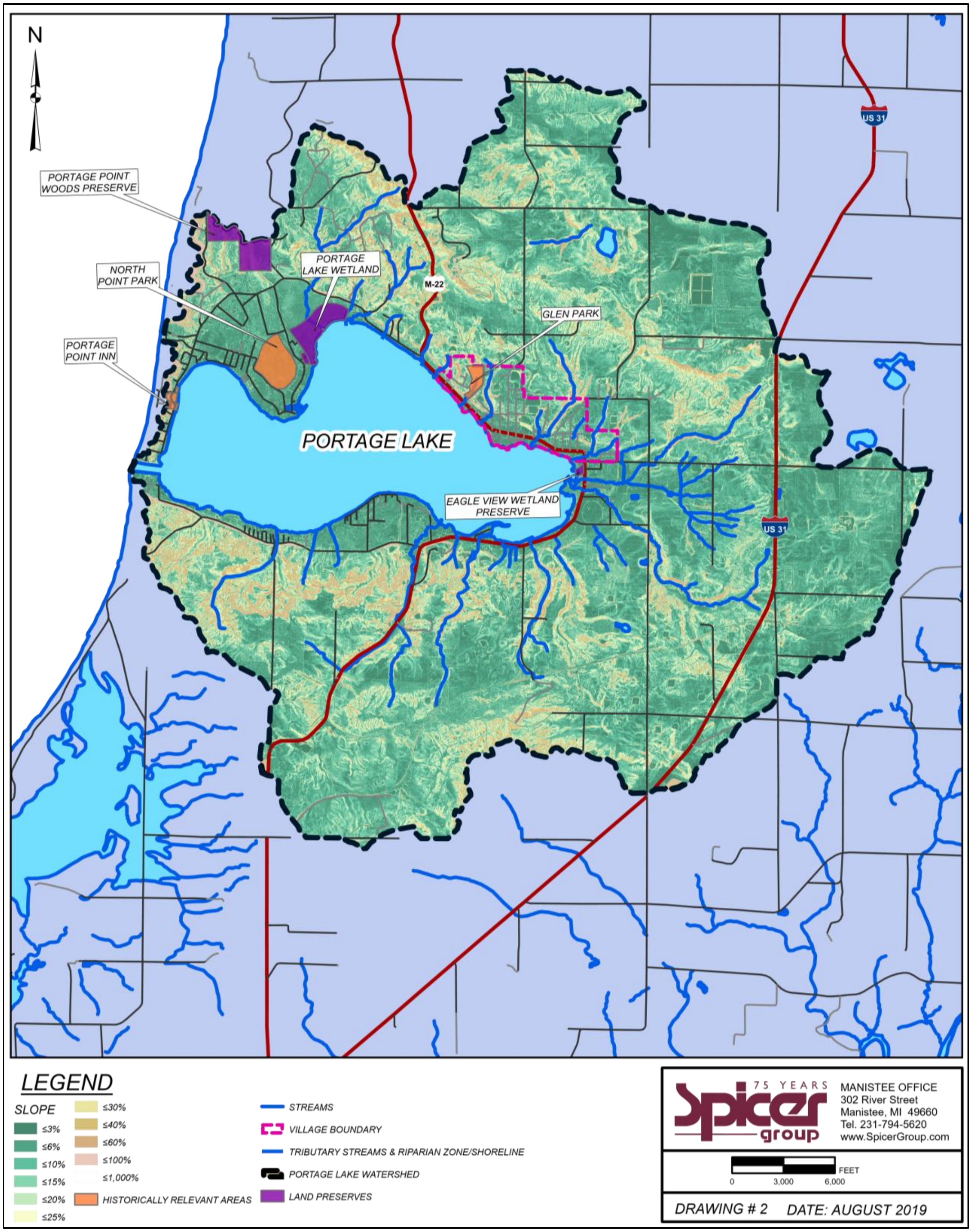

Figure 122. *Priority areas map 2*

SOURCE: Manistee County 2015, Spicer Group Inc., 2019.

CRITICAL AREAS

Critical areas within the Watershed are defined as areas in need of restoration or are sources of pollutants. Critical areas are shown at two levels: general critical areas and specific critical areas. General critical areas represent broader areas where, in general, attention is needed while specific critical areas are the clearly identified critical locations within the Watershed where attention is needed. Identification of these areas, **Table 38** and **Figure 123** and **124**, allowed for targeted goals and objectives to be created for the watershed, Chapter 8. With the implementation of this plan, these critical areas will be addressed and managed to improve the overall quality of the Portage Lake Watershed.

Table 38. *Critical areas within the Portage Lake Watershed*

Critical Area	Potential Issues/Importance	Pollutant/ Threat
General Critical Areas		
Village of Onekama	Stormwater and land use changes can increase pollutant loading, particularly in areas of higher population density, such as the Village of Onekama. Alterations to streambanks and shoreline can occur and impact habitat and water quality.	Sediment, nutrients, and bacteria
Homes and Businesses with Onsite Septic Systems around Portage Lake	If septic systems are not maintained properly, failure can cause nutrient, bacterial, and other contamination of groundwater and/or surface water.	Human pathogens, bacteria, and nutrients
Tributary Streams	Tributary streams are heavily impacted by the surrounding landscape. Stormwater and potential failing septic system leakage can mix with water flowing through streams. Human activity can also lead to the blockage of fish passage in these streams.	Sediment and nutrients
Stormwater Outfalls	Stormwater flows untreated into Portage Lake from surrounding roads, businesses, and homes. Best management practices can be used to reduce the pollutants conveyed through the storm sewer system.	Sediment, nutrients, and toxic chemicals (e.g. metals), trash

Table 38 cont. *Critical areas within the Portage Lake Watershed*

Critical Area	Potential Issues/Importance	Pollutant/ Threat
General Critical Areas		
Farmland Areas/ Orchards	Exposed soils and the potential use of herbicides, pesticides, and fertilizers increase the impact that farmlands have on water quality within the Watershed. The use or non-use of best management practices also greatly impacts the pollutants leaving the site.	Sediment, nutrients, and toxic chemicals
Boat Launches/ Marinas	Grading and erodible soils at these sites increase sediment quantities entering Portage Lake. These areas are also a hot spot for the introduction of aquatic and terrestrial invasive species.	Sediment, petroleum products, invasive species
Camps	These large sites, often near the shore of Portage Lake can be a source for sediment, pesticides, and trash into the surrounding waters.	Sediment, nutrients, and trash
Channel	Sedimentation/filling in of the channel can limit access to and from Lake Michigan from Portage Lake.	Sediment
Road Crossings	Road crossings over tributary streams could lead to reduced fish passage and cause the introduction of pollutants from roadways depending on the condition of the crossing and management of the roadway.	Sediment, nutrients, and toxic chemicals (e.g. petroleum products and salt)
Road Ends	Road ends provide access to Portage Lake for the general public. These sites have the potential for invasive species introduction, erosion, loss of riparian habitat, and an entry point of a wide range of contaminants and trash into Portage Lake. A map of all road ends around Portage Lake can be found in **APPENDIX E: ROAD ENDS MAP**.	Sediment, nutrients, invasive species, trash, and toxic chemicals (e.g. petroleum products and salt)
Roads adjacent to Portage Lake	The introduction of pollutants from roadways close to Portage Lake depending on the condition of the road and management of the roadway.	Sediment, nutrients, and toxic chemicals (e.g. petroleum products and salt)

Table 38 cont. *Critical areas within the Portage Lake Watershed*

Critical Area	Potential Issues/Importance	Pollutant/ Threat
Specific Critical Areas		
Manistee County Fairgrounds	The close proximity of the fairgrounds to Stream #8 and Portage Lake causes runoff from the site to quickly enter Portage Lake. The site has compacted soils/impervious surfaces causing increased runoff which can pick up pollutants, such as sediment from exposed soils and bacteria from the wash station. There is also the potential for redevelopment of this site.	Sediment, nutrients, and bacteria
Eurasian Watermilfoil Colonies*	Treatment and control of Eurasian watermilfoil (EWM) has been difficult due to changing lake conditions, transport by boats, and crossbreeding with native species. Current treatment is not having a negative impact on aquatic health but should be continued to better control EWM.	Invasive species
Phragmites Stands*	Overall, phragmites is under control and only requires spot treatment around Portage Lake and in key spots in Onekama Township where it has become established.	Invasive species
Golf Courses	The potential use of herbicides, pesticides, and fertilizers increase the impact that golf courses have on water quality within the Watershed.	Sediment, nutrients, and toxic chemicals

** Areas not mapped due to change of location on a year to year basis.*

SOURCE: Spicer Group Inc., 2019.

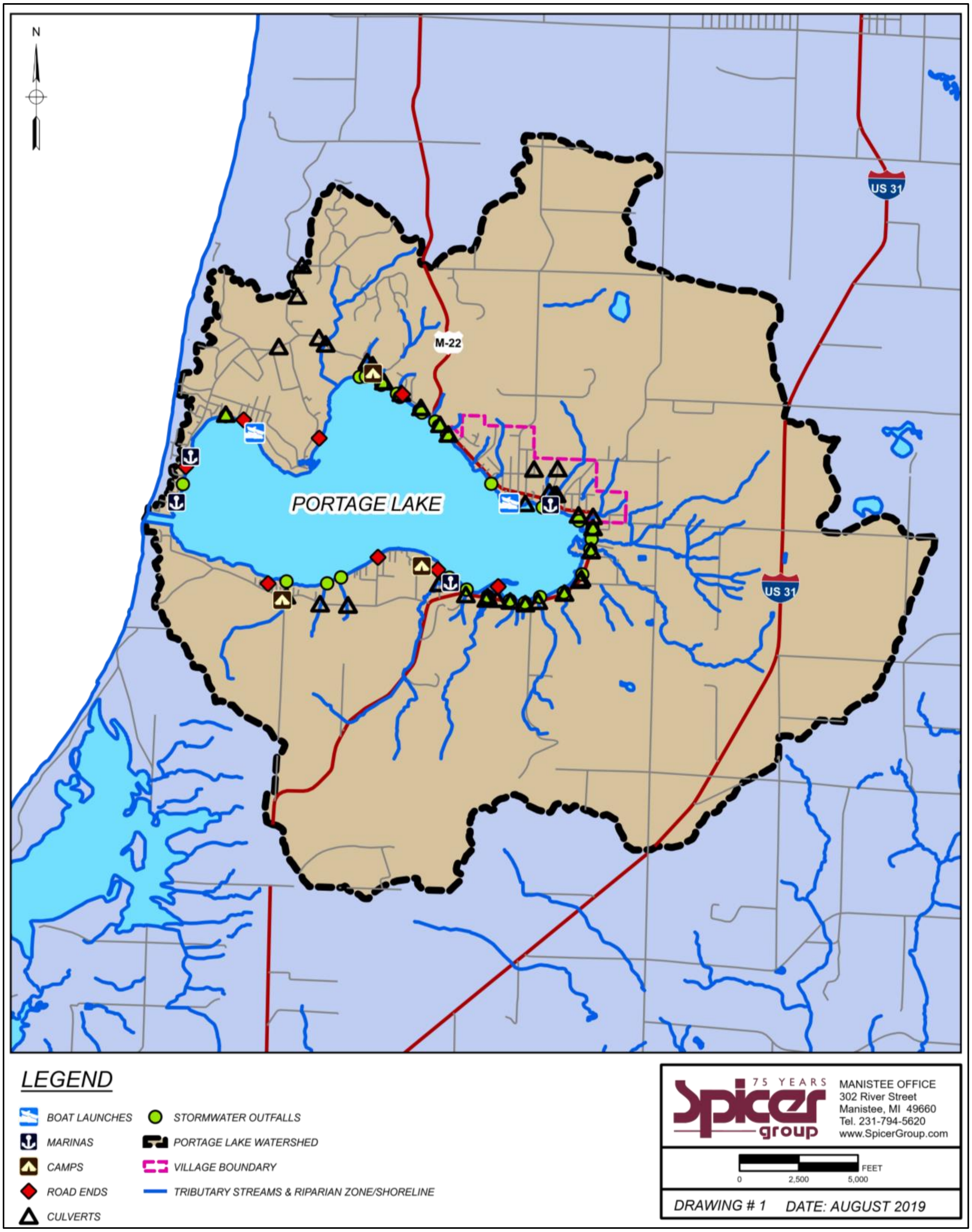

Figure 123. *Critical areas map 1*

SOURCE: Spicer Group Inc., 2019.

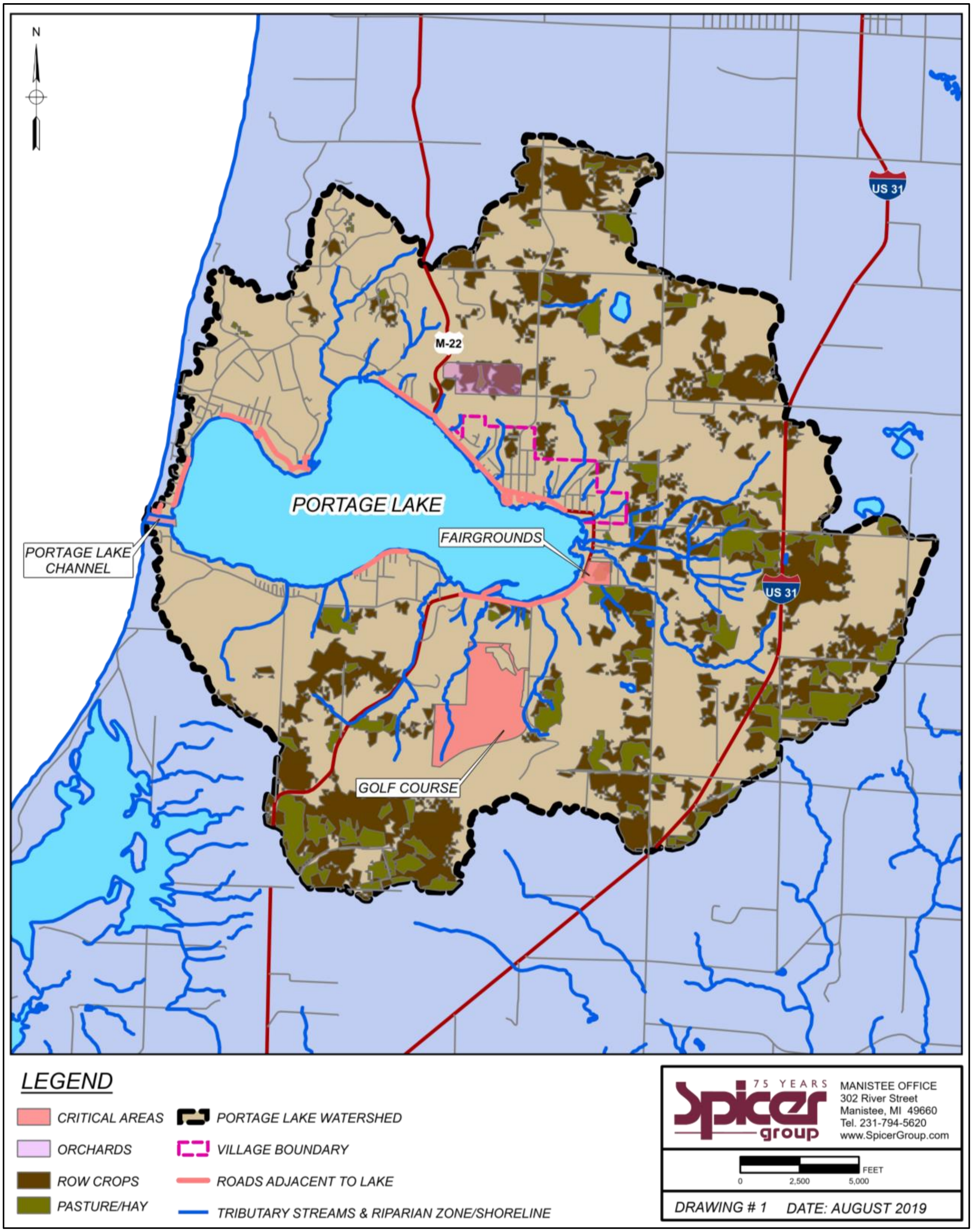

Figure 124. *Critical areas map 2*

SOURCE: Manistee County 2015, 2016 NLCD Land Cover, Spicer Group Inc., 2019.

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CHAPTER 8: PORTAGE LAKE WATERSHED TEN YEAR PLAN

GOALS AND OBJECTIVES

The goals presented below, were selected based on the numerous public meetings that were conducted in the Watershed, a household survey, previous studies, and current water quality monitoring.

List of Goals and Objectives

GOAL 1 - PUBLIC HEALTH: Ensure that participants in water-based recreation are not exposed to pathogens or toxic chemicals, and are not consuming water, wild fish or wildlife with contaminants in excess of advisories.

- **1.A. -** Monitor Portage Lake and Lake Michigan to determine that state water quality standards for total and partial body contact recreation are being met.
- **1.B. -** Prevent releases of hazardous substances that pose a risk to human health through the consumption of contaminated fish or wildlife taken in the Watershed.
- **1.C. -** Monitor swimmer's itch reports and collect information to better reduce exposure.
- **1.D. -** Protect groundwater from contamination sources to protect public drinking water supplies.

GOAL 2 - AQUATIC ECOSYSTEM: Protect the quality of water resources in the Portage Lake Watershed, as well as other essential habitats, to maintain the integrity and functions of the aquatic ecosystem.

- **2.A. -** Monitor Portage Lake to assure that future loadings of nutrients, specifically phosphorus, do not exceed levels that would change the current mesotrophic status of Portage Lake.
- **2.B. -** Protect wetland habitats contiguous to Portage Lake and tributary streams to assure that they continue to provide natural filtration and function as spawning, nursery, and refuge areas for resident fish and wildlife populations.
- **2.C. -** Protect the shallow (littoral) zone habitat from physical alteration and the spread of invasive plant species.
- **2.D. -** Implement site-specific best management practices to address stormwater runoff, soil erosion, shoreline protection, and pollutant source areas at identified problem areas.

GOAL 3 - WATER-BASED RECREATION: Protect and enhance the quality of and access to water-based recreational opportunities within the Portage Lake Watershed for people of all ages and abilities.

- **3.A. -** Maintain adequate depths in the Portage Lake Channel to assure safe, easy access between Portage Lake and Lake Michigan.
- **3.B. -** Actively support sustainable fish community management objectives for Portage Lake Watershed that focus on self-reproducing populations of both warmwater and coldwater fish species in Portage Lake and in tributaries.
- **3.C. -** Promote, maintain, and where practicable enhance accommodations for non-boating public recreational uses of Portage Lake.
- **3.D. -** Provide a forum to help resolve conflicts between recreational users of Portage Lake by anticipating problems and proposing alternative solutions that provide for equitable allocation of surface and shoreline natural resources.

GOAL 4 - NATURAL RESOURCE AND CULTURAL ASSETS: Invest in protection and enhancement of land-based natural resources and related cultural assets that provide recreational and educational benefits unique to the Watershed and contribute to the quality of life and economic well-being of local residents while expanding the vacation experiences of visitors.

- **4.A. -** Preserve, enhance, and promote access and use of the scenic vistas in the Watershed.
- **4.B. -** Preserve and enhance public understanding and appreciation of specific historical sites, structures, centennial farms, and historical artifacts to provide a better understanding of natural resources of the region.

GOAL 5 - LOCAL MANAGEMENT AND IMPLEMENTATION INSTITUTIONS AND COMMUNITY EDUCATION: Establish mechanisms to provide sustained local leadership, community engagement, and fundraising needed to assure implementation and updating of the Portage Lake Watershed Forever Plan.

- **5.A. -** Maintain an organizational structure that encourages sustained local leadership needed to engage the public, manage projects, and raise funds needed to implement and periodically update this plan.
- **5.B. -** Provide sufficient resources to support plan implementation.
- **5.C. -** Ensure that growth and development in the communities within the Watershed is directed to areas with existing adequate infrastructure in a compact and mixed-use manner.

GOAL 6 - INFORMATION AND EDUCATION: Establish and promote public awareness about watershed issues that support effective implementation of watershed planning goals, objectives, and tasks.

- **6.A. -** Establish a baseline of public knowledge and awareness about issues affecting water quality in the Portage Lake Watershed.

- **6.B. -** Establish a clearing house for Watershed materials relevant to the general public and to specific stakeholder groups.
- **6.C. -** Implement a mechanism to ensure that stakeholders have current and accurate information about monitoring and other test results.
- **6.D. -** Implement a pollution protection program to protect groundwater from hazardous chemicals and other threats.
- **6.E. -** Distribute information about best practices related to shoreline landscaping practices and other threats.
- **6.F. -** Promote recognition of the agricultural heritage in the Watershed, present agriculture, the use of local agricultural products, and sustainable agricultural practices of the region.
- **6.G. -** Distribute information about the location of scenic vistas, historical sites, and other local highlights.

IMPLEMENTATION TASKS AND ACTIONS

An Implementation Tasks and Actions table, **Table 39** below, was created to keep track of the implementation of the goals and tasks listed above. The table is broken up by goal and has the priority and milestone listed for each task. A timeline for the next ten years was created as well to ensure that milestones are being met in a timely fashion and throughout plan implementation. The total estimated cost, potential partners, and any other notes are also included within the table. Each column is described in detail below.

Priority

Each task and action has been assigned a priority level based on one or more of the following factors: importance within the Portage Lake Watershed, urgency to correct or reduce an existing issue, need to enact a specific task or action before a problem develops, and the overall need to balance low, medium, and high priorities over the course of ten years.

Priority Key

- L – Low
- M – Medium
- H – High

Cost Estimate

An estimated total cost is provided, when applicable and calculable, for each task. This cost includes the costs associated with staff time, volunteer time, and equipment/ materials utilized. **Table 40** summarizes the anticipated overall cost of each goal for the plan's ten-year time span.

Milestones

Milestone(s) are identified, when possible, to establish an interim, measurable benchmark for determining progress of a specific task or action.

Timeline

Based on the ten-year span of the Watershed Management Plan, the year in which the task or action is to begin, or end is noted.

Potential Partners

The potential partners specified are those who have the interest, expertise, or capacity to implement the task or action; new potential partners can be added at any time. Potential partners are not obligated to fulfill the task or action. However, it is expected that potential partners will consider pursuing funds to implement the task or action, work with other identified potential partners, and communicate any progress with Portage Lake Watershed Forever.

ABBREVIATIONS

AES: Alliance for Economic Success (formerly Manistee Economic Development Office)
County: Manistee County
EGLE: Michigan Department of Environment, Great Lakes, and Energy, formerly MDEQ
Garden Club: Portage Lake Garden Club
Harbor Commission: Portage Lake Harbor Commission
Health Dept.: District Health Department #10
Historical Museum: Manistee County Historical Museum
LRBOI: Little River Band of Ottawa Indians
MCCF: Manistee County Community Foundation
MCD: Manistee Conservation District
MCRC: Manistee County Road Commission
MDNR: Michigan Department of Natural Resources
MDOT: Michigan Department of Transportation
MISIN: Michigan Invasive Species Information Network
MISIP: Michigan Swimmer’s Itch Partnership
MSU Ext.: Manistee County Michigan State University Extension Office
OESC: Onekama Economic Sustainability Committee
Onekama Twp.: Onekama Township
PIW: Plant it Wild
PLA: Portage Lake Association
PLWF: Portage Lake Watershed Forever
School: Onekama Consolidated Schools

Townships: Onekama, Bear Lake, Manistee, and Brown Townships
USACE: United States Army Corps of Engineers
USCG: United States Coast Guard
USDA-NRCS: United States Department of Agriculture – Natural Resources Conservation Service
USFWS: United States Fish and Wildlife Service
Village: Village of Onekama

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Table 39. Implementation Tasks and Actions

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 1 - Public Health: Ensure that participants in water-based recreation are not exposed to pathogens or toxic chemicals, and are not consuming water, wild fish or wildlife with contaminants in excess of advisories.																
1.A. Monitor Portage Lake and Lake Michigan to determine that state water quality standards for total and partial body contact recreation are being met.	**1.A.1.** Annual monitoring at the Village Beach, Langland Park, and additional sites within the Watershed according to the EGLE's most recent protocols and requirements for total body contact recreation.	H	Monitor annually; Post results immediately in effective areas.	Refer to Monitoring Plan	**PLWF**, Onekama Twp., Village, Health Dept., EGLE	$52,500	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor
	1.A.2. Evaluate results and sampling plan to determine if more frequent sampling or additional actions, if any, are needed if sample results exceed state standards.	H	Evaluate as needed, but at least once every three years.		**PLWF,** Onekama Twp., Village, Health Dept., EGLE	$25,000			Evaluate			Evaluate			Evaluate	
	1.A.3. Annual monitoring at the Village Beach, Langland Park, and additional sites within the Watershed according to the EGLE's most recent protocols and requirements for partial body contact recreation.	H	Monitor annually; Post results immediately in effective areas.	Refer to Monitoring Plan	**PLWF**, Onekama Twp., Village, Health Dept., EGLE	$12,500	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor
	1.A.4. Monitor new and or additional areas based on current monitoring results.	H	Review results every five years.	Refer to Monitoring Plan	**PLWF,** Onekama Twp., Village, Health Dept., EGLE	$25,000	Review					Review				
1.B. Prevent releases of hazardous substances that pose a risk to human health.	**1.B.1.** Advocate for mercury emission reductions as part of regional Great Lakes effort to reduce levels.	L	Annually encourage other partners.		**PLWF**, encourage other partners	$20,000	Advocate	Advocate	Advocate	Advocate	Advocate	Advocate	Advocate	Advocate	Advocate	Advocate
	1.B.2. Establish a plan to reduce exposure of emerging contaminants (i.e. PFAs or PFOs) that are found to be at adverse levels to human health.	L	Plan established by year six; Update every three years.		**PLWF**	$3,750							Established			Update
1.C. Monitor swimmer's itch reports and collect information to better reduce exposure.	**1.C.1.** Document any activities that encourage congregations or increased abundance of suspected host waterfowl and propose appropriate actions.	L	Document annually.		**PLWF**, Onekama Twp., Village, EGLE, MNDR, LRBOI, MISIP	$10,000	Document	Document	Document	Document	Document	Document	Document	Document	Document	Document
	1.C.2. Establish a mechanism for reporting and tracking incidences of swimmer's itch in Portage Lake to gather ongoing data of incidences.	H	Establish reporting mechanism by year two; Review every three years.	Reporting system, phone system, etc.	**PLWF**	$1,500		Establish			Review			Review		
	1.C.3. Monitor for cercarial dermatitis (swimmer's itch) at selected site on Portage Lake.	M	Monitor reported problem sites (if any) during July.	Refer to Monitoring Plan	**PLWF,** EGLE, MSIP, Onekama Twp., Village, Universities	$3,000	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 1 - Public Health: Ensure that participants in water-based recreation are not exposed to pathogens or toxic chemicals, and are not consuming water, wild fish or wildlife with contaminants in excess of advisories.																
1.C. Monitor swimmer's itch reports and collect information to better reduce exposure.	**1.C.4.** Review results from neighboring MSIP lakes to determine if additional sampling/ monitoring is needed.	L	Review results during years that sampling is done.		**PLWF,** EGLE, MSIP	$3,000	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed
1.D. Protect groundwater from contamination sources to protect public drinking water supplies.	**1.D.1.** Advocate for the implementation of the sanitary sewer system around Portage Lake.	H	Approval of project within five years.		**PLWF**, Municipalities within the Watershed	$10,000	Advocate	Advocate	Advocate	Advocate	Advocate					
	1.D.2. Assist with the MCD's annual collection of hazardous waste.	L	Assist annually at event.		**PLWF**, MCD	$2,000	Volunteer	Volunteer	Volunteer	Volunteer	Volunteer	Volunteer	Volunteer	Volunteer	Volunteer	Volunteer
	1.D.3. Determine impacts of known environmental contamination sites on groundwater and advocate for rapid response and appropriate testing by the EGLE and other public agencies.	H	As needed.		**PLWF**, EGLE, Health Dept.	$7,500	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed
	1.D.4. Assure proper safeguards are in place to prevent spills from refueling of boats, cars, and mechanical devices around the lake.	H	Safeguards in place by year two; Monitor annually.		**PLWF**	$5,000		In-place	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor
	1.D.5. Promote zoning to assure that areas that are close to the lake are protected.	H	Discuss with local zoning commissions every five years.		**PLWF**, Townships	$1,250	Discuss					Discuss				
	1.D.6. Work with the EGLE and other public agencies to determine potential sites of environmental contamination.	M	Begin identification of sites by year two; Complete by year ten.		**PLWF**, EGLE, other public agencies	$6,250		Identify	Identify	Identify	Identify	Identify	Identify	Identify	Identify	Identify
	1.D.7. Keep information current on oil and gas wells that are not currently active but have not been officially abandoned.	M	Complete a full review by year three; Update every three years.		**PLWF**, EGLE, Health Dept., County	$3,750			Review			Update			Update	
	1.D.8. Continue support of the requirement of point of sale septic inspections.	H	Meet and review applicability every two years.		**PLWF**, Village, Onekama Twp., Planning Commissions, Health Dept.	$10,000		Review		Review		Review		Review		Review

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 1 - Public Health: Ensure that participants in water-based recreation are not exposed to pathogens or toxic chemicals, and are not consuming water, wild fish or wildlife with contaminants in excess of advisories.																
1.D. Protect groundwater from contamination sources to protect public drinking water supplies.	**1.D.9.** Work with the Planning Commission to develop a septic system ordinance requiring routine inspection and pumping.	H	Develop draft ordinance by year ten.		**PLWF**, Village, Onekama Twp., Planning Commissions, Health Dept.	$10,000										Draft complete
	1.D.10. Advocate for and implement groundwater pollution prevention best management practices in the Watershed.	H	Develop list of suggested BMPs by year five; Begin implementation by year ten.		**PLWF**, Health Dept., MCD, MSU Ext., LRBOI	$23,250					List Developed					Implementation
GOAL 2 - Aquatic Ecosystem: Protect the quality of water resources in the Portage Lake Watershed, as well as other essential habitats, to maintain the integrity and functions of the aquatic ecosystem.																
2.A. Monitor Portage Lake to assure that future loadings of nutrients, specifically phosphorus, do not exceed levels that would change the current mesotrophic status of Portage Lake.	**2.A.1.** Monitor total phosphorus, transparency, and chlorophyll *a*.	H	Monitor sites annually.	Refer to Monitoring Plan	**PLWF**, Onekama Twp., Village, EGLE, MDNR, LRBOI, Health Dept.	$38,500	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor
	2.A.2. Determine what additional actions, if any, are needed to control phosphorus loading based on inspections, surveys, and monitoring.	H	Review results every two years beginning in year two.		**PLWF**, EGLE, MDNR, MCD, MSU Ext., USDA-NRCS, Health Dept.	$7,500		Review		Review		Review		Review		Review
	2.A.3. Inventory existing stormwater point-source discharges from the Village of Onekama and other areas with direct discharges to Portage Lake and tributary streams.	H	Inventory completed by 2020. Update every ten years.	Refer to Monitoring Plan	**PLWF**, Village, Onekama Twp., EGLE, Health Dept., MSU Ext.	$10,000	Complete									
	2.A.4. Inventory existing significant nonpoint sources of stormwater that discharge to discharges to Portage Lake and tributary streams.	H	Inventory completed by year five.		**PLWF**	$2,500					Complete					
	2.A.5. Perform wet weather sampling of stormwater for phosphorus and other water quality parameters.	H	Sample annually.	Refer to Monitoring Plan	**PLWF**	$10,000	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
	2.A.6. Monitor streams and storm drains annually and document accordingly.	H	Monitor annually.	Refer to Monitoring Plan	**PLWF**	$39,000	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 2 - Aquatic Ecosystem: Protect the quality of water resources in the Portage Lake Watershed, as well as other essential habitats, to maintain the integrity and functions of the aquatic ecosystem.																
2.A. Monitor Portage Lake to assure that future loadings of nutrients, specifically phosphorus, do not exceed levels that would change the current mesotrophic status of Portage Lake.	**2.A.7.** Monitor *Cladophora* algae during the middle of the summer as an index to detect nearshore nutrient sources.	M	Monitor every five years.	Refer to Monitoring Plan	**PLWF**, EGLE, MDNR, LRBOI, Onekama Twp.	$1,500	Monitor				Monitor					Monitor
	2.A.8. Determine algal composition and perform algal identification within Portage Lake.	M	Monitor annually.	Refer to Monitoring Plan	**PLWF**, Onekama Twp., Village	$3,000	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor	Monitor
	2.A.9. Sample dissolved oxygen (DO) levels in the epilimnion of Portage Lake to determine whether DO levels meet state water quality standards.	M	Annual sampling.	Refer to Monitoring Plan	**PLWF**, Onekama Twp., Village, EGLE, MDNR, LRBOI, Health Dept.	$35,000	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
	2.A.10. Determine if additional DO sampling is needed to determine whether the severity, depth, and period of oxygen depletion below the thermocline has increased significantly.	M	Review annually.	During the Lake Manager's review of the annual report; Refer to Monitoring Plan	**PLWF**, EGLE, MDNR, LRBOI, Health Dept.	$5,000	Review	Review	Review	Review	Review	Review	Review	Review	Review	Review
	2.A.11. Continue efforts to determine type, locations, potential discharges, and impact from any historical industrial uses on or adjacent to Portage Lake.	L	Identify areas by year five; Review status every five years.		**PLWF**, Village, Onekama Twp., Historical Museum	$2,500					Identify					Review
2.B. Protect wetland habitats contiguous to Portage Lake and tributary streams to assure that they continue to provide natural filtration and function as spawning, nursery, and refuge areas for resident fish and wildlife populations.	**2.B.1.** Update recently identified and mapped significant contiguous wetland areas associated with Portage Lake and tributary streams.	H	Update every five years.	Refer to Monitoring Plan	**PLWF**, EGLE, MDNR, LRBOI, USFWS, MSU Ext., MCD	$12,500					Update					Update
	2.B.2. Determine whether existing federal, state, and local regulations are adequate to protect these areas from injury should future development occur.	H	Determine by year two.		**PLWF**, EGLE, MDNR, USFWS	$1,000	Research	Complete								
	2.B.3. Make recommendations for actions to local units of government, if needed, to assure that critical contiguous areas are protected.	L	Have process for review set by year three.	Involve the Wetlands Committee to provide review and comment and make recommendations	**PLWF**, EGLE, MDNR, LRBOI, USFWS	$2,250	Develop	Develop	Complete							
2.C. Protect the shallow (littoral) zone habitat from physical alteration and the spread of invasive plant species.	**2.C.1.** Survey the shoreline and land adjacent to Portage Lake, with particular attention to the presence of exotic, invasive species.	M	Survey every five years.	Refer to Monitoring Plan	**PLWF**, EGLE, MDNR, LRBOI, USFWS, Onekama Twp., Village, MSU Ext., School	$21,000	Survey				Survey					Survey

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 2 - Aquatic Ecosystem: Protect the quality of water resources in the Portage Lake Watershed, as well as other essential habitats, to maintain the integrity and functions of the aquatic ecosystem.																
2.C. Protect the shallow (littoral) zone habitat from physical alteration and the spread of invasive plant species.	**2.C.2.** Survey aquatic plants with attention to invasives using the latest surveying techniques.	M	Survey annually.	Refer to Monitoring Plan	**PLWF,** MISIN, EGLE, MDNR	$47,000	Survey	Survey	Survey	Survey	Survey	Survey	Survey	Survey	Survey	Survey
	2.C.3. Advocate for meaningful federal requirements and support Michigan's efforts to control invasive species through ballast water discharge controls for ocean-going vessels entering the Great Lakes.	M	Initiate in year one.		**PLWF**, encourage other partners	$10,000	Support	Support	Support	Support	Support	Support	Support	Support	Support	Support
	2.C.4. Review treatment options and make recommendations to the Onekama Township Board for management and treatment of invasive species.	M	Minimum of two treatment option recommendations to present annually.	Monthly reports are given to Onekama Township with updates and treatment options	**PLWF**, EGLE, MDNR, LRBOI, USFWS, MCD, MSU Ext., MISIN	$11,000	Review	Review	Review	Review	Review	Review	Review	Review	Review	Review
	2.C.5. Treat and manage invasive species in and around Portage Lake.	M	Treat annually.	Refer to Monitoring Plan	**PLWF**, EGLE, MDNR, Onekama Twp., MISIN	$ 686,000	Treat	Treat	Treat	Treat	Treat	Treat	Treat	Treat	Treat	Treat
	2.C.6. Develop and implement a program to identify and make recommendations for the application of best management practices to address significant soil erosion and sedimentation sources on lands riparian to Portage Lake and tributaries.	L	Develop and implement a program by year five.		**PLWF**, USDA-NRCS, MCD, MSU Ext., County, EGLE, MDNR, LRBOI	$3,750	Develop	Develop	Develop	Develop	Implement					
	2.C.7. Identify possible threats to the shoreline and excessive sediment sources.	L	Identify threats by year five.	Example- Wave action of boats	**PLWF**	$2,000					Identify					
	2.C.8. Identify and utilize technology to map the unimproved shoreline areas of Portage Lake.	L	Map by year five.	Use of drones, GIS, LiDAR, etc.	**PLWF**, County, Onekama Twp., Village	$15,000					Map					
	2.C.9. Evaluate the effectiveness of existing federal, state, and local regulations to protect critical undisturbed areas from impairment and make recommendations to protect these areas.	L	Evaluate by year five.		**PLWF**, EGLE, MDNR	$1,000	Evaluate	Evaluate	Evaluate	Evaluate	Complete					
	2.C.10. Work with partners to demonstrate natural shoreline protection techniques on Portage Lake.	L	Determine potential locations of implementation by year five; Complete one project by year ten.		**PLWF**, MCD, PLGC, MSU Ext.	$1,250					Location List					Project Complete

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 2 - Aquatic Ecosystem: Protect the quality of water resources in the Portage Lake Watershed, as well as other essential habitats, to maintain the integrity and functions of the aquatic ecosystem.																
2.D. Implement site-specific best management practices to address stormwater runoff, soil erosion, shoreline protection, and pollutant source areas at identified problem areas.	**2.D.1.** Determine the most effective methods to address issues in the Watershed; implement as appropriate.	H	Plan in place by year five, list of potential projects by year ten.		**PLWF**, PLA, MDNR, EGLE, MSU Ext., MCD, PIW	$8,125					Plan Complete					List Complete
GOAL 3 - Water-Based Recreation: Protect and enhance the quality of and access to water-based recreational opportunities within the Portage Lake Watershed for people of all ages and abilities.																
3.A. Maintain access to Portage Lake for boat-based recreation.	**3.A.1.** Support and participate in the efforts of the Portage Lake Harbor Commission to secure adequate, sustained funding for the dredging of Portage Lake Channel to depths required to accommodate recreational boating access.	H	Evaluate outside funding needs every five years.		**PLWF**, Harbor Commission, USACE, other partners as appropriate	$ 30,000	Evaluate					Evaluate				
	3.A.2. Support improvements and maintain existing boating access, marina facilities, and current public access sites for launching of watercraft into Portage Lake.	H	Develop list of potential projects by year two; Complete five maintenance projects by year ten.	Maintain current signage at access sites	**PLWF**, Onekama Twp., Village	$2,500		Develop List								Complete projects
	3.A.3. Support efforts to acquire additional properties for boating and non-boating public access to Portage Lake.	H	Identify properties by year three; Support acquisition of two additional properties by year ten.	Also supports 3.C.3. below	**PLWF**, Onekama Twp., Village	$ 2,500			Identify							Acquire
	3.A.4. Support maintenance of north and south piers of the Portage Lake Channel breakwall to reduce the frequency of maintenance dredging and at the same time accommodate larger vessels.	M	Ongoing.		**PLWF**, USACE, Onekama Twp., Harbor Commission, Village, Local Businesses	$6,250	Support	Support	Support	Support	Support	Support	Support	Support	Support	Support
	3.A.5. Monitor use to identify capacity and identify other concerns at public access sites for launching of watercraft into Portage Lake.	H	Monitor every two years.		**PLWF**, MDNR, Onekama Twp., Village, MCRC	$2,500		Monitor		Monitor		Monitor		Monitor		Monitor

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 3 - Water-Based Recreation: Protect and enhance the quality of and access to water-based recreational opportunities within the Portage Lake Watershed for people of all ages and abilities.																
3.B. Actively support sustainable fish community management objectives for Portage Lake Watershed that focus on self-reproducing populations of both warmwater and coldwater fish species in Portage Lake and in tributaries.	**3.B.1.** Inventory easily measured physical, biological, and chemical conditions within tributary streams.	L	Complete annual inventory.	Refer to Monitoring Plan	**PLWF**, MCD, MSU Ext., EGLE, LRBOI, Onekama Twp., Village	$37,500	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory	Inventory
	3.B.2. Monitor conditions within and adjacent to tributary streams to protect fish habitat.	L	Monitor every two years.	Refer to Monitoring Plan	**PLWF,** MDNR, USFWS, LRBOI	$1,250		Monitor		Monitor		Monitor		Monitor		Monitor
	3.B.3. Assist with fisheries surveys in Portage Lake and in tributaries.	L	Complete survey every ten years.	Refer to Monitoring Plan	**PLWF,** MDNR, USFWS, LRBOI	$3,500										Survey
	3.B.4. Actively support fish planting and stocking programs to ensure fishable populations.	L	Ongoing.		**PLWF,** MDNR, Manistee County sport fishing, Manistee Area Charter Boat Association	$10,000	Support	Support	Support	Support	Support	Support	Support	Support	Support	Support
	3.B.5. Determine, in conjunction with other local, state, federal, and tribal resource management agencies, locations on Portage Lake where shore-based fishing opportunities can be enhanced.	M	Determine by year five.		**PLWF**, MCCF, AES, EGLE, MDNR, USFWS, LRBOI, USACE	$2,500	Evaluate	Evaluate	Evaluate	Evaluate	List of locations					
3.C. Promote, maintain, and where practicable enhance accommodations for **non-boating public recreational uses** of Portage Lake.	**3.C.1.** Review Manistee County Parks and Recreation Plan for any changes to public access sites on Portage Lake.	M	Review every five years.	For any new public access sites determine the capacity and appropriateness of various uses and identify opportunities for enhancement	**PLWF**, Onekama Twp., Village, County Planning Department, Onekama Parks and Recreation	$2,250					Review & Update					Review & Update
	3.C.2. Prepare recommendations to the public agencies that control non-boating public recreational uses sites for enhancements.	M	Recommendations outlined by year five.	Including activities such as swimming, wading, lakeside walks, and wildlife viewing	**PLWF**, Onekama Twp., Village	$2,750	Prepare	Prepare	Prepare	Prepare	Distribute					
	3.C.3. Consider the purchase or acquisition of property within the Portage Lake Watershed for habitat protection, public use, access, and recreation.	H	Have potential property list completed by year five; Update list and priority every two years.	Update identified key properties within the Watershed (1,000 ft. from any stream/shoreline)	**PLWF**, encourage other partners	$5,000					List Complete		Update		Update	

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 3 - Water-Based Recreation: Protect and enhance the quality of and access to water-based recreational opportunities within the Portage Lake Watershed for people of all ages and abilities.																
3.D. Provide a forum to help resolve **conflicts between recreational users** of Portage Lake by anticipating problems and proposing alternative solutions that provide for equitable allocation of surface and shoreline natural resources.	**3.D.1.** Cooperate with the appropriate public authorities and other affected parties to implement recommendations for conflict resolution (e.g. No Wake Zone Meetings, education of no wake zones, etc.).	L	Host a forum every five years to discuss recommendations for conflict resolution. Put article in newsletter every five years.	Ongoing case by case conflict resolution	**PLWF**, MDNR, Village, USCG	$3,250					Public Forum					Public Forum
GOAL 4 - Natural Resource and Cultural Assets: Invest in protection and enhancement of land-based natural resources and related cultural assets that provide recreational and educational benefits unique to the Watershed and contribute to the quality of life and economic well-being of local residents while expanding the vacation experiences of visitors.																
4.A. Preserve, enhance, and promote access and use of the scenic vistas in the Watershed.	**4.A.1.** Map the location of scenic vistas in the Watershed that local residents and visitors identify as significant places.	L	Map by year five; Update every five years.		**PLWF**, Townships, Village, County	$15,000					Map					Update
4.B. Preserve and enhance public understanding and appreciation of specific historical sites, structures, centennial farms, and historical artifacts to provide a better understanding of natural resources of the region.	**4.B.1.** Update mapped sites of historical significance in the Watershed within the Manistee County Parks and Recreation Plan.	L	Complete updates by year five; Review by year ten.		**Manistee County**, PLWF, Historical Museum, County	$12,500					Update					Review
	4.B.2. Develop a plan to encourage private and public efforts to preserve, protect, and provide interpretation of sites of historical significance in cooperation with other public entities, private organizations, and other interested stakeholders.	L	Develop by year six.		**PLWF**, LRBOI, Historical Museum, PLA, service clubs	$6,750						Plan Developed				
GOAL 5 - Local Management and Implementation Institutions and Community Education: Establish mechanisms to provide sustained local leadership, community engagement, and fundraising needed to assure implementation and updating of the Portage Lake Watershed Forever Plan.																
5.A. Maintain an organizational structure that encourages sustained local leadership needed to engage the public, manage projects, and raise funds needed to implement and periodically update this plan.	**5.A.1.** Continue to utilize the Manistee County Community Foundation to hold and administer funds in support of the implementation of the Portage Lake Watershed Forever Plan.	H	Evaluate every two years and modify services as appropriate.		**PLWF**, AES	$27,500		Evaluate		Evaluate		Evaluate		Evaluate		Evaluate
	5.A.2. Maintain the Portage Lake Watershed Forever Endowment Fund; the Portage Lake Watershed Forever Annual Fund and the Portage Lake Watershed Wetlands Fund.	H	Review funds annually.	Ensure funds are available for next years expected expenses	**PLWF**	$2,500	Review	Review	Review	Review	Review	Review	Review	Review	Review	Review

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 5 - Local Management and Implementation Institutions and Community Education: Establish mechanisms to provide sustained local leadership, community engagement, and fundraising needed to assure implementation and updating of the Portage Lake Watershed Forever Plan.																
5.A. Maintain an organizational structure that encourages sustained local leadership needed to engage the public, manage projects, and raise funds needed to implement and periodically update this plan.	**5.A.3.** Provide a vehicle through which donations can be accepted and to maximize potential tax benefits for donors while minimizing the administrative burden on the PLWF by utilizing the Manistee County Community Foundation.	H	Have mechanism in place by year two.		**PLWF**	$1,000	Develop	Mechanism in place								
	5.A.4. Maintain the legal status of the Portage Lake Watershed Forever organization as a Michigan nonprofit corporation.	H	Complete requirements annually.		**PLWF**, AES, MCCF	$1,000	Maintain	Maintain	Maintain	Maintain	Maintain	Maintain	Maintain	Maintain	Maintain	Maintain
	5.A.5. Ensure that the established bylaws are upheld and amend as appropriate.	L	Review of bylaws every five years.	Last revised in 2015	**PLWF**	$1,000	Review					Review				
	5.A.6. Continue development of the PLWF Board of Directors to ensure capable and consistent leadership for plan implementation.	L	Review plan implementation every five years.		**PLWF**, AES, MCCF	$3,000					Review					Review
	5.A.7. Utilize fiscal agent services of the Alliance for Economic Success and assess, evaluate, and modify the services as appropriate.	L	Review usefulness every five years.		**PLWF**, AES	$ 1,000					Review					Review
	5.A.8. Evaluate the operating model of the PLWF to ensure it fulfills the mission and purpose of PLWF today and in the future while making efficient use of available resources for plan implementation.	L	Evaluate operation every five years.		**PLWF**	$1,000					Review					Review
5.B. Provide sufficient resources to support plan implementation.	**5.B.1.** Secure funding to provide for paid staff, or a secure commitment from an experienced volunteer, to assist in upholding of the 2012 established bylaws of the organization and as needed revisions to the plan.	H	Submit for grant in year one.	Grant for 3-year position	**PLWF**	$15,000	Submit									
	5.B.2. Secure funding to provide for paid staff, or a secure commitment from an experienced volunteer, to assist in initiating work on the actions identified in this plan, track implementation progress, and update the plan as needed.	H	Submit for grant in year one.	Grant for 3-year position	**PLWF**	$15,000	Submit									

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 5 - Local Management and Implementation Institutions and Community Education: Establish mechanisms to provide sustained local leadership, community engagement, and fundraising needed to assure implementation and updating of the Portage Lake Watershed Forever Plan.																
5.B. Provide sufficient resources to support plan implementation.	**5.B.3.** Secure funding to provide for paid staff, or a secure commitment from an experienced volunteer, to assist in securing funds, in-kind contributions, and volunteer participants needed to sustain public interest in the plan and meet public expectations.	H	Submit for grant in year one.	Grant for 3-year position	**PLWF**	$15,000	Submit									
	5.B.4. Evaluate the best funding methods to assure long-term financial support needed to involve stakeholders in the implementation and periodic updates of this plan.	H	Evaluation completed by year five.	Portage Lake Forever Endowment Fund	**PLWF**, MCCF	$22,500	Evaluate	Evaluate	Evaluate	Evaluate	Complete					
	5.B.5. Continue to discuss with other area watershed organizations to identify and explore opportunities for shared administration.	L	Discuss every two years.		**PLWF**, other watershed organizations	$2,500	Discuss		Discuss		Discuss		Discuss		Discuss	
	5.B.6 Work with Onekama Township to study costs and grants available.	L	Annually.		**PLWF**, Onekama Twp.	$10,000	Study	Study	Study	Study	Study	Study	Study	Study	Study	Study
5.C. Ensure that growth and development in the communities within the Watershed is directed to areas with existing adequate infrastructure in a compact and mixed-use manner.	**5.C.1.** Work with the appropriate authority in joint planning coordination; provide input as necessary.	H	Ongoing.		**PLWF**, AES, LRBOI, MCCF, MCD, MDOT, MSU Ext., OESC	$16,250	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate
	5.C.2. Work with Planning Commission to strengthen the current riparian overlay of Portage Lake.	M	Develop list of areas to be improved by year three. Develop action plan by year eight.		**PLWF**, AES, Health Dept., LRBOI, MCCF, MCD, MDOT, MSU Ext.	$8,750			List Developed					Action Plan		
GOAL 6 - Information and Education: Establish and promote public awareness about watershed issues that support effective implementation of watershed planning goals, objectives, and tasks.																
6.A. Establish a baseline of public knowledge and awareness about issues affecting water quality in the Portage Lake Watershed.	**6.A.1.** Use analysis of the 2017 plan update survey and other means to identify Watershed/water quality issues where public knowledge needs development.	H	Update by year two; Complete another survey by year ten.	Method: Survey, meetings, website Audience: General public, tourist, riparian landowners	**PLWF**, PLA, MDNR, EGLE, School, MSU Ext., MCD, PIW	$5,250		Update								Survey
	6.A.2. Develop follow-up mechanisms to determine the effectiveness of efforts. Analyze results to identify key issues needing further attention.	H	As needed, but at least every five years.	Method: Survey, meetings, website Audience: General public, tourist, riparian landowners	**PLWF**, PLA, MDNR, EGLE, MSU Ext., MCD, PIW	$4,250				Develop	Analyze				Develop	Analyze

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 6 - Information and Education: Establish and promote public awareness about watershed issues that support effective implementation of watershed planning goals, objectives, and tasks.																
6.A. Establish a baseline of public knowledge and awareness about issues affecting water quality in the Portage Lake Watershed.	**6.A.3.** Supply information to the public pertaining to Part 5 Rules and contact information for reporting releases to waters of the state.	M	Initiate in year two.	Method: Kiosk/bulletin boards, newsletters, lake management reports, social media, website, meetings Audience: General public, riparian landowners, local government	**PLWF,** Onekama Twp., Village, Health Dept.	$5,750		Supply	Supply	Supply	Supply	Supply	Supply	Supply	Supply	Supply
6.B. Establish a clearing house for Watershed materials relevant to the general public and to specific stakeholder groups.	**6.B.1.** Update current website to assure that it is user-friendly and accessible.	H	Update by year two; Review design every three years.	Method: Website, survey, social media Audience: General public, stakeholder groups	**PLWF**	$3,000		Update			Review			Review		
	6.B.2. Assure that PLWF materials are updated, current, accurate, relevant, user-friendly, and readily accessible.	H	Annually review materials.	Method: Website, survey, social media Audience: General public, riparian landowners, local governments, tourists, local farmers, businesses	**PLWF**	$5,000	Review	Review	Review	Review	Review	Review	Review	Review	Review	Review
	6.B.3. Provide means for feedback on the PLWF website and distributed materials.	M	Feedback mechanism in place by year two; Review feedback mechanism every four years.	Method: Website, survey, social media Audience: General public, riparian landowners, local governments, tourists, local farmers, businesses	**PLWF**	$21,000		Mechanism in place				Review				Review
	6.B.4. Educate the community on the grant proposal for sanitary sewers around the lake.	L	Post information on the website by year two.	Method: Website, social media, newsletter, newspaper, meetings, kiosk/bulletin boards Audience: General public, riparian landowners, local governments	**PLWF**	$1,000		Post								
6.C. Implement a mechanism to ensure that stakeholders have current and accurate information about monitoring and other test results.	**6.C.1.** Inform stakeholders of *E. coli* monitoring results.	H	Immediately upon results, annual summary.	Method: Kiosk/bulletin boards, newsletters, social media, website, meetings Audience: Riparian owners, local governments, general public, tourists	**PLWF**, MSU Ext., MCD, PLA	$5,000	Inform	Inform	Inform	Inform	Inform	Inform	Inform	Inform	Inform	Inform

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 6 - Information and Education: Establish and promote public awareness about watershed issues that support effective implementation of watershed planning goals, objectives, and tasks.																
6.C. Implement a mechanism to ensure that stakeholders have current and accurate information about monitoring and other test results.	**6.C.2.** Provide information about swimmer's itch, its causes, steps to minimize exposure and the Portage Lake reporting system.	H	Immediately upon results, annual summary.	Method: Website, e-mail, social media, newsletter, comment card, brochure, newspaper Audience: General public, riparian landowners, tourists, local governments	**PLWF**, Onekama Twp., Village, MSU Ext., MCD, PLA, EGLE, MNDR, LRBOI, Oakland University, MISIP	$17,500	Educate	Educate	Educate	Educate	Educate	Educate	Educate	Educate	Educate	Educate
	6.C.3. Continue efforts to educate the public about invasive species and means to report/control them.	H	Annually; have reporting mechanism in place by year two.	Method: Website, social media, kiosk/bulletin boards, newsletter, brochure, newspaper Audience: General public, riparian landowners, tourists, local governments	**PLWF**, MSU Ext., MCD, PLA	$13,000	Educate	Reporting	Educate	Educate	Educate	Educate	Educate	Educate	Educate	Educate
	6.C.4. Distribute information about cost-effective ways to have drinking water tested for bacteria and contaminants.	L	Distribute annually.	Method: Brochure, newspaper, newsletter, website, social media Audience: General public, businesses	**PLWF**, Health Dept., EGLE, MCD, USDA-NRCS, MSU Ext., EGLE, School, LRBOI	$15,750	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute
	6.C.5. Implement mechanisms to ensure anglers have the best information on state consumption advisories for fish taken from Portage Lake.	H	Post information annually.	Method: Website, social media, kiosk/bulletin board, newsletter, newspaper Audience: Anglers, general public, tourists	**PLWF**, charter boat operators, Sportfishing Association, marinas, MDNR, LRBOI	$15,750	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute	Distribute
6.D. Implement a pollution protection program to protect groundwater from hazardous chemicals and other threats.	**6.D.1.** Distribute information about the proper maintenance and operation of septic systems.	H	Distribute annually; Review and update every five years.	Method: Website, workshop newsletter, newspaper, video, social media, Audience: General public, riparian landowners, businesses	**PLWF**, Health Dept., EGLE, MCD, realtors	$20,250	Update					Update				
	6.D.2. Provide education on point of sale ordinance that require septic tank/tile filed system inspections at time of sale in order to determine system failure rates and to upgrade failing systems.	H	Distribute annually; Review and update every five years.	Method: Brochure, video, newsletter, newspaper, website, social media, Audience: General public, riparian landowners, businesses	**PLWF**, encourage other partners	$16,250		Update					Update			

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 6 - Information and Education: Establish and promote public awareness about watershed issues that support effective implementation of watershed planning goals, objectives, and tasks.																
6.D. Implement a pollution protection program to protect groundwater from hazardous chemicals and other threats.	**6.D.3.** Distribute information about limiting phosphorus loadings through use of low- or zero-phosphorus fertilizers.	H	Distribute annually; Review and update every five years.	Method: Brochure, social media, newspaper, website, newsletter Audience: Riparian landowners, businesses, general public	**PLWF**, Health Dept., EGLE, MCD, Local Businesses	$16,250			Update					Update		
	6.D.4. Distribute information about the impact of plastics, coal tar sealants, and other environmental threats.	H	Distribute annually; Review and update every five years.	Method: Brochure, newspaper, newsletter, website, social media Audience: Riparian landowners, local governments, general public	**PLWF**, EGLE, Local Businesses, PLA, MDNR, MCD	$16,250				Update					Update	
	6.D.5. Distribute information on the important functions of wetlands.	H	Distribute annually; Review and update every five years.	Method: Brochure, newspaper, newsletter, website, social media Audience: Riparian landowners, local governments, general public	**PLWF**, MDNR, Garden Club, EGLE, MCD, PLA	$16,250					Update					Update
	6.D.6. Work with the local community to encourage the creation of rain gardens, bio-swales, and other means to curtail runoff (e.g. rain barrels).	H	Distribute annually; hold two presentations by year ten.	Method: Presentations, website, social media, newsletter, brochure Audience: Riparian landowners, local governments, businesses, general public	**PLWF**, MDNR, Garden Club, EGLE, MCD, PLA	$16,250										Present
6.E. Distribute information about best practices related to shoreline landscaping practices and other threats.	**6.E.1.** Provide information about near shore littoral zones and the impacts of beach grooming, shoreline hardening, sea walls, and permanent mooring structures.	H	Distribute annually; Review and update every five years.	Method: Brochure, newspaper, newsletter, website, social media Audience: Riparian landowners, local governments	**PLWF**, EGLE, Garden Club, PIW	$16,250	Update					Update				
	6.E.2. Work with local governmental units to encourage implementation of near shore littoral zones.	H	Ongoing.	Method: Meetings, e-mail, letter, presentations Audience: Local governments	**PLWF**, EGLE, Local Businesses, PLA, MDNR, MCD	$6,250	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate	Coordinate

Table 39 cont. *Implementation Tasks and Actions*

Objectives	Tasks	Priority (L,M,H)	Milestone	Notes	Potential Partners	Estimate Total Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GOAL 6 - Information and Education: Establish and promote public awareness about watershed issues that support effective implementation of watershed planning goals, objectives, and tasks.																
6.E. Distribute information about best practices related to shoreline landscaping practices and other threats.	**6.E.3.** Educate the public on the possible threats, wave action of boats occurring close to the shoreline, and excessive sediment sources.	H	Distribute annually; Review and update every five years.	Method: Brochure, newspaper, newsletter, website, social media Audience: Riparian landowners, general public, tourists, local governments	**PLWF**, PLA	$13,750		Update					Update			
6.F. Promote recognition of the agricultural heritage in the Watershed, present agriculture, the use of local agricultural products, and sustainable agricultural practices of the region.	**6.F.1.** Encourage and facilitate development of a program to celebrate local agricultural products.	L	Program developed and in place by year three.	Method: Guides, newspaper, newsletter, social media, website, kiosk/bulletin board Audience: General public, tourists, businesses, local farmers	**PLWF**, USDA-NRCS, MCD, MSU Ext., AES, Local Farmers and Businesses	$1,650			Develop Program							
	6.F.2. Continue recommendation of locally grown agricultural products and encourage their sale and use in partnership with local farmers and other interested stakeholder organizations and individuals.	L	Develop sustainable partnerships by year two.	Method: Brochure, newspaper, newsletter, social media, website, kiosk/bulletin board Audience: General public, tourists, businesses, local farmers	**PLWF**, AES, USDA-NRCS, MCD, MSU Ext., Local Farmers and Businesses	$4,100		Develop Partnership								
	6.F.3. Encourage local farmers to participate in the Michigan Agriculture Environmental Assurance Program (MAEAP).	L	Distribute annually; Review and update every five years.	Method: Website, social media, letters, workshop Audience: Local farmers	**PLWF**, MAEAP, Local Farmers	$1,650			Update					Update		
6.G. Distribute information about the location of scenic vistas, historical sites, and other local highlights.	**6.G.1.** Recommend education, information, and voluntary actions by private landowners and public agencies about how to protect and enhance public access and enjoyment of scenic vistas.	M	Distribute annually; Review and update every five years.	Method: letter, meetings Audience: Private landowners and public agencies that own property that provides scenic vistas	**PLWF**, MDNR, EGLE, PLA, LRBOI, Public Library	$61,250				Update					Update	
	6.G.2. Compile and distribute information about public access facilities currently available for non-boating users.	M	Compile information by year two; Distribute annually; Update every four years	Method: Brochure, website, social media, newspaper, newsletter, bulletin board Audience: General public, tourists	**PLWF**, MDNR, EGLE, PLA, LRBOI, Onekama Parks and Recreation	$20,000		Compile				Update				Update

SOURCE: Spicer Group Inc., 2019.

Table 40. *Summary of costs for task implementation broken down by goal*

Goal	Anticipated Cost
Goal 1 - Public Health	$192,000
Goal 2 - Aquatic Ecosystem	$958,250
Goal 3 - Water-Based Recreation	$111,750
Goal 4 - Natural Resource and Cultural Assets	$34,250
Goal 5 - Local Management and Implementation Institutions and Community Education	$143,000
Goal 6 - Information and Education	$370,025
Total Anticipated Cost	**$1,809,275**

SOURCE: PLWF, Spicer Group Inc., 2019.

Information and Education Strategy

This Information and Education strategy addresses the communication needs associated with implementing the Portage Lake Watershed Forever Plan. Increasing awareness and understanding about how actions on the land within a watershed can impact water quality is a critical step toward water quality protection and improvement.

During the planning process, a variety of means were used to inform the public and other stakeholders about the planning process and outcomes, and also to seek input to be used in the development of the plan: a resident survey was conducted, numerous focus groups were held with stakeholders, and watershed gatherings were held. These activities helped to educate community members about the update process and the benefits of having a watershed management plan and engaged them in the update of this plan.

To help inform future public education efforts, a series of questions were included in the household survey conducted by Northsky in 2017. These questions asked residents where they obtain their information about the watershed and which sources of information they trust. Local newspapers, brochures, and fact sheets were the top sources of information, with the internet being the second most popular source. The most trustworthy sources of information by residents are Portage Lake Watershed Forever, Manistee Conservation District, EGLE, and PLA (For more detailed information about these efforts and findings refer to the **SOURCES OF INFORMATION** section of this plan.) These public engagement efforts helped to shape the goals and objectives of the watershed plan and helped to identify specific needs and strategies for information and education.

The purpose of the Information and Education strategy is to establish and promote educational programs that support effective implementation of watershed planning goals, objectives, and tasks. Goal Six in **Table 39. Implementation Tasks and Actions** outlines the key tasks in this strategy. Each of these tasks includes the objective, target audience, and the method that will be used. It is important to note that a great deal of educational material exists on many of the issues this plan seeks to address. Therefore, to keep costs down, existing materials will be reviewed and modified for the Portage Lake Watershed whenever possible rather than generating new sources of information.

Priority Goals and Tasks

The three main priorities that the Watershed is focusing on are public health, aquatic ecosystem health, and groundwater protection. The Watershed has already dedicated resources to these priorities, and they will continue to be the primary focus for the next two to three years. After this time period the priorities of the Watershed will be reevaluated based on current progress, available resources, and other factors to determine if additional priorities should be added or if any current high priority items should now be medium or low priority.

Currently work is being done to educate the public on septic system care and maintenance, Task 6.D.2. from **Table 39**. Education is key in reducing the number of system failures due to lack of maintenance and catching failures and other problems early. Along with education on septic systems, continued support and education on the benefits for a sanitary sewer to serve residents within the Watershed, Tasks 1.D.1. and 6.B.4. from **Table 39** is being done. This benefits all three priorities of the Watershed. Public health and groundwater are protected by preventing the introduction of bacteria and nutrients into groundwater and surface water. The nutrients released due to failure can lead to eutrophic conditions and degrade aquatic ecosystems.

This also ties in with other education being done within the Watershed on groundwater protection, Task 6.D.1., that discusses septic systems as well as harmful chemical storage and disposal and ways to promote infiltration/ groundwater recharge. The other educational focus relates to phosphorus loading and the impact it has on aquatic ecosystem health, Task 6.D.3.. Landowners, specifically riparians, are the primary target for this education that emphasizes the impact of fertilizer application. However, this information will be available to everyone in the Watershed and will cover additional sources of nutrients.

To determine the effectiveness of the education and outreach, the water quality needs to be monitored in Portage Lake and its tributaries. Continuing water quality monitoring for basic water parameters (i.e. temperature, dissolved oxygen, pH) and nutrients (nitrogen and phosphorus) is also a high priority, Tasks 2.A.1., 2.A.9., and 2.A.10. from **Table 39**. It is important to have long term data to determine if any changes both good and bad are occurring. A detailed plan for Portage Lake and tributary monitoring can be found in the Monitoring Plan, **Table 41**. Continued treatment of invasive species, particularly Eurasian watermilfoil and Phragmites, plays a big role in aquatic ecosystem health. If left unchecked these and other invasive species could degrade the aquatic ecosystem within Portage Lake. Tasks 2.C.4. and 2.C.5. call for review of treatment options and treating invasive species in and around Portage Lake.

MONITORING

The true test of the efficacy of this Watershed Management Plan will be the implementation of the plan goals and objectives. Implementation of watershed plan goals and objectives for site-specific activities will require continuous monitoring. Evaluation of monitoring activities will also be necessary to determine the progress and effectiveness of the proposed activities.

Monitoring Plan

The **Portage Lake Watershed Monitoring Plan** summarizes the monitoring areas that correspond to specific action items listed under goals and objectives. For elements that involve sampling, a map of current monitoring locations can be found in **Figure 125**, however these locations may change depending on future monitoring needs. The coordinates for each sampling point can be found in **APPENDIX F: MONITORING POINT COORDINATES**. Monitoring of conditions within the Portage Lake Watershed is a key component of this Watershed Plan considering the focus is on sustaining current conditions that support designated and other beneficial uses. The proposed Monitoring Plan will also help fill information gaps on both habitat conditions and conformance with water quality standards. The intent of the Monitoring Plan is to detect changes in environmental conditions early enough to develop corrective actions before significant impairments occur.

Table 41 includes the frequency and timing of samples within the calendar year along with the associated tasks from the Implementation Tasks and Actions Table that correspond to each monitoring activity. As a not-for-profit group, the Portage Lake Watershed Forever organization will seek public-agency and private-entity partners, train volunteer watershed stakeholders and, when necessary, raise funds in order to implement the proposed Monitoring Plan. In some cases, technical laboratory services will be contracted to perform needed chemical or bacteriological analyses. The **Implementation Tasks and Actions** table details the anticipated costs of these monitoring activities, including staff time, volunteer time, cost of analysis, equipment costs, and any other costs associated with the task listed. The **Implementation Tasks and Actions** table also details the years during which samples will occur and the potential partners involved in completing the task.

The Monitoring Plan reflects the priorities of the watershed stakeholders based upon available information and the potential threats to protected and desired uses. The end point and measures of success are based upon maintaining the current water quality conditions within the Watershed since they are easily meeting state water quality standards. In the absence of specific water quality standards or if current conditions are well below state standards, other measures have been established. The Monitoring Plan is broken down into lake monitoring, tributary stream monitoring, stormwater monitoring, groundwater monitoring, and other Watershed-wide monitoring. These categories are then broken down further into water quality monitoring and surveys. The Monitoring Plan also provides for collecting information on non-water-related desired natural resource uses that the Portage Lake Watershed Forever organization is also including in its Watershed Plan.

ABBREVIATIONS

AVAS: Aquatic Vegetation Assessment Sites
CLMP: MiCorps Cooperative Lake Management Program
DO: Dissolved oxygen
GPS: Global positioning system
ORP: Oxidative reduction potential
TDS: Total dissolved solids
TN: Total nitrogen
TP: Total phosphorus

Table 41. *Portage Lake Watershed Monitoring Plan*

	Monitoring Type	Analyses	Locations	Timeframe	Frequency	Implementation Task Reference
PORTAGE LAKE MONITORING						
WATER QUALITY	***Escherichia coli (E. coli)***	*E. coli*	**Portage Lake Beaches** ▪ Portage Point Inn (E01) ▪ Little Eden Camp (E02) ▪ Village of Onekama Beach (E03) ▪ Covenant Bible Camp (E04) ▪ Wik-A-Te-Wah (E05) ▪ Langland Park (E06) (see **Figure 125**)	May 31st – October 1st	**Monthly:** ▪ Portage Point Inn ▪ Little Eden Camp ▪ Village of Onekama Beach ▪ Covenant Bible Camp ▪ Wik-A-Te-Wah **Weekly:** ▪ Langland Park NOTE – Triplicate samples collected at each location	**Table 39** ▪ 1.A.1 (pg. 202) ▪ 1.A.3 (pg. 202) ▪ 1.A.4 (pg. 202)
WATER QUALITY	***E. coli***	*E. coli*	**Road Ends** ▪ Portage Point Road (Hilltop) (RE01) ▪ Bayview (Batemore) (RE02) ▪ Ardmore Road (RE03) ▪ 3rd Street (RE04) ▪ Leonard Road (RE05) ▪ Morey Road (RE06) (see **Figure 125**)	May 31st – October 1st	▪ Biweekly sample events ▪ Triplicate samples collected at each location	**Table 39** ▪ 1.A.3 (pg. 202) ▪ 1.A.4 (pg. 202)

Table 41 cont. *Portage Lake Watershed Monitoring Plan*

	Monitoring Type	Analyses	Locations	Timeframe	Frequency	Implementation Task Reference
			PORTAGE LAKE MONITORING			
WATER QUALITY	***Escherichia coli* (*E. coli*)**	*E. coli*	**Shoreline** ▪ 3A ▪ 3B ▪ 3D (see **Figure 125**)	▪ Spring ▪ Late Summer	Two sample events per year	**Table 39** ▪ 1.A.3 (pg. 202) ▪ 1.A.4 (pg. 202)
WATER QUALITY	**General Water Quality Parameters**	▪ Secchi depth ▪ pH ▪ Conductivity ▪ TDS ▪ Turbidity ▪ ORP ▪ DO ▪ Temperature	**Shoreline** ▪ 3A ▪ 3B ▪ 3D (see **Figure 125**)	▪ Spring ▪ Late Summer	Two sample events per year	**Table 39** ▪ 2.A.1. (pg. 204) ▪ 2.A.10. (pg. 205)
WATER QUALITY	**Nutrients**	▪ TP ▪ Nitrogen ▪ Total alkalinity ▪ Chlorophyll *a* ▪ Nitrates ▪ Ammonia	**Shoreline** ▪ 3A ▪ 3B ▪ 3D (see **Figure 125**)	▪ Spring ▪ Late Summer	Two sample events per year	**Table 39** ▪ 2.A.1. (pg. 204)
WATER QUALITY	**Algal Composition & Identification**	Algal composition & identification	**Shoreline** ▪ 3A ▪ 3B ▪ 3D (see **Figure 125**)	▪ Spring ▪ Late-Summer	Two times per year for shoreline locations	**Table 39** ▪ 2.A.8. (pg. 205)

Table 41 cont. *Portage Lake Watershed Monitoring Plan*

	Monitoring Type	Analyses	Locations	Timeframe	Frequency	Implementation Task Reference
			PORTAGE LAKE MONITORING			
WATER QUALITY	**General Water Quality Parameters**	▪ Secchi depth ▪ pH ▪ Conductivity ▪ TDS ▪ Turbidity ▪ ORP ▪ DO ▪ Temperature	**Deep Basins** Two deepest basins in Portage Lake, ~ 60 feet in depth (see **Figure 125**)	▪ Spring ▪ Mid-Summer ▪ Fall	▪ Three sample events per year ▪ Data collected at 10-foot intervals at each sample site	**Table 39** ▪ 2.A.1. (pg. 204) ▪ 2.A.9. (pg. 205) ▪ 2.A.10. (pg. 205)
WATER QUALITY	**Nutrients**	▪ TP ▪ Nitrogen ▪ Total alkalinity ▪ Chlorophyll *a* ▪ Nitrates ▪ Ammonia	**Deep Basins**: Two deepest basins in Portage Lake, ~ 60 feet in depth (see **Figure 125**)	▪ Spring ▪ Mid-Summer ▪ Fall	▪ Three times per year ▪ Three sets of samples collected at each site: - Surface - Mid-thermocline - Bottom of the lake	**Table 39** ▪ 2.A.1. (pg. 204)
WATER QUALITY	**Algal Composition & Identification**	Algal composition & identification	**Deep Basins**: Two deepest basins in Portage Lake, ~ 60 feet in depth (see **Figure 125**)	▪ Spring ▪ Mid-Summer ▪ Fall	Three sample events per year	**Table 39** ▪ 2.A.8. (pg. 205)
WATER QUALITY	**Swimmer's Itch (cercarial dermatitis)**	*Cercariae* Species	▪ Village of Onekama Beach (SI01) ▪ Covenant Bible Camp (SI02) (see **Figure 125**)	July	Sample per incidence	**Table 39** ▪ 1.C.2. (pg. 202) ▪ 1.C.3. (pg. 202)

Table 41 cont. *Portage Lake Watershed Monitoring Plan*

	Monitoring Type	Analyses	Locations	Timeframe	Frequency	Implementation Task Reference
			PORTAGE LAKE MONITORING			
SURVEYS	**Shoreline Survey**	Use Cooperative Lakes Monitoring Program (CLMP) methods to survey: ▪ Wetlands ▪ Erosion ▪ Shoreline development ▪ *Cladophora*	Shoreline of Portage Lake	Late May – Early June	▪ One sample event every five years ▪ Method: Utilize boat/kayak/canoe, drones, walk the shoreline, in order to survey the shoreline according to CLMP report methods	**Table 39** ▪ 2.A.7. (pg. 205) ▪ 2.C.1. (pg. 205)
SURVEYS	**Fisheries Surveys** Creel, walleye, general lake survey, tributary	▪ Panfish ▪ Game fish ▪ Rough fish ▪ Other	▪ Public access sites ▪ Entirety of Portage Lake ▪ Tributaries (see **Figure 125**)	April 1st – October 31st	▪ Survey once every ten years ▪ Methods: - Creel: Survey at public access sites, on lake in a boat - Walleye: Electroshocking - Lake: Netting and electroshocking - Tributary: Electroshocking	**Table 39** ▪ 3.B.3. (pg. 208)

Table 41 cont. *Portage Lake Watershed Monitoring Plan*

	Monitoring Type	Analyses	Locations	Timeframe	Frequency	Implementation Task Reference
			PORTAGE LAKE MONITORING			
SURVEYS	**Native and Invasive Aquatic Plant Survey**	▪ Native/Invasive: - Aquatic Vegetation Assessment Sites (AVAS) Survey, fall ▪ Invasive: - Full lake survey & preparation for treatment, spring - Pre/Post treatment surveys, summer	▪ Use grid-point surveys along with other techniques such as GPS, AVAS surveys, drones, submersible robots and volunteer mapping such as the ciBioBase used in 2015 & 2016	▪ Spring – Full lake survey ▪ Summer – Pre/post treatment surveys ▪ Fall – AVAS	Annually as determined by past surveys	**Table 39** ▪ 2.C.2. (pg. 206)
SURVEYS	**Invasive Plant Treatments**	▪ Treatment according to approved EGLE permit standards ▪ Pre and post surveys conducted for all treatments	▪ Portage Lake and shoreline	▪ Late-summer/fall: Phragmites ▪ Summer: Exotics	Treat multiple times annually, dependent on field observations	**Table 39** ▪ 2.C.5. (pg. 206)
			TRIBUTARY STREAM MONITORING			
WATER QUALITY	***E. coli***	*E. coli*	▪ Schimke Creek ▪ Onekama Creek ▪ Glen Creek ▪ Dunham Creek ▪ Stream #9 ▪ Stream #7	▪ Spring ▪ Fall	Twice annually at four sites	**Table 39** ▪ 1.A.1. (pg. 202) ▪ 1.A.3. (pg. 202) ▪ 1.A.4. (pg. 202)

Table 41 cont. *Portage Lake Watershed Monitoring Plan*

	Monitoring Type	Analyses	Locations	Timeframe	Frequency	Implementation Task Reference
TRIBUTARY STREAM MONITORING						
WATER QUALITY	***E. coli cont.***		▪ Hansen Creek ▪ Others as needed (see **Figure 125**)			
WATER QUALITY	**General Water Quality/ Quantity Parameters**	▪ Temperature ▪ DO ▪ pH ▪ Conductivity ▪ TDS ▪ Turbidity ▪ ORP ▪ TP ▪ TN ▪ Ammonia ▪ Flow rate	▪ Schimke Creek ▪ Onekama Creek ▪ Glen Creek ▪ Dunham Creek ▪ Stream #9 ▪ Stream #7 ▪ Hansen Creek (see **Figure 125**)	▪ Spring ▪ Late-summer	▪ Monitor up to seven tributaries twice annually ▪ Method: - Sample tributaries immediately before confluence with Portage Lake - Sample additional points upstream as needed	**Table 39** ▪ 2.A.6. (pg. 204) ▪ 3.B.1. (pg. 208)
SURVEYS	**Environmental Conditions Survey**	▪ Inventory benthos ▪ Bank erosion sites ▪ Road/stream crossing ▪ Fish migration barriers ▪ Habitat ▪ Wetlands ▪ Bank cover	▪ Schimke Creek ▪ Onekama Creek ▪ Glen Creek ▪ Dunham Creek ▪ Stream #9 ▪ Stream #7 ▪ Hansen Creek (see **Figure 125**)	Summer	Survey one stream every two years on a rotating basis	**Table 39** ▪ 2.A.6. (pg. 204) ▪ 2.B.1. (pg. 205) ▪ 3.B.2. (pg. 208)

Table 41 cont. *Portage Lake Watershed Monitoring Plan*

	Monitoring Type	Analyses	Locations	Timeframe	Frequency	Implementation Task Reference
STORMWATER MONITORING						
WATER QUALITY	**General Water Quality Monitoring**	▪ Temperature ▪ DO ▪ pH ▪ Conductivity ▪ TDS ▪ Turbidity ▪ ORP ▪ TP ▪ TKN ▪ Nitrate ▪ Velocity	▪ 1st Street (SW#7) ▪ 3rd Street (SW#6) ▪ 4th Street (SW#5) ▪ Zosel Park (SW#2) ▪ Additional storm structures as needed (see **Figure 125**)	Monitor post-significant rainfall event	One wet weather sample event annually	**Table 39** ▪ 2.A.5. (pg. 204) ▪ 2.A.6. (pg. 204)
SURVEYS	**Storm Infrastructure Inventory**	▪ Location ▪ Structure type ▪ Material ▪ Size ▪ Condition	Storm structures within Portage Lake Watershed	Year-round	One inspection every ten years	**Table 39** ▪ 2.A.3. (pg. 204)
WATERSHED-WIDE MONITORING						
SURVEYS	**Terrestrial Invasive Plant Survey**	▪ Purple Loosestrife (*Lythrum salicaria*) ▪ Phragmites (*Phragmites australis)*	Entire watershed	Fall	Annually	**Table 39** ▪ 2.C.1. (pg. 205) ▪ 2.C.5. (pg. 20)

Table 41 cont. *Portage Lake Watershed Monitoring Plan*

	Monitoring Type	Analyses	Locations	Timeframe	Frequency	Implementation Task Reference
WATERSHED-WIDE MONITORING						
SURVEYS	**Terrestrial Invasive Plant Survey cont.**	▪ Japanese Knotweed *(Fallopia japonica)* ▪ Yellow Iris *(Iris pseudacorus)* ▪ Others				

SOURCE: Public Sector Consultants Inc., 2007, updated by Spicer Group, Inc. in 2019.

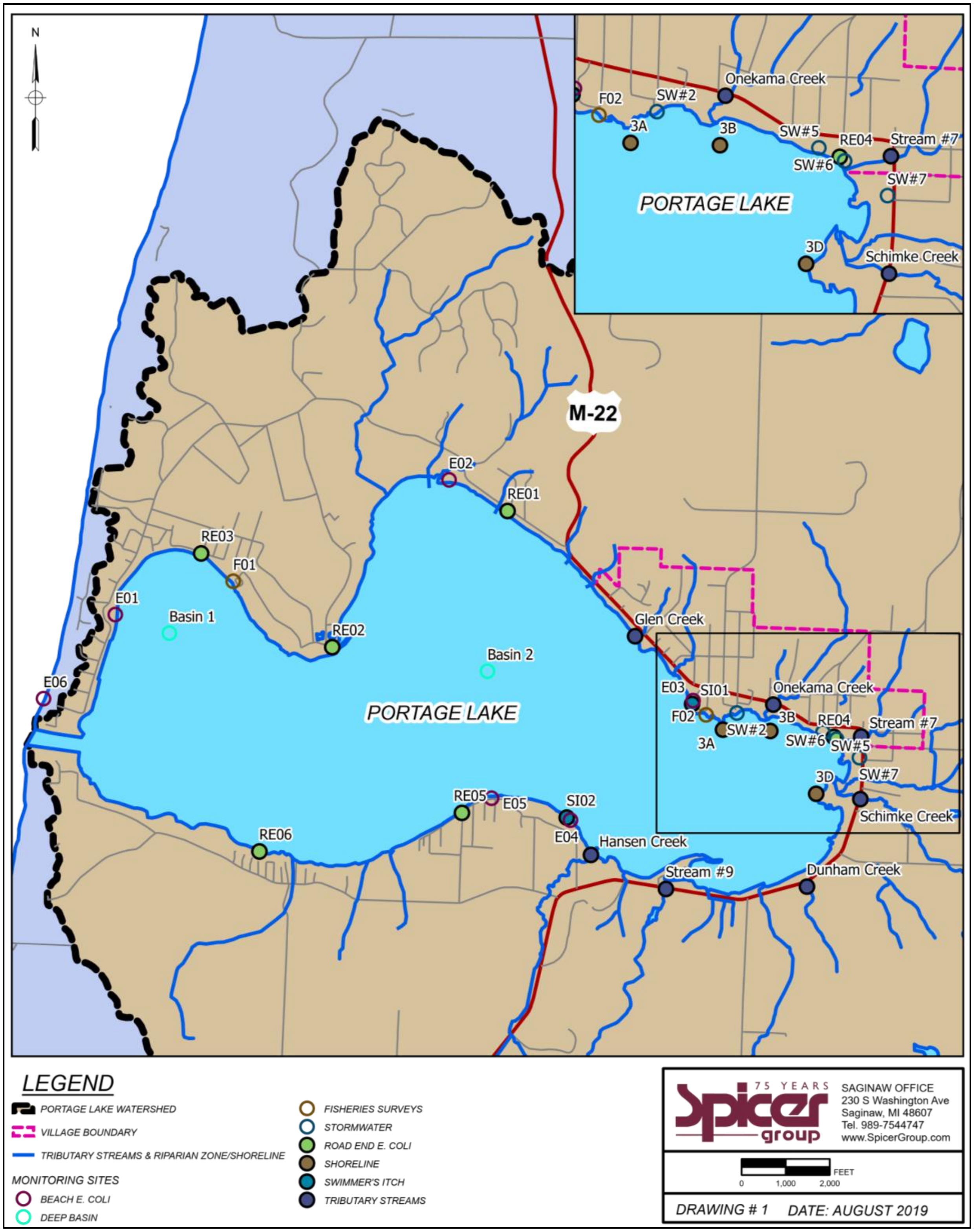

Figure 125. *Portage Lake monitoring plan sample locations*

SOURCE: Spicer Group Inc., 2019.

<u>Importance of Monitoring for Watershed Priority Goals and Tasks</u>

PUBLIC HEALTH

Monitoring of *E. coli* bacteria to determine compliance with both total body and partial body contact recreation water quality standards will require more frequent sampling and added sites in the future. Testing in public swimming areas will be conducted in compliance with the District Health Department #10's Uniform Sanitary Code and will include the popular swimming areas in Portage Lake as well as the swimming area in Lake Michigan immediately north of the Portage Lake Channel. In addition to beach testing, *E. coli* sampling will also be done at additional shoreline sites, road end sites, and selected tributary stream outlets per the Monitoring Plan.

AQUATIC ECOSYSTEM HEALTH

The primary concerns and/or threats to ecosystem health in the Portage Lake Watershed are over-enrichment or eutrophication and loss of critical physical habitat. Fortunately, historical monitoring of productivity of Portage Lake has created a baseline that can be used to determine changes in the productivity or trophic status of the lake. Total phosphorus, transparency, and chlorophyll *a* have been monitored and reported on and together can be used to establish a trophic status index (TSI), which has been used widely throughout Michigan, Wisconsin, and other states to monitor productivity.

Dissolved oxygen (DO) concentrations in Portage Lake will be measured to establish conformance with state water quality standards as well as to supplement information related to the potential threat of over-enrichment. While current information indicates that state standards are being met, more information is needed on DO levels during a 24-hour period to assure that minimum levels are being met both in the summer stratification period and throughout the year. In addition, DO measurements will be made to determine whether the period of DO depletion in deeper portions of the lake is increasing in terms of intensity or length of time during the period of spring through fall temperature stratification.

A *Cladophora* algae survey will also be conducted to establish whether there are significant nearshore sources of phosphorus (e.g. septic tank/tile field, sheet runoff coming from lawns, stormwater runoff from impervious surfaces) that are contributing to enrichment of the lake. This information will be used in combination with *E. coli* monitoring to evaluate the effectiveness of current septic tank/tile fields serving a significant portion of the residences surrounding Portage Lake. The planned *Cladophora* survey can be compared to the previous algae surveys that provide a baseline for measuring changes over time. Along with the *Cladophora* survey, general algal composition and identification of Portage Lake will be conducted on an annual basis.

A baseline survey of rooted aquatic plants (macrophytes) was completed in 2009 to determine the status of various exotic, invasive plant species identified in this plan. Since then, annual monitoring of both aquatic and terrestrial invasive species and native species has been in Portage Lake and along the shoreline. The Monitoring Plan calls for monitoring macrophyte growth with particular attention to identifying areas that have purple loosestrife, phragmites within adjacent wetland areas, and Eurasian watermilfoil in the lake proper. These three species are very aggressive, and monitoring can assist in determining whether their abundance represents a threat to designated protected uses (e.g. swimming, boating, habitat for fish and wildlife) that needs to be addressed.

The remaining undisturbed shoreline habitat in Portage Lake and the habitat quality in tributary streams have been identified as critical to the survival, reproduction, and growth of resident fish and wildlife populations. The Monitoring Plan outlines efforts to identify critical shoreline wetlands and other undisturbed shoreline littoral zones in the lake and conditions on tributary streams through use of trained volunteers. Although the details of the specific sampling techniques, mapping, and recording of information by the volunteers are yet to be determined, successful use of volunteers in other watersheds (e.g. Clinton River, Rouge River, and Huron River) will be used as models for developing this program. In partnership with the MDNR, the USFWS, the EGLE, and the Little River Band of Ottawa Indians, sampling of fish populations in Portage Lake and its tributaries, and hoped-for benthos monitoring by the EGLE, will complement other information on ecosystem health and habitat changes.

EVALUATION

In cooperation with its partners, the Portage Lake Watershed Forever organization will routinely evaluate the monitoring results. Where baseline information is currently available, new monitoring information will be compared to baseline information. If significant adverse changes are noted, actions will be recommended to expand monitoring efforts to further define the source of the problem or, if the source is known, direct action will be taken to correct the problem. Where specific numeric or narrative water quality standards apply, exceedances will be reported, and actions needed to implement best management practices and/or to institute regulatory actions will be recommended. Results for each year will be evaluated after the State of the Lake Report has been made available. Unless otherwise specifically noted, the monitoring results and the watershed plan will be reevaluated every five years beginning in 2020. If the review of monitoring results identifies significant problems prior to the established evaluation date, further direct actions will be taken to address the documented problem and, if appropriate, immediate actions and public notification will occur to minimize potential imminent threats to public health or the environment.

A measure of success will be confirmation that all water quality standards continue to be met and designated uses are protected. If information is uncovered through monitoring that state water quality standards are not being met, or that other changes have occurred that will likely impair protected or desired uses, further actions will be recommended to address the most likely sources of the impairments. Where state standards are not available or current lake values are well below state standards, the measure of success will be no evidence of significant deterioration of current environmental conditions based off of the historical criteria presented in **Table 42**. The state or national guidelines are also listed in the parameter criteria along with the historical levels. The historical criteria values are three percentiles calculated using monitoring parameters from the 2009 through 2016 State of the Lake Reports. If measured values are below the Acceptable Level (shown in green), no action needs to be taken; and if values reach the Awareness Level (shown in orange), additional monitoring should be done. The Action Level (shown in red) represents the level, that once surpassed, best management practices should be implemented.

Successful establishment of the institutional structure to assure implementation of the recommendations of this plan is critical. While volunteers can contribute substantially to the monitoring effort, the Portage Lake Watershed Forever organization needs to continue to improve its structure and operations as recommended to assure that it has staff that can organize and manage the elements in the Monitoring Plan and evaluate the results.

Table 42. *Evaluation levels for monitored parameters in the Portage Lake Watershed*

Monitoring Parameter	Parameter Criteria	Regulatory Notes
Escherichia coli (E. coli)	***Regulatory Criteria:*** ▪ Should not exceed 130 (CFU/100mL) as a monthly geometric mean of at least five samples. ▪ Should not exceed 300 (CFU/100mL) at any time. ***Portage Lake Historical Criteria[1]:*** ▪ Acceptable Level: 4 CFU/100 mL ▪ Awareness Level: >4 CFU/100 mL ▪ Action Level: 30 CFU/100 mL	Regulatory criteria from the State of Michigan's Part 4 Rules.

Table 42 cont. *Evaluation levels for monitored parameters in the Portage Lake Watershed*

Monitoring Parameter	Parameter Criteria	Regulatory Notes
Swimmer's Itch	***Regulatory Criteria:*** Currently, there is not a numerical standard for the Swimmer's Itch parasite. However, if a numerical standard and standard testing method is developed in the next 10 years, the metrics may be applicable to Portage Lake. ***Portage Lake Historical Criteria:*** There is not existing, numerical, historical Swimmer's Itch results on Portage Lake.	There has been Swimmer's Itch research conducted on Portage Lake and other northern Michigan lakes by Oakland University.
Phosphorus	***Regulatory Criteria:*** ▪ Concentrations remain below 50 ppb (0.05 mg/L). ***Portage Lake Historical Criteria[1]:*** ▪ Acceptable Level: 0.007 mg/L ▪ Awareness Level: 0.011 mg/L ▪ Action Level: 0.019 mg/L	Recommendation for tributaries from the United States Protection Agency (USEPA).
Ammonia	***Regulatory Criteria:*** ▪ Aquatic Maximum Value (AMV)[2] is 1.5 mg/L at 67.6°F and pH of 8.44. ▪ Final Chronic Value (FCV)[3] is 0.47 mg/L at 67.6°F and pH of 8.44. ***Portage Lake Historical Criteria[1]:*** ▪ Acceptable Level: 0.03 mg/L ▪ Awareness Level: 0.04 mg/L ▪ Action Level: 0.19 mg/L	Regulatory Criteria is from the State of Michigan's Part 4, Rule 57 Water Quality Values for Ammonia. This value is dependent on temperature and pH.
Nitrate	***Regulatory Criteria:*** ▪ Currently, there is not a surface water standard mandated by the State of Michigan or federally. ***Portage Lake Historical Criteria[1]:*** ▪ Acceptable Level: 0.21 mg/L ▪ Awareness and Action Level: 0.23 mg/L	Not Applicable

Table 42 cont. *Evaluation levels for monitored parameters in the Portage Lake Watershed*

Monitoring Parameter	Parameter Criteria	Regulatory Notes
Dissolved Oxygen	***Regulatory Criteria:*** ▪ For waterbodies supporting coldwater fisheries, which includes Portage Lake and its tributaries, DO concentrations shall be a minimum of 7 mg/L at all times.	Regulatory criteria from the State of Michigan's Part 4 Rules. Portage Lake has had DO concentrations well above 7 mg/L in the epilimnion, but near zero mg/L DO in the hypolimnion.
Temperature	***Regulatory Criteria:*** To protect coldwater fisheries, during the summer months, temperatures should not exceed 68°F for tributaries entering Portage Lake. In Portage Lake, temperatures should not exceed the following temperatures (°F) each month: JAN – 45, FEB – 45, MAR – 50, APR – 60, MAY – 70, JUN – 75, JUL – 80, AUG – 85, SEP – 80, OCT – 70, NOV – 60, DEC – 50 ***Portage Lake Historical Criteria[1]:*** ▪ 25th Percentile: 65°F ▪ 50th Percentile: 67.6°F ▪ 75th Percentile: 73.9°F	Regulatory criteria from the State of Michigan's Part 4 Rules.
pH	***Regulatory Criteria:*** ▪ Remain in the pH range of 6.5 and 9.0. ***Portage Lake Historical Criteria[1]:*** ▪ 50th Percentile: 8.3 ▪ 75th Percentile: 8.44 ▪ 90th Percentile: 8.58	Regulatory criteria from the State of Michigan's Part 4 Rules.
Cladophora	***Regulatory Criteria:*** There is currently no regulatory criteria for *Cladophora*. ***Portage Lake Historical Criteria:*** There is currently not enough numerical data to determine historical surface area of *Cladophora*.	Not Applicable

Table 42 cont. *Evaluation levels for monitored parameters in the Portage Lake Watershed*

Monitoring Parameter	Parameter Criteria	Regulatory Notes
Cladophora Cont.	For future *Cladophora* surveys, compare observations to the most recent *Cladophora* survey, and monitor areas of heavy growth for the next 10 years. Measurements can be made in terms of square feet, acreage, etc.	
Chlorophyll *a*	***Additional Criteria:*** Based off of Tip of the Mitt volunteer lake monitoring data, chlorophyll *a* concentrations in similar northern Michigan lakes range from 0 - 0.005 mg/L. ***Portage Lake Historical Criteria[1]:*** ▪ Acceptable Level: 0.0034 mg/L ▪ Awareness Level: 0.0080 mg/L ▪ Action Level: 0.0133 mg/L	Not Applicable

SOURCE: Spicer Group Inc., 2019.

[1]Percentiles generated from 2009 – 2016 data from State of the Lake Reports. Acceptable Level (green text) indicates 50th percentile. Awareness Level (orange text) indicates 75th percentile. Action Level (red text) indicates 90th percentile. Percentiles are weighted low as levels undetected by lab equipment were assumed to be zero.

[2]Aquatic Maximum Value (AMV) means the highest concentration of a material in the ambient water column to which an aquatic community can be exposed to without resulting in unacceptable effects. Concentration table from EGLE can be found in ***APPENDIX G: AQUATIC MAXIMUM VALUES AND FINAL CHRONIC VALUES****.*

[3]Final Chronic Value (FCV) means the level of a substance or a mixture of substances that does not allow injurious or debilitating effects in an aquatic organism resulting from repeated long-term exposure to a substance relative to the organism's lifespan. Concentration table from EGLE can be found in ***APPENDIX G: AQUATIC MAXIMUM VALUES AND FINAL CHRONIC VALUES****.*

Tracking of Plan Implementation

Portage Lake Watershed Forever intends on tracking the progress of tasks and objectives outlined in the Watershed Management plan using existing management framework. Annually, PLWF creates a status report of activities, objectives, and goals reached throughout the year. These items include, but are not limited to, fundraiser efforts, work completed by various committees, outreach events, monitoring efforts, and any other notable projects that have been started or completed throughout the year. A spreadsheet is used to track annual fundraising efforts so that the information can be included within the annual Watershed status report. The status report is then shared with those who attend the annual Watershed Meeting in November of each year.

Specific to water quality and environmental monitoring, a State of the Lake Report is produced each year by the consultant who performs the work. The report tracks and compares water quality monitoring results to previous years' data. Data is collected within a variety of waterways, including Portage Lake, its tributary streams, and storm drains. Additionally, the report outlines aquatic vegetation and aquatic invasive species that have been observed and treated on Portage Lake. Other monitoring efforts and activities completed by various groups, including the District #10 Health Department, community members, and other conservation groups will be documented by the organization doing the work, and tracked by the PLWF.

Tracking all activities relevant to the Watershed Management Plan will be beneficial in determining which goals and objectives are near completion, and which are in need of additional resources or time. By tracking and achieving the goals and objectives within in the Watershed Management Plan, Portage Lake and its watershed will remain a place where many generations of people will come to enjoy and appreciate the natural beauty of the area.

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APPENDIX A: HISTORICAL WATER QUALITY DATA

Michigan Department of Natural Resources Water Quality Data
(MDNR, Michigan/USEPA, 1974 and 1985 STORET Water Quality Data)
As part of the then-routine monitoring program of Great Lakes tributaries by the MDNR, water quality samples were collected at various depths at the two deepest locations in the western and central basins, Basin 1 and Basin 2 respectively, of Portage Lake in July and again in September of both 1974 and 1985. At the time the MDNR included water quality monitoring that is now the responsibility of the EGLE.

A Shoreline Algal Survey, NW Michigan Regional Planning and Development Commission
(Northwest Michigan Regional Planning and Development Commission, 1983)
This is a USEPA-supported project to evaluate the need for sanitary sewers completely around Portage Lake originally proposed in a 1976 plan. The survey encompassed all shoreline areas of the lake and focused on the use of *Cladophora* as an indicator algal species in combination with models to evaluate phosphorus loadings and sources.

Portage Lake USEPA Phase I Diagnostic/Feasibility Study 1993
(SEG, 1993)
The most recent comprehensive water quality study of Portage Lake and its watershed is the Portage Lake USEPA Phase I Diagnostic/Feasibility Study (Phase I Study), prepared by the Snell Environmental Group, Inc (SEG). It was completed in 1993 with funding support from Onekama Township and a 50 percent matching grant from the USEPA, Region V, through the then MDNR Clean Lakes Program. The study describes the physical properties of the lake and watershed and its historic and present uses, and summarizes previous information collected on the status of the lake and the watershed. SEG collected water samples beginning in January 1991 and continuing through February 1992. Samples were collected monthly at three lake locations at multiple depths for the periods March through April and September through February. The same locations were sampled twice a month from May through August. Six additional lake littoral zone areas were also sampled at the surface each month from May through October.

A variety of parameters were measured for water samples collected from Portage Lake including temperature, pH, conductivity, dissolved oxygen (DO), nitrate and nitrite nitrogen, ammonia, Kjeldahl nitrogen, orthophosphate, total phosphorus, suspended solids, chlorophyll *a*, and Secchi disk transparency. The analyses of the data collected focused on four primary parameters: total phosphorus, chlorophyll *a*, Secchi disk transparency, and DO. These parameters are typically used to evaluate the trophic status[1] of lakes and in combination can be used to detect significant changes that may be occurring due to human activity.

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[1] Classification of the condition of a water body is based on the degree to which sun energy is converted to aquatic plant and algal growth (i.e. productivity). Generally, lakes are classified as oligotrophic (unproductive) or eutrophic (very productive), and those in-between are called mesotrophic.

Four streams (Dunham, Glen, Schimke, and Onekama Creeks) were sampled at their lake outlets twice a month during April and May and once a month during the 12-month study period. 11 smaller streams and drain outlets were sampled at their lake outlets in May, August, and November. Parameters measured on tributaries included flow, temperature, pH, conductivity, DO, nitrite, orthophosphate, total phosphorus, and suspended solids. The analysis of stream data collected focused on three primary parameters: flow, total phosphorus, and suspended solids.

Michigan Department of Natural Resources Fish Contaminant Monitoring 1991
(as cited in SEG, 1993)
The MDNR reported on various heavy metals and organic compounds measured in fish taken from Portage Lake in 1991 and the results were reported in the 1993 Phase I Study.

Onekama Township Bacteriological Sampling 1985–1990
(as cited in SEG, 1993)
From 1985 through 1990, representatives of Onekama Township collected lake water samples for fecal coliform analyses to determine compliance with then State Health Department standards for safe total body contact recreation.

Onekama High School Water Quality Monitoring 1993–2007
(Onekama High School, 2007)
Onekama High School students have tracked water quality in Portage Lake from 1993 through the present including monitoring temperature, pH, DO near the surface, Secchi disk transparency, chlorophyll *a*, and total phosphorus at three lake locations (same locations sampled during Phase I Study) in both the spring and the fall of each year.

Department of Natural Resources Water Quality Monitoring 1999 and 2007
(MDNR, 1999 and 2007)
The Fisheries Division of the MDNR collected water quality samples and determined the dissolved oxygen concentration at various depths in one-day sampling events during 1999 and 2007.

Status of the Fishery Resource Report 2000
(MDNR, 2000)
The last intensive survey of the fisheries of Portage Lake was completed in June of 1999 and reported in the MDNR Status of the Fishery Resource Report 2000-9. The Fishery Resource Report outlined the history of the lake, land use in the watershed, development along the shoreline, basic water chemistry, and the status of the fish population.

Little River Band of Ottawa Indians (LRBOI) Walleye Recruitment Assessments of Portage Lake
(LRBOI, 2005 and 2006)
The Little River Band of Ottawa Indians, as part of a larger study of fish populations in their tribal area of interest, conducted field investigations during 2005 and 2006 to determine the status of walleye recruitment and growth in Portage Lake.

A Biological Survey of McGowan's and Schimke Creeks, Manistee County
(MDEQ, 2007d)
During August of 2003, the MDEQ Water Bureau, Surface Water Quality Assessment Section conducted field investigations on McGowan's and Schimke Creeks. The focus of the studies was to determine the biological integrity and physical habitat in these two largest tributaries to Portage Lake.

Onekama Township Bacteriological Sampling 2007
(Onekama Township, 2007)
Five popular swimming beaches were sampled during July and August 2007 for E. coli bacteria to determine compliance with state water quality standards for total body contact recreation.

State of the Lake 2009
(Lakeshore Environmental, INC., 2009)
First of a series of annual lake management reports written by various consultants. The report summarizes aquatic ecology, physical and watershed characteristics, Portage Lake water quality, fish community, macrophyte analysis, invasive species, and management improvement methods.

State of the Lake 2010
(Lakeshore Environmental, INC., 2010)
The report summarizes aquatic ecology, physical and watershed characteristics, Portage Lake water quality, fish community, macrophyte analysis, invasive species, and management improvement methods.

Why Aquatic Herbicides Affect Aquatic Plants and Not You
(Carole Lembi, Purdue University, 2010)
Slide presentation transcript explaining aquatic plants, how aquatic herbicides work, and how they do not have a negative impact on humans.

State of the Lake 2011
(Lakeshore Environmental, INC., 2011)
The report summarizes aquatic ecology, physical and watershed characteristics, Portage Lake water quality, fish community, macrophyte analysis, invasive species, and management improvement methods.

State of the Lake 2012
(Restorative Lake Sciences, LLC, 2013)
The report summarizes aquatic ecology, physical and watershed characteristics, Portage Lake water quality, macrophyte analysis, invasive species, and management improvement methods.

Basic Limnology
(Herb Lenon, Tuesdays with Water series, 2012)
A report summarizing what limnology is. The report explains various parameters, such as watershed, shoreline development, water depths, retention time, photic zone, epilimnion, hypolimnion, and other terms that have importance in limnology.

State of the Lake 2013
(PLM Lake & Land Management Corp., 2013)
The report summarizes aquatic ecology, physical and watershed characteristics, Portage Lake water quality, macrophyte analysis, invasive species, and management improvement methods. Additionally, water quality analysis was performed on tributary streams, stormdrains, and along the shoreline. Lake management practices performed throughout the year (i.e. invasive species treatment) were also documented.

State of the Lake – Portage Lake, Summary of 39 Years of Water Quality Monitoring
(Herb Lenon, 2013)
Summarizes the past 39 years of water quality monitoring effort and results. Covers parameters such as dissolved oxygen, water clarity, aquatic macrophyte population, native plants, chlorophyll *a*, total phosphorus, pH, tributary drains, nitrogen, E. coli, storm drain monitoring, and data gaps that need to be filled in future monitoring efforts.

State of the Lake Community Program
(PLM Lake & Land Management Corp., 2013)
Presentation summarizing aquatic invasive species, aquatic invasive species observed in Portage Lake, treatment methods, general lake management practices, and water quality practices.

State of the Lake 2014
(PLM Lake & Land Management Corp., 2014)
The report summarizes aquatic ecology, physical and watershed characteristics, Portage Lake water quality, trophic status, macrophyte analysis, invasive species, and management improvement methods. Additionally, water quality analysis was performed on tributary streams, storm drains, and along the shoreline. Lake management practices performed throughout the year (i.e. invasive species treatment) were also documented.

State of the Lake 2015
(PLM Lake & Land Management Corp., 2015)
The report summarizes aquatic ecology, physical and watershed characteristics, Portage Lake water quality, trophic status, macrophyte analysis, invasive species, and management improvement methods. Additionally, water quality analysis was performed on tributary streams, storm drains, and along the shoreline. Lake management practices performed throughout the year (i.e. invasive species treatment) were also documented.

State of the Lake Summary 2015
(Herb Lenon, 2015)
Provides an abridged version of the 2015 State of the Lake Report, covering the following information: Aquatic vegetation surveys, exotic invasive species control, phytoplankton, zooplankton, lake water quality, tributary water quality, storm drain water quality, trophic status, and general conclusion.

Survey of Swimmer's Itch Parasites in Michigan Lakes
(Thomas R. Raffel, 2016)
Project summary of goals, methods, project collaborators, preliminary results, and the 2016 survey schedule. Essentially, the goal of the project was to measure the distribution and abundance of swimmer's itch parasites in Michigan. This was a research project being conducted by Oakland University.

State of the Lake 2016
(PLM Lake & Land Management Corp., 2016)
The report summarizes aquatic ecology, physical and watershed characteristics, Portage Lake water quality, trophic status, macrophyte analysis, invasive species, and management improvement methods. Additionally, water quality analysis was performed on tributary streams, storm drains, and along the shoreline. Lake management practices performed throughout the year (i.e. invasive species treatment) were also documented.

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2017 Forest Health Highlights
(Michigan Department of Natural Resources, 2017)
Report summarizes various forest diseases and pests that are causing harm to forests.

2016 Michigan Fish Consumption Data & Recommendation Sheets
(Michigan Department of Natural Resources, 2016)
Report shows the raw data, calculations, and consumption recommendations of different fish species across the state.

2014 Portage Lake Creel Report
(Michigan Department of Natural Resources, 2017)
Concludes results of shoreline interviews with anglers about catch counts. Interviews occurred at random between the months of April and October.

Invasive Species Treatment and Concerns for the Walleye Fishery in Portage Lake
(Herb Lennon, 2010)
A personal letter explaining what seems to be a decline in walleye populations in the summer of 2009 and the optimistic future for abatement of Eurasian watermilfoil.

APPENDIX B: ENDANGERED, THREATENED, AND SPECIES OF CONCERN DESCRIPTIONS

ENDANGERED SPECIES

PIPING PLOVER

This shorebird will grow upwards of 1.5 to 2.2 ounces with an overall length of 7¼ inches and wingspan of about 15 inches. These birds have a very short yet robust bill and coloration that matches their dry sandy habitats. They commonly reside in open sandy areas with light vegetation and cobble. During the nesting season, Piping Plovers will commonly move to seeps, interdunal wetlands and creeks. The presence of these birds may be confirmed via their prolific "peep-lo" whistle.

Figure 1. *Piping plover*
Photo from Wildlife NYC

Development of previously natural shorelines is the main cause of this species population decline. Specific examples of habitat destruction include marina construction, dredging and artificial shorelines such as break walls. These changes in the landscape ultimately reduce breeding areas and may cause long term changes to other aspects of the shoreline. Since 1988, predator enclosures have been used around plover nests and have resulted in an increase in hatching success.

MIGRANT LOGGERHEAD SHRIKE

Loggerhead Shrike have black white and gray plumage that generally measure 8 to 10 inches in length and a wingspan of roughly 13 inches. A distinctive black mask runs across their heads above their eyes and slightly hooked beak. Loggerhead Shrikes heads are bluish gray on top with the coloration continuing down their backs while having lightly barred white bellies and breasts. The black wings and tails sport white accents.

Figure 2. *Migrant loggerhead shrike*
Photo by Larry Kirtley, Government of Ontario

Loggerhead Shrikes generally reside in open grasslands, agricultural areas, hedges, and shrubbery. The sparse trees within this habitat serve vital to these birds as nesting cover and lookouts. Habitat for Loggerhead Shrikes is threatened by both natural and anthropologic fronts. Vegetation succession may replace prairies with forests, while alterations in land use may cause urbanization to spread into these vital breeding areas. As a predatory bird, the Loggerhead Shrike is vulnerable to pesticide applications in agricultural areas.

INDIANA BAT

Averaging in length from 3.3 to 8.3 centimeters the Indiana Bat is small with grayish brown fur. Dark wings contrasted by pink bellies with stumpy round ears are common within their family Myotis. To discern Indiana Bats from their relatives one must check for the presence of an elevated ridge on the calcar (structure that allows support between the heel and tail). Since these bats reside in colonies under bark or within hollow dead trees, they are susceptible to deforestation, collection of firewood, and vandalism. Another significant source of population loss is from severe winters and disturbances during hibernation periods. Historically these bats resided near riparian corridors. Protection of the remaining population would be supported by reductions in human interactions with dead trees and other possible hibernacula.

Figure 3. *Indiana bat*
Photo by Ann Froschauer
USFWS

PUGNOSE SHINER

This minnow has a distinctive seemingly vertical mouth, eight dorsal rays and is naturally rare. They grow to a general length of 3.8 to 5.6 centimeters and have a pale-yellow coloration. Habitat for the Pugnose Shiner consists of vegetated lakes, pools and slowly flowing streams. Observations in the wild deduce that this species is extremely intolerant to turbidity.

Figure 4. *Pugnose shiner*
Photo by Konrad Schmidt
MSU Extension

Due to their small size and nature of their habitat they are challenging to sample and may be a source of ambiguity in population measurements. Management of the Pugnose Shiner should be spearheaded with reductions in sediment transport, shoreline protection and prevention of macrophyte over abundance.

THREATENED SPECIES

PITCHER'S THISTLE

This perennial thistle is found along the shore of the Great Lakes where there are open sand dunes and occasionally lag gravel within those regions. It is critical that habitat remains intact when near the Great Lakes shoreline.

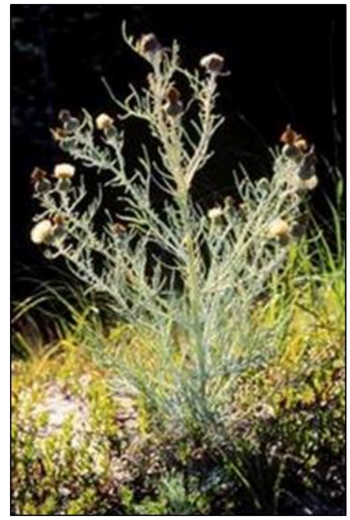

Figure 5. *Pitcher's thistle*
Photo by Susan R. Crispin MSU Extension

Major disruptions in the natural landscape of these dunes such as housing developments will be detrimental to Pitcher's Thistles. This plant has shown to be resilient to light foot and off-road vehicle traffic. Repeated exposure to the aforementioned traffic will destabilize these dune habitats by reducing the presence and root structure of resident plants. This degradation of dune stability will lead to stressors on this increasingly rare plant.

Since there is a high demand for properties along the Great Lakes shoreline, the threat to Pitcher's Thistles is increasing. Developments along the shoreline will indubitably have an effect in the presence of this plant. Currently, two of the largest colonies of Pitcher's Thistles reside in Sleeping Bear Dunes National Lakeshore and Ludington State Park/Manistee National Forest.

WILD RICE

Found in emergent marshes, lakeshores, and slowly flowing streams, wild rice is a tall aquatic grass (two-three meters). The leaves, whether submerged or emergent, measure 1 to 4.5 centimeters wide. Identification may be done by observing female spikelets on the upper half of the stalk, and male spikelets on the lower half of the stalk. There are several varieties and may appear with slight differences between them.

Figure 6. *Wild rice*
Photo from UNH Center for Freshwater Biology

Wild Rice may be protected by maintaining the current hydrology of regions that express possible habitat qualities. Nutrients offered by agricultural runoff has shown to have negative implications on this plant's survival. Invasives such as narrow-leaf cattails, phragmites and purple loosestrife serve as competition for habitat.

Broomrape


Figure 7. Broomrape
Photo by Fred Harris
Minnesota DNR

Broomrape is a tiny herbaceous flower (5 to 15 centimeters) found on open dunes. This parasitic by nature plant will grow on the roots of wormwood. Foliage consists of hairy leaves leading to a cluster of tubular flowers on the top. Clusters of Broomrape can be found on sand dunes along the Great Lakes shoreline.

Dune protection is vital in the preservation of this unique flower. The natural fluctuations that dunes undergo due to the driving forces of nature are beneficial to Broomrape as the slow processes give many opportunities for Broomrape to take advantage of the microsites required for successful rooting. Habitat must be protected from development, ORV and foot traffic to ensure successful protection.

Ginseng


Figure 8. Ginseng
Photo by Judd Patterson
Ney York DEC

Found in dense canopied forests, Ginseng is herbaceous flower that has five palmately compounded leaves (Cluster of leaves originate from single point). Ginseng flowers are greenish-white in coloration and develop into red berries. This plant's main threat is the illegal harvesting of its roots where they are used in herbal remedies. Protection of this plant requires the prohibition of its harvesting, preservation of forests in their natural state and reductions in clear cutting. In this case, leaving the forest untouched by anthropologic activity is the best practice.

Lake Huron Locust


Figure 9. Lake Huron locust
Photo by David Cuthrell
MSU Extension

This light gray grasshopper covered in dark brown and white spots sports a dark brown band on the wings. The Lake Huron Locust is isolated to high quality dune environments with a low plant density. When this insect's habitat requirements are fulfilled, their population is commonly abundant. The Lake Huron Locust is threatened solely because of reductions in their specific habitat requirements. These reductions are a result of shoreline development within the Great Lakes. Although sensitive to alterations in landscape, these locusts have been observed to live with medium human interference. Sustained populations have been observed on private lands where the dunes condition remained intact.

LEAST BITTERN

Figure 10. *Least bittern*
Photo by Judd Patterson
Ney York DEC

Averaging 11 to 14 inches long with a 16 to 18-inch wingspan, Least Bitterns are a small marsh bird. They express rich green-black plumage on their backs, tails and crowns while the rest of the body is a light brown with white strips on the shoulders. Since these birds are often considered secretive, they are much easier to identify when hearing their exclusively low dove-like call. Least Bitterns nest in dense patches of emergent vegetation over 4 to 30 inches of water that are generally within a few meters of open water. The nests commonly consist of woven cattails, bulrushes, or twigs and resemble hand baskets due to their unique shape. Protection of this species requires protection of shallow wetlands consisting of dense emergent vegetation. As stated by multiple authors, a wetland covered in half vegetation and half open water serves to be habitat for the largest volume of wetland birds. Management should be directed to promote this ratio of water to cover. Eutrophication, chemical contamination, and siltation also serve as possible threats to the Least Bittern.

TRUMPETER SWAN

Figure 11. *Trumpeter swan*
Photo by Ryan P. O'Connor

As the largest swan in North America, Trumpeter Swans deviate from their similar relatives by their low pitch nasal honking and unique black bill with a point between their eyes. Many wetlands are suitable for swan nesting including ponds, lakes and marshes. It is common to see nests placed upon muskrat houses. Trumpeter Swans have been reintroduced at various locations throughout the state. To uphold the current populations, proactive decisions must be made to protect their open water spaces required for take-off and landing. Trumpeter Swans also benefit from lush submergent and emergent vegetations when seeking shelter, cover and food. As a naturally territorial species, it would further benefit these swans by forming a no-activity zone around known nesting locations. Trumpeter Swans are also currently being out competed by Mute Swans, an aggressive invasive species. Control of Mute Swan populations would allow more opportunity for Trumpeters to increase in population.

COMMON LOON

Figure 12. *Common loon*
Photo by Phil Swanson
Nebraska Bird Library

This large and dense waterfowl measures in at 32 inches head to tail with a five-foot wingspan. When ready to breed the Common Loon flaunts a distinct white breast, black head, red eyes and checkerboard back. Loons commonly nest on undeveloped inland lake islands sheltered from the wind. It is uncommon to see them on lakes smaller than 11 acres. These birds are susceptible to human interruptions during the breeding season. It is best to maintain a ¼ mile distance from active nests during the breeding season. To best prevent adverse interactions constructive habitat maintenance should be scheduled during the non-breeding season (September-February). It is also recommended that the use of herbicides is reduced in inland lakes where loons are present.

CERULEAN WARBLER

Figure 13. *Cerulean warbler*
Photo from USDA Kentucky

Due to their tendency to live high in the canopy of mature deciduous forests, the Cerulean Warbler is challenging to identify. This small bird has 2 white stripes on each wing and sports exuberant blue feathers in males. These birds also have short tails with black rings around their necks.

Threats to these birds include deforestation and fragmentation of mature deciduous forests within stream valleys. Other negative impacts may originate from loss of specific species of trees, specifically, oaks, sycamores, elms and American Chestnut. Cerulean Warblers also are being threatened by the Brown-headed Cowbird, a species of bird that parasitizes nests of a plethora of birds.

RED-SHOULDERED HAWK

Figure 14. *Red-shouldered hawk*
Photo by Michael R. Penskar
MSU Extension

Red-shouldered Hawks are easily distinguished by their unique features including red coloration of underparts and linings of wings, five-six white tail bands and translucent crescents visible on their primary wing feathers. Although named after the presence of red shoulders, this trait is not always visible. Their presence may be confirmed by a distinctive and repeating “kee-yer” call but is commonly confused with the call of blue jays.

Fragmentation of forest habitat is the leading issue concerning the survival of this predatory bird. Construction of roads, deforestation and subdivision developments are leading sources of this fragmentation. This change in the landscape will lead to deterioration of nesting structure and availability of prey. As these once dense forests shift to more open and isolated stands this habitat tends to give the advantage to competitors such as the red-tailed hawk (*Buteo jamaicensis*) and great horned owl (*Bubo virginianus*).

LOUISIANA WATERTHRUSH

This large warbler has a white underside with brown patches and a brown back and wings. They measure on average 6 inches in length and a 9.5-inch wingspan. There is a distinct white line that runs from the top of the beak to the back of the head. The Louisiana Waterthrush is commonly mistaken with the similar Northern Waterthrush. An experienced eye will notice the more excessive tail bobbing of the Louisiana Waterthrush when discerning between the two.

Figure 15. *Louisiana waterthrush*

Photo by Nigel Voaden
Cornell Lab of Ornithology

These warblers reside within broad forested areas adjacent to clean streams and nest along the water's edge. It is vital that these birds have a natural substrate in their habitat. Threats to this species include deforestation, habitat fragmentation, and alterations in natural shorelines. To best preserve the current populations, do not apply pesticides or herbicides in areas likely to support these birds.

LAKE STURGEON

Living to the ripe age of 150 years at times, Lake Sturgeon are an iconic member of the Great Lakes fish family. Lake Sturgeon have a body lined with 5 rows of armor plates called scutes and a hydrodynamic body. Their preference as a benthic (bottom) dwelling fish is noted by the ventrally placed mouth and four barbells used to find food. Lake sturgeon are noted as one of the few species in the Great Lakes to sport a heterocercal tail (lopsided caudal fin). Residing mainly in large rivers and shallow areas of larger lakes consisting a minimal vegetation and abundant in gravel. While most spawning will occur in flowing streams with gravel bottoms, sturgeon have shown to accept rocky unprotected shorelines as suitable spawning grounds. As a general trend across the world, sturgeon populations are declining. This massive shift is likely due to loss of spawning grounds, barriers in natural watercourses preventing migrations, and the pressure of fishing. In the Great Lakes specifically, spawning ground may be affected by zebra

Figure 16. *Lake sturgeon*

Photo by Konrad Schmidt
Sea Grant Michigan

mussels, eggs may be eaten by round gobies, and general health of sturgeon may be reduced due to seas lamprey parasitism. Chemical contamination may also be a growing issue with Great Lakes populations.

LAKE HERRING OR CISCO

Lake Herring are a salmonid with a long round body. These fish have a forward projected lower jaw and an upper jaw extending back to the pupil. Identification of these fish is successfully done by counting the number of gill rakes (cartilage extensions under gill plate). Fish in Lakes Huron and Michigan have anywhere from 40-43 rakes. While these fish may spend most of their time in pelagic waters 18 to 53 meters deep, they may enter Portage Lake during the spawning season. Lake Herring will spawn in 9 to 12 meters of rocky bottom waters. Threats to Lake Herring include invasives such as Alewife and Sea Lampreys. In smaller bodies of inland waters, such as Portage Lake, eutrophication is their largest threat. More productive waters will favor Alewife, so reductions in nutrient loading are an effective method in increasing Lake Herring populations.

Figure 17. *Lake herring or cisco*
Photo from Sea Grant Michigan

SPOTTED TURTLE

Spotted Turtles can grow to a shell length of 3.5 to 5.4 inches and may be identified by the presence of small yellow spots on their carapace (top half of shell). This is not a distinguishing factor, however, as not all specimens express this trait and it may fade with age. The plastron (bottom half of shell) is commonly a yellow or orange coloration with black patches.

Figure 18. *Spotted turtle*
Photo by Jim H. Harding
MSU Extension

These turtles require clear, slowly moving or still shallows with a soft bottom. While they are predominantly considered an aquatic turtle, they will migrant upland during the mating season to breed. Like most cold-blooded animals, the Spotted Turtle can be seen warming their bodies in the sun in the springtime. Another trend these turtles follow in thermal regulation involve seeking ground shelter during hot weather and nights. Due to their late sexual maturity, it is suggested that high survival rates of juveniles is critical for the protection and growth of these reptiles. Protection of Spotted Turtles habitat is crucial in their recovery. This can be done by keeping developments an adequate distance from wetlands and reductions in road salt applications.

SPECIES OF CONCERN

ROUND PIGTOE

This golden-brown mussel has a thick shell that is round, hence the name Round Pigtoe. They grow to a diameter of four inches with lobes placed closely to the hinge. A discerning quality of these mollusks is the faint green lines presence near the beak. The Round Pigtoe is found in medium to large rivers on a variety of substrates such as mud, sand and gravel. In general, hydrologic alterations, silt deposition, pollution, and invasive mussels are a threat to native mussels. Preventing the growth of these impacts will help the Round Pigtoe succeed in remaining intact.

Figure 19. *Round pigtoe*
Photo from Illinois Natural History Survey

BROWN WALKER

The brown shell of these snails is longer than wide, never exceeding 4.5 millimeters in length. These aquatic snails are believed to live on clay banks of medium to large clean water rivers. During the winter, these snails will hibernate under leaf litter and thicker vegetation along moist banks. Identification of these snails may be assisted by observing a shell opening roughly ¼ the length of the shell. Maintaining adequate vegetation along riverbanks is necessary to reduce mortality during the hibernation months. They are also susceptible to the use of pesticides upstream of their habitat.

Figure 20. *Brown walker*
Photo by D. Dourson Carnegie Museum of Natural History

WOOD TURTLE

The Wood Turtle has a shell with a flattened appearance growing to a size of 6 to 10 inches in length. The shell features a keel (elevated ridge) down the center and offset cone shaped scutes. These elevated scutes are highlighted by the visible concentric growth rings. Wood Turtles prefer medium sized river that measure between 7-100 feet and contain a hard or gravel substrate. Shaded shoreline filled with herbaceous vegetation such as wild berries, grass, willows and alder trees contribute to foraging. Wood Turtles are a sought-after species in the commercial pet trade and has resulted in illegal poaching of the wild populations. As for environmental factors, ensuring proper water quality, minimizing sediment transport, reducing herbicides and preventing developments will help to reduce stress on these turtles. Preserving

Figure 21. *Wood turtle*
Photo from Conserve Wildlife NJ

the established hydrology of their habitat will help to ensure there is proper sandy shoreline required for nesting.

Blanding's Turtle

These turtles have a smooth surfaced high arch shell and exquisite yellow undersides edged in black accents. Commonly growing between 6 to 11 inches, these are a medium sized aquatic turtle. Blanding's Turtles commonly inhabit clear shallow waters with rich vegetation and soft bottoms. Still to slowly moving water adjacent to uplands qualify as suitable habitat for these turtles. Due to their breeding season requirements, it is necessary to preserve both habitat wetland and breeding uplands. Ensuring proper water quality via best management practices, reductions in herbicide and pesticide applications, and prevention of development near qualifying wetlands will help protect their sensitive habitat.

Figure 22. *Blanding's turtle*
Photo from Ohio DNR

Eastern Box Turtle

As with all box turtles, the plastron (bottom half of shell) is hinged allowing the Eastern variant to completely encase themselves in protective armor. The carapace (top half of shell) has a very expressed dome shape black or brown in color with randomly patterned yellow or orange markings. These turtles are the only true terrestrial turtles native to Michigan, but still remain close to water sources for hydration. These reptiles tend to live in habitats ranging from forests, fields, pastures and vegetated dunes. It's is imperative that open areas with full sun are available to achieve reproductive success. Protection of this unique turtle is focusing on the preservation of suitable habitat hydrology. Changes in hydrology may be a result of improper ORV traffic, developments and road building. Lastly, public education regarding the laws of capturing wild animals to become pets must be promoted.

Figure 23. *Eastern box turtle*
Photo by Steve Grund
MSU Extension

Bigmouth Shiner

Peaking in length around the three-inch mark, Bigmouth Shiners are considered a small minnow. Their coloration can be described in three horizontally oriented segments, an olive top, black midsection and a silver underside. When observing the minnow from head to tail it is noted how the scales may appear crowded towards the gill covers and become increasingly spread out with

Figure 24. *Bigmouth shiner*
Photo from North American Native Fishes

progression towards the tail. The Bigmouth Shiner has a triangular head due to the sharp angle defined by its nose. Bigmouth Shiners may be found in creeks less than three feet deep with a moderately fast current. Shiners are commonly sensitive to turbid waters, so it is necessary to reduce sediment transport. Shoreline stabilization structures such as bulkheads have shown to not influence the Bigmouth Shiner's ability to reproduce.

EASTERN MASSASAUGA

Figure 25. *Eastern massasauga*
Photo by Joseph Sage
MSU MNFI

Considered the only venomous snake in Michigan, the Eastern Massasauga grows to be 18 to 30 inches long. Identification of this reptile may be confirmed by the rattle on their posterior end as they are the only rattlesnake who's range involves Michigan. As common with most venomous snakes, the Eastern Massasauga has vertical pupils, and a triangular shaped head. Their coloration involves the alternating light and dark brown blotches along their body. These snakes are generally found in many types of wetland environments. In the northern region of the Lower Peninsula, they tend to stay in open wetland and cedar swamps. Fragmentation of suitable habitat is one of the largest threats; therefore, road construction, developments and any other physical boundaries should be minimized. These cold-blooded creatures are less active between November and March, so land maintenance should be performed in that window to minimize impact on existing populations.

AMERICAN BITTERN

Figure 26. *American bittern*
Photo by Christy Hand
South Carolina DNR

Sizing in at 23 to 33 inches long, this is considered a medium bird. A robust neck and short legs give this bird a unique appearance in their wetland habitats. Adults express contrasting white and brown plumage in mottled streaking patterns. These members of the heron family hunt by slowing wading in the shallows of large wetlands or by standing still waiting for an opportunity to strike. American Bitterns are challenging to observe due to their tactical use of camouflage. Disappearing in the cattails and other vegetation is done by holding still and pointing their beak up, effectively matching the predominantly vertical lines surrounding them with their streaked colorations. Preservation of this bird is correlated to the preservation of their densely vegetated shallow wetlands. Proactive actions towards reducing chemical contaminations, sediment transport, and nutrient loading will serve to protect these birds and their associated food supply.

NORTHERN GOSHAWK

Figure 27. *Northern goshawk*
Photo by Steve Garvie
Los Padres Forest Watch

This drab brown to gray predatory bird is generally found in deciduous forests. Considered a large bird, they have a long wingspan and tailfeathers that form a rounded posterior end. The Northern Goshawk has a distinct white line that runs over their eyes with the head expressing a black top. Beneficial practices for their preservation includes the conservation of large hardwood forests, specifically large trees for nesting. While mainly found in deciduous forests, they have been present at lower frequencies in conifers as well.

BALD EAGLE

Figure 28. *Bald eagle*
Photo from National Parks Service

Being the national bird, the Bald Eagle is a large predatory bird with a wingspan between 6 to 7.5 feet. Mature Eagles are distinguished by their brown body and contrasting white head. Their hooked beak designed for a carnivorous diet matches in color to their yellow feet. Bald Eagles build the largest tree nests of any animal species, up to one ton in weight. During the first 12 weeks of the breeding season, these birds are affected significantly by human activity. To ensure minimal impact on Bald Eagles, a ¼ mile buffer zone is required from mid-March to the end of June. Maintenance activities in the proximal location of nests should be scheduled outside this time frame.

NORTHERN HARRIER

Figure 29. *Northern harrier*
Photo by Gordon Ellmers
New York DEC

These raptors are predatory in nature and express sexual dimorphism. Female Northern Harriers are identified by their brown anterior and buff colored posterior. Males are smaller, less structured and change from a light gray on their head and body to white on the outer sides. Another discerning attribute of males is the black tips found on their wings. Northern Harriers prefer to hunt in open landscapes dominated by herbaceous vegetation. Loss of these habitats is the main threat to their dwindling populations. Efforts to recuperate their populations are currently directed towards preserving these open grasslands via prescribed burning. Responsible efforts ensure this burning is not done during the nesting season.

MARSH WREN

Figure 30. *Marsh wren*
Audubon Field Guide

Marsh Wren are predominantly rust and drab tan colored with black and white streaking on its back. The head has white eyelines with a broad black stripe running down the head and neck. Their nests may be found suspended in dense cattails hanging over deep marshes. Preservation of deep-water marshes consisting of narrowleaf cattails, cordgrass and open water will help to sustain the existing population. Dense live vegetation may be secured by executing controlled burns during the winter months.

GRASSHOPPER SPARROW

Figure 31. *Grasshopper sparrow*
Photo by Jim Rathert
Los Padres Forest Watch

This small insect and seed eating sparrow will grow to be four-five inches in length. Their markings include a white stripe that connects their beak and backs of head, a flattened head, and buffy breast. These sparrows may be found in any locations with dense grass vegetation such as thick grasslands, and hayfields. The birds appear in higher frequencies in locations with drier soils. Recuperation of their historic populations requires the maintenance of these tall grassland environments. Management practices include controlled burning to hinder the growth of shrubs and other woody vegetation. Treatments such as controlled burning should be performed in sections at a time to ensure the grassland always contains a diverse vegetative portfolio.

OSPREY

Figure 32. *Osprey*
Photo from Chesapeake Bay Program

These large hawks can grow two feet in length with black and white coloration. Distinguishing aspects to their plumage include the black patches on the undersides of their narrow wings that are visible when in flight. Their heads are mainly white but have a black eyeline. With time, Ospreys have begun to adapt to nesting in manmade structures such as telephone poles, windmills and buoys. Historically, this bird of prey would nest exclusively in trees and snags. To promote population growth, it is recommended to leave tall dead trees standing near open waters for the purpose of hunting perches and nesting. Another conservation focus is to maintain a ¼ mile buffer zone during the mating season of April to July.

DWARF BULRUSH

These are very small grass-like plants that grow in coastal plain marshes. Dwarf Bulrush generally appear as a small cluster of round projections with a group of spikelets towards the end. They grow in the sandy peat containing shores of soft water wetlands. Western lower Michigan serves as vital habitat due to the vast area of lake plain landscapes. Conserving the current hydrology of their range will ensure they have adequate time and area to recuperate in numbers. Other threats include mechanical disruption via ORV traffic and other activities that alter the current state of soils.

Figure 33. *Dwarf bulrush*
Photo from MSU Extension

HILL'S THISTLE

The Hill's Thistle can grow anywhere between 12 to 24 inches and is supported by a robust main stem. The flower of these thistles is a single vibrant pink head with numerous small petals. These plants primarily appear in oak barrens, forest openings, and pine barrens. These hardy plants have also been observed growing through limestone pavement. Vegetative progression is the main threat to Hill's Thistles as they prefer to be in locations with scattered trees and openings. Controlled and wildfires are the best way to prevent the reduction in these plants' habitats. The northern region of the lower peninsula is the most common place to find this species of concern.

Figure 34. *Hill's thistle*
Photo by Phyllis Higman
MSU Extension

SLOE PLUM

Predominantly favoring dry prairie habitat, oak barrens, and oak-pine savannahs, the Sloe Plum (also known as Alleghany Plum) is a small shrub. Considered to be straggly due to its seemingly nondirectional black thorny branches. At a maximum three meters tall, they flower very early in the growing season with clusters of white flowers each posing the opportunity to grow into a bitter fruit. Due to loses in prairie habitat when compared to historic land cover, the population of these shrubs has decreased with time. They can periodically be found along road right of ways and driveway cuts as well. It is believed that the Sloe Plum would benefit from controlled burns as to prevent vegetative progression.

Figure 35. *Sloe plum*
Photo by Ryan P. O'connor
MSU Extension

Woodland Vole

Woodland voles have a combined head and body length between 83 and 120 mm; the tail ranges from 15 to 40 mm in length. They weigh between 14 and 37 g. The fur on the back varies from light to dark brown in color. The belly fur is whitish or silvery. Because they live partly underground, their eyes, ears, and tails are very small, and their foreclaws are somewhat enlarged for digging. Woodland voles live in deciduous forests in eastern North America. They burrow near the surface of the forest floor, moving through thick decaying leaves and loose soil.

Figure 36. *Woodland vole*
Photo from Hilton Pond Center

Little Brown Bat

Their back is a brown color with golden, red and olive hues; these mammals may grow to be only 2.4 to 3.9 inches long. The undersides of Little Brown Bats come in a drab greyish brown color. These bats have small ears and hair that extends past the toes of their long feet. These bats spend the days resting in cool humid roosts due to their nocturnal circadian rhythm. Due to this roosting behavior, Little Brown Bats are susceptible to a new fungus called "white-nose syndrome". First recorded in 2007, this epidemic has caused bat population along the eastern United States to dwindle and has been confirmed in Manistee County since 2014.

Figure 37. *Little brown bat*
Photo from USDA Forest Service Southern Research Station

Northern Long-eared Bat

Hailing from a genus of bats known for their small ears, this member is one of the few outliers. As noted by their name, the Northern Long-eared Bat is a medium sized bat (3 to 3.7 inches) with large protruding ears. These bats commonly roost in between the bark and wood of trees, or really any structure that contains a crevice where they can comfortably rest. They have been observed in locations ranging from sheds to old mines. Wintering is spent in hibernacula that commonly involves caves and mines. White-nose syndrome has affected this increasingly rare species to a greater degree than other species.

Figure 38. *Northern long-eared bat*
Photo from USFWS

EASTERN PIPISTRELLE

These small bats grow to be 2.8 to 3.2 inches in length and have a unique red forearm that assists in their identification. Their fur is a rust color with their wing membranes being a rich black color. These bats are found everywhere between the Western Upper Peninsula and the southwest corner of Michigan. During the day and winter months these bats will rest in deep crevices and caves. In Manistee County, a colony has been identified living in a hydroelectric facility. Protection of these bats promotes the minimization of disturbances within their hibernacula. This tactic recommends the gating of entrances to their colonies.

Figure 39. *Eastern pipistrelle*
Photo by D.H. Snyder
Smithsonian Museum of Natural History

APPENDIX C: COMMUNITY CONVERSATIONS

Table 1. *Stakeholder groups and number of participants engaged through community conversations and community forum*

Stakeholder group	Number of participants
Year-round residents	11
Seasonal residents	35
Youth/students (Onekama High School)	15
Educators	4
Village, township, county, and tribal government	11
Recreation, tourism, business, and civic organizations	7
Agriculture and land developers/managers	13
Natural resource managers	14
Community Forum (general public)	38
Total	148

SOURCE: Public Sector Consultants Inc., 2007.

Table 2. *Summary of responses from community conversations and community forum*

Question	Responses
What are some of the things you do in the watershed?	▪ Participate in numerous water and land-based recreational activities ▪ Enjoy natural beauty, live, work, educate, manage/protect the health of the watershed
What do you consider to be some of the biggest problems facing the Portage Lake watershed right now?	▪ Lack of complete/accurate/current fact-based information about the watershed ▪ Lack of understanding about how actions impact water quality ▪ Development of sensitive areas ▪ Loss of critical habitat ▪ Invasive species ▪ Lack of channel dredging

Table 2 cont. *Summary of responses from community conversations and community forum*

Question	Responses
Cont. What do you consider to be some of the biggest problems facing the Portage Lake watershed right now?	▪ Nutrient loading from fertilizer application and improperly maintained septic systems ▪ Not enough long-term planning ▪ Lack of communication among local units of government or collaborative planning ▪ Lack of economic development ▪ Decreasing number of students and young families
What are some possible solutions to these problems?	▪ Information, education, and outreach ▪ Leveraging additional financial, human, and technical resources ▪ Implementation of best management practices (BMPs); joint planning ▪ Land use planning ▪ Economic development planning ▪ Dredging ▪ Water quality monitoring
Have you ever had a conflict with other people who use the watershed differently than you do?	▪ Personal watercrafts and other lake users ▪ Development that impacts critical habitat and views ▪ Users of road ends as public access sites and nearby property owners do? ▪ Hunters and other watershed users ▪ Various watercraft users and fisherman ▪ Government regulations and property owners

Table 2 cont. *Summary of responses from community conversations and community forum*

Question	Responses
Are there certain cultural, historic or environmental sites or resources that you think should be protected?	▪ Parks and public access sites ▪ Camps ▪ Beaches ▪ Views and vistas ▪ Trails ▪ Farming/agriculture ▪ Historical sites and structures ▪ Rural character ▪ Fair grounds ▪ Critical habitat and sensitive areas (water quality, wetlands, dunes, feeder creeks, forests) ▪ Fishery ▪ School
How do you get most of your information about the Portage Lake watershed?	▪ Local newsletters and web sites ▪ Federal, state, and local agencies and organizations ▪ Word of mouth ▪ Teachers ▪ Past studies and plans
Are there certain sources of information you consider more trustworthy than others?	▪ Most are trusted ▪ No central source for fact-based information about the watershed

Table 2 cont. *Summary of responses from community conversations and community forum*

Question	Responses
Imagine the Portage Lake watershed 50 years from now- what do you want it to look like?	▪ Not a lot different from now ▪ Enhanced and more parks and public access and trails ▪ Views and vistas maintained ▪ Abundant fish and wildlife ▪ Lack of exotic and invasive species ▪ Excellent water quality ▪ Protected fragile environments ▪ Outstanding schools with water curriculum ▪ Protected and wisely planned community ▪ Engaged community ▪ Multiple generations live and work ▪ Vibrant cultural focus

SOURCE: Public Sector Consultants Inc., 2007.

APPENDIX D: L-THIA RESULTS

Table 1. *Average annual lead loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Commercial	59	1.26	131	2.11	NA	NA	193	3.34
High Density Residential	672	3.83	58	0.39	89	0.59	2,194	13
Low Density Residential	1,043	1.30	1,664	2.06	618	0.77	3,403	3.94
Forestland	5,494	0.62	5,667	0.64	5,292	0.60	3,408	0.39
Water/ Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	0.46	2,694	0.63	1,802	0.42	1,532	0.36
Agricultural	3,593	1.13	2,729	0.86	3,310	1.04	2,701	0.85
Total	**15,745**	**8.60**	**15,793**	**6.69**	**11,781**	**3.43**	**15,745**	**21.86**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Table 2. *Average annual copper loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Commercial	59	1.41	131	2.24	NA	NA	193	3.37
High Density Residential	672	3.83	58	0.39	89	0.59	2,194	13
Low Density Residential	1,043	1.30	1,664	2.06	618	0.77	3,403	3.94
Forestland	5,494	1.25	5,667	1.29	5,292	1.21	3,408	0.78
Water/ Wetlands	2,938	0	2,851	0	670	0	2,314	0

Table 2 cont. *Average annual copper loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Grass/Pasture	1,946	0.91	2,694	1.26	1,802	0.85	1,532	0.72
Agricultural	3,593	1.13	2,729	0.86	3,310	1.04	2,701	0.85
Total	**15,745**	**9.84**	**15,793**	**8.09**	**11,781**	**4.45**	**15,745**	**21.65**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Table 3. *Average annual zinc loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Commercial	59	16.14	131	37.31	NA	NA	193	55.46
High Density Residential	672	37	58	2.64	89	3.98	2,194	129
Low Density Residential	1,043	9.99	1,664	17	618	5.51	3,403	36
Forestland	5,494	0.75	5,667	0.77	5,292	0.72	3,408	0.46
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	0.55	2,694	0.76	1,802	0.51	1,532	0.43
Agricultural	3,593	10.44	2,729	7.33	3,310	9.41	2,701	7.33
Total	**15,745**	**74.86**	**15,793**	**65.81**	**11,781**	**20.13**	**15,745**	**228.68**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Table 4. *Average annual cadmium loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Commercial	59	0.09	131	0.21	NA	NA	193	0.30
High Density Residential	672	0.37	58	0.03	89	0.05	2,194	1.22
Low Density Residential	1,043	0.11	1,664	0.17	618	0.06	3,403	0.35
Forestland	5,494	0.12	5,667	0.13	5,292	0.12	3,408	0.08
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	0.09	2,694	0.13	1,802	0.08	1,532	0.07
Agricultural	3,593	0.75	2,729	0.57	3,310	0.69	2,701	0.56
Total	**15,745**	**1.53**	**15,793**	**1.23**	**11,781**	**1.00**	**15,745**	**2.58**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Table 5. *Average annual BOD loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Commercial	59	2,233	131	4,967	NA	NA	193	7,309
High Density Residential	672	12,700	58	1,096	89	1,680	2,194	41,466
Low Density Residential	1,043	3,694	1,664	5,890	618	2,186	3,403	12,050
Forestland	5,494	60	5,667	63	5,292	58	3,408	37
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	44	2,694	62	1,802	40	1,532	34

Table 5 cont. *Average annual BOD loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Agricultural	3,593	3,013	2,729	2,287	3,310	2,775	2,701	2,264
Total	**15,745**	**21,744**	**15,793**	**14,365**	**11,781**	**6,739**	**15,745**	**63,160**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Table 6. *Average annual COD loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Commercial	59	11,268	131	25,061	NA	NA	193	36,871
High Density Residential	672	24,653	58	2,127	89	3,264	2,194	80,494
Low Density Residential	1,043	7,172	1,664	11,434	618	4,247	3,403	23,394
Forestland	5,494	0	5,667	0	5,292	0	3,408	0
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	0	2,694	0	1,802	0	1,532	0
Agricultural	3,593	0	2,729	0	3,310	0	2,701	0
Total	**15,745**	**43,093**	**15,793**	**38,622**	**11,781**	**7,511**	**15,745**	**140,759**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Table 7. *Average annual oil & grease loading (lbs/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)	Acres	Loading (lbs/yr)
Commercial	59	872	131	1,942	NA	NA	193	2,859
High Density Residential	672	844	58	72	89	110	2,194	2,763
Low Density Residential	1,043	245	1,664	392	618	144	3,403	802
Forestland	5,494	0	5,667	0	5,292	0	3,408	0
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	0	2,694	0	1,802	0	1,532	0
Agricultural	3,593	0	2,729	0	3,310	0	2,701	0
Total	**15,745**	**1,961**	**15,793**	**2,406**	**11,781**	**254**	**15,745**	**6,424**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

Table 8. *Average annual fecal strep loading (millions of coliform/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (M coliform /yr)	Acres	Loading (M coliform /yr)	Acres	Loading (M coliform /yr)	Acres	Loading (M coliform /yr)
Commercial	59	7,947	131	17,677	NA	NA	193	26,006
High Density Residential	672	126,786	58	10,949	89	16,794	2,194	413,935
Low Density Residential	1,043	36,885	1,664	58,808	618	21,847	3,403	120,308
Forestland	5,494	0	5,667	0	5,292	0	3,408	0
Water/Wetlands	2,938	0	2,851	0	670	0	2,314	0
Grass/Pasture	1,946	0	2,694	0	1,802	0	1,532	0

Table 8 cont. *Average annual fecal strep loading (millions of coliform/yr) from L-THIA output*

Source	Pre-Developed Land Use (2001)		L-THIA Generated Land Use (2006)		Pre-Developed Land Use (2016)		Post-Developed Land Use (2040)	
	Acres	Loading (M coliform /yr)	Acres	Loading (M coliform /yr)	Acres	Loading (M coliform /yr)	Acres	Loading (M coliform /yr)
Agricultural	3,593	0	2,729	0	3,310	0	2,701	0
Total	**15,745**	**171,618**	**15,793**	**87,434**	**11,781**	**38,641**	**15,745**	**560,249**

SOURCE: Spicer Group Inc., 2019, with data from MRLCC, 2001, NLCD, 2006, NRCS, 2016 data, the 2007 MSU CEVL and LPI for 2040 data.

NOTE: M denotes millions of coliform, Different data sets were used for land cover and because of this the total area of the watershed is not identical between 2001, 2006 and 2016.

APPENDIX E: ROAD ENDS MAP

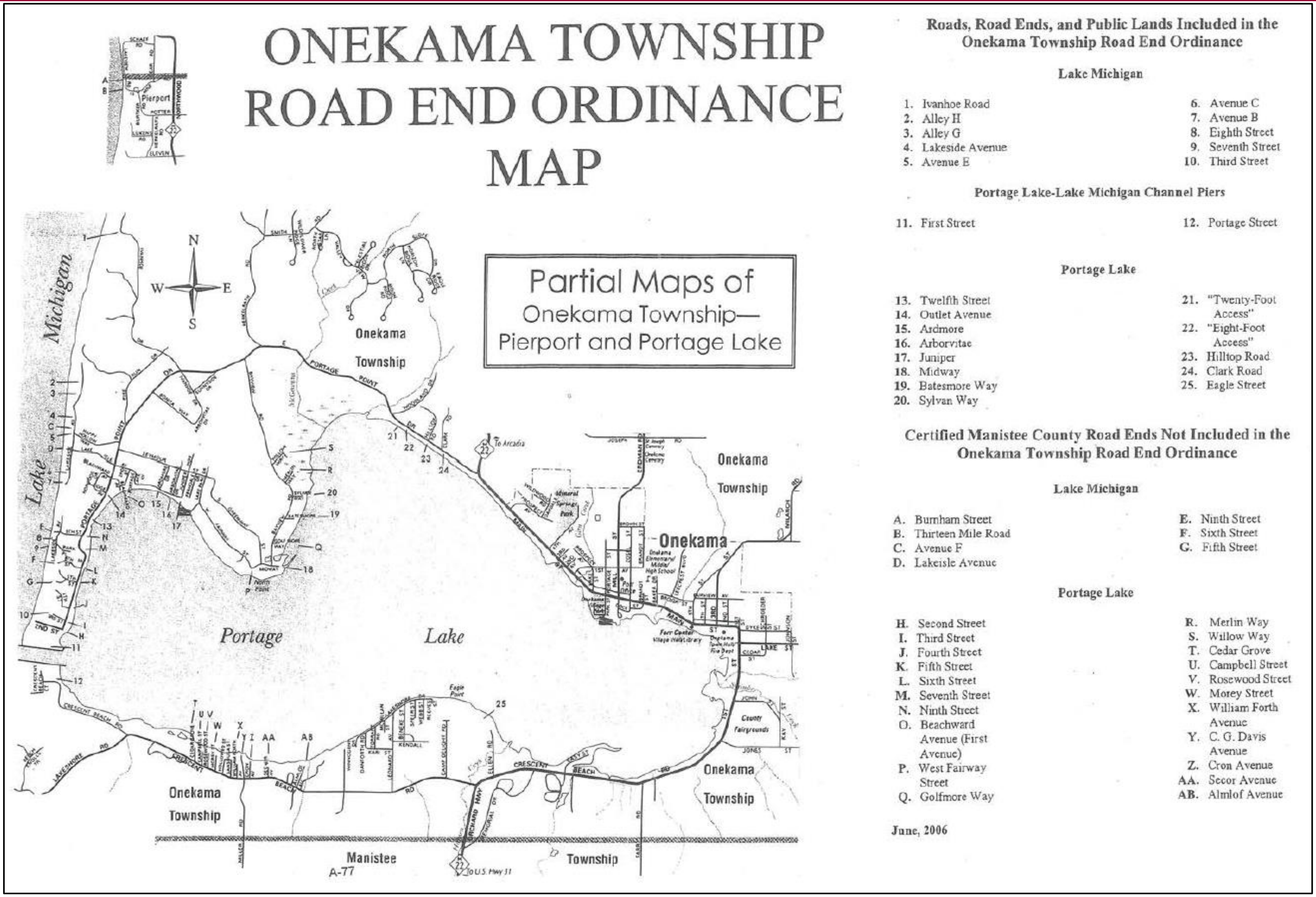

Figure 1. *Road end map for Portage Lake and Lake Michigan*

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APPENDIX F: MONITORING POINT COORDINATES

Table 1. *Monitoring locations and coordinates*

Monitoring Type	Location	Map ID	Latitude	Longitude
Tributary Monitoring	Hansen Creek	Hansen Creek	44.35299	-86.21612
Tributary Monitoring	Dunham Creek	Dunham Creek	44.35131	-86.19734
Tributary Monitoring	Stream #9	Stream #9	44.35098	-86.20956
Tributary Monitoring	Stream #7	Stream #7	44.36071	-86.19292
Tributary Monitoring	Onekama Creek	Onekama Creek	44.36259	-86.20060
Tributary Monitoring	Schimke Creek	Schimke Creek	44.35683	-86.19289
Tributary Monitoring	Glen Creek	Glen Creek	44.36664	-86.21272
Swimmer's Itch Monitoring	Village of Onekama Beach	SI01	44.36251	-86.20765
Swimmer's Itch Monitoring	Covenant Bible Camp	SI02	44.35527	-86.21829
Stormwater Monitoring	1st Street	SW#7	44.35940	-86.19304
Stormwater Monitoring	3rd Street	SW#6	44.36052	-86.19505
Stormwater Monitoring	4th Street	SW#5	44.36093	-86.19625
Stormwater Monitoring	Zosel Park	SW#2	44.36201	-86.20374
Shoreline Monitoring	3D	3D	44.35709	-86.19672
Shoreline Monitoring	3B	3B	44.36094	-86.20081
Shoreline Monitoring	3A	3A	44.36096	-86.20492
Road End *E. Coli* Monitoring	Portage Point Road (Hilltop)	RE01	44.35759	-86.22401
Road End *E. Coli* Monitoring	Bayview (Batemore)	RE02	44.36555	-86.23894
Road End *E. Coli* Monitoring	Ardmore Road	RE03	44.35453	-86.25049
Road End *E. Coli* Monitoring	3rd Street	RE04	44.36065	-86.19528
Road End *E. Coli* Monitoring	Leonard Road	RE05	44.35543	-86.22738
Road End *E. Coli* Monitoring	Morey Road	RE06	44.35275	-86.24487
Fisheries Survey Sites Monitoring	F01	F01	44.35284	-86.24766

Table 1 cont. *Monitoring locations and coordinates*

Monitoring Type	Location	Map ID	Latitude	Longitude
Fisheries Survey Sites Monitoring	F02	F02	44.36185	-86.20641
Deep Basin Monitoring	Basin 2	Basin 2	44.36427	-86.22544
Deep Basin Monitoring	Basin 1	Basin 1	44.36620	-86.25310
Beach *E. Coli* Monitoring	Portage Point Inn	E01	44.35061	-86.25782
Beach *E. Coli* Monitoring	Little Eden Camp	E02	44.35945	-86.22914
Beach *E. Coli* Monitoring	Village of Onekama Beach	E03	44.36272	-86.20757
Beach *E. Coli* Monitoring	Covenant Bible Camp	E04	44.35512	-86.21797
Beach *E. Coli* Monitoring	Wik-A-Te-Wah	E05	44.35638	-86.22485
Beach *E. Coli* Monitoring	Langland Park	E06	44.36195	-86.26388

SOURCE: Spicer Group Inc., 2019, with data from 2009-2017 State of the Lake Report.

APPENDIX G: AQUATIC MAXIMUM VALUES AND FINAL CHRONIC VALUES

Table 1. *Aquatic maximum value (AMV; mg/L) at various pH and temperatures*

	Temperature (°C)																	
pH	**0-13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
6.5	34	31	29	26	24	22	21	19	17	16	15	14	12	11	11	9.7	9.0	8.2
6.6	32	30	27	25	23	21	20	18	17	15	14	13	12	11	10	9.3	8.6	7.9
6.7	31	28	26	24	22	20	19	17	16	15	13	12	11	10	9.6	8.9	8.2	7.5
6.8	29	27	25	23	21	19	18	16	15	14	13	12	11	9.9	9.1	8.4	7.7	7.1
6.9	27	25	23	21	19	18	16	15	14	13	12	11	10	9.2	8.5	7.8	7.2	6.6
7.0	25	23	21	19	18	16	15	14	13	12	11	10	9.2	8.5	7.8	7.2	6.6	6.1
7.1	23	21	19	18	16	15	14	13	12	11	9.9	9.1	8.4	7.7	7.1	6.5	6.0	5.5
7.2	20	19	17	16	15	13	12	11	11	9.7	8.9	8.2	7.5	6.9	6.4	5.9	5.4	5.0
7.3	18	17	15	14	13	12	11	10	9.3	8.6	7.9	7.3	6.7	6.2	5.7	5.2	4.8	4.4
7.4	16	15	13	12	11	10	9.6	8.9	8.2	7.5	6.9	6.4	5.9	5.4	5.0	4.6	4.2	3.9
7.5	14	13	12	11	9.9	9.1	8.4	7.7	7.1	6.5	6.0	5.5	5.1	4.7	4.3	4.0	3.6	3.4
7.6	12	11	10	9.2	8.4	7.8	7.2	6.6	6.1	5.6	5.1	4.7	4.3	4.0	3.7	3.4	3.1	2.9
7.7	10	9.2	8.4	7.8	7.2	6.6	6.1	5.6	5.1	4.7	4.4	4.0	3.7	3.4	3.1	2.9	2.6	2.4
7.8	8.4	7.7	7.1	6.5	6.0	5.5	5.1	4.7	4.3	4.0	3.7	3.4	3.1	2.9	2.6	2.4	2.2	2.0
7.9	7.0	6.4	5.9	5.5	5.0	4.6	4.3	3.9	3.6	3.3	3.1	2.8	2.6	2.4	2.2	2.0	1.9	1.7
8.0	5.8	5.3	4.9	4.5	4.2	3.8	3.5	3.2	3.0	2.8	2.5	2.3	2.1	2.0	1.8	1.7	1.5	1.4
8.1	4.8	4.4	4.1	3.7	3.4	3.2	2.9	2.7	2.5	2.3	2.1	1.9	1.8	1.6	1.5	1.4	1.3	1.2
8.2	4.0	3.6	3.4	3.1	2.8	2.6	2.4	2.2	2.0	1.9	1.7	1.6	1.5	1.3	1.2	1.1	1.0	1.0
8.3	3.3	3.0	2.8	2.5	2.3	2.2	2.0	1.8	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.94	0.86	0.80
8.4	2.7	2.5	2.3	2.1	1.9	1.8	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.91	0.84	0.77	0.71	0.66
8.5	2.2	2.0	1.9	1.7	1.6	1.5	1.3	1.2	1.1	1.0	1.0	0.89	0.82	0.75	0.69	0.64	0.59	0.54
8.6	1.8	1.7	1.6	1.4	1.3	1.2	1.1	1.0	0.94	0.87	0.80	0.74	0.68	0.62	0.57	0.53	0.49	0.45
8.7	1.5	1.4	1.3	1.2	1.1	1.0	0.93	0.85	0.78	0.72	0.66	0.61	0.56	0.52	0.48	0.44	0.40	0.37
8.8	1.3	1.2	1.1	1.0	0.91	0.84	0.77	0.71	0.66	0.60	0.56	0.51	0.47	0.43	0.40	0.37	0.34	0.31
8.9	1.1	1.0	0.91	0.84	0.77	0.71	0.65	0.60	0.55	0.51	0.47	0.43	0.40	0.37	0.34	0.31	0.29	0.26
9.0	0.91	0.84	0.77	0.71	0.66	0.60	0.56	0.51	0.47	0.43	0.40	0.37	0.34	0.31	0.29	0.26	0.24	0.22

SOURCE: EGLE, accessed August 2019

Table 2. *Final chronic value (FCV; mg/L) at various pH and temperatures*

	Temperature (°C)																		
pH	**0-7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
6.5	5.3	5.0	4.7	4.4	4.1	3.9	3.6	3.4	3.2	3.0	2.8	2.6	2.5	2.3	2.2	2.0	1.9	1.8	1.7	1.6
6.6	5.2	4.9	4.6	4.3	4.0	3.8	3.6	3.3	3.1	2.9	2.7	2.6	2.4	2.3	2.1	2.0	1.9	1.8	1.6	1.5
6.7	5.1	4.8	4.5	4.2	4.0	3.7	3.5	3.3	3.1	2.9	2.7	2.5	2.4	2.2	2.1	2.0	1.8	1.7	1.6	1.5
6.8	5.0	4.7	4.4	4.1	3.9	3.6	3.4	3.2	3.0	2.8	2.6	2.5	2.3	2.2	2.0	1.9	1.8	1.7	1.6	1.5
6.9	4.9	4.6	4.3	4.0	3.8	3.5	3.3	3.1	2.9	2.7	2.6	2.4	2.3	2.1	2.0	1.9	1.7	1.6	1.5	1.4
7.0	4.7	4.4	4.1	3.9	3.6	3.4	3.2	3.0	2.8	2.6	2.5	2.3	2.2	2.0	1.9	1.8	1.7	1.6	1.5	1.4
7.1	4.5	4.2	4.0	3.7	3.5	3.3	3.1	2.9	2.7	2.5	2.4	2.2	2.1	2.0	1.8	1.7	1.6	1.5	1.4	1.3
7.2	4.3	4.0	3.8	3.5	3.3	3.1	2.9	2.7	2.6	2.4	2.3	2.1	2.0	1.9	1.7	1.6	1.5	1.4	1.3	1.3
7.3	4.1	3.8	3.6	3.3	3.1	2.9	2.8	2.6	2.4	2.3	2.1	2.0	1.9	1.8	1.6	1.5	1.4	1.4	1.3	1.2
7.4	3.8	3.5	3.3	3.1	2.9	2.7	2.6	2.4	2.3	2.1	2.0	1.9	1.7	1.6	1.5	1.4	1.3	1.3	1.2	1.1
7.5	3.5	3.3	3.1	2.9	2.7	2.5	2.4	2.2	2.1	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0
7.6	3.2	3.0	2.8	2.6	2.5	2.3	2.2	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.1	1.0	0.93
7.7	2.9	2.7	2.5	2.4	2.2	2.1	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0	1.0	0.89	0.84
7.8	2.5	2.4	2.2	2.1	2.0	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0	1.0	0.91	0.85	0.80	0.75
7.9	2.2	2.1	2.0	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0	1.0	0.91	0.85	0.80	0.75	0.70	0.66
8.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0	1.0	0.90	0.84	0.79	0.74	0.69	0.65	0.61	0.57
8.1	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.1	1.0	0.94	0.88	0.82	0.77	0.72	0.68	0.64	0.60	0.56	0.52	0.49
8.2	1.4	1.3	1.3	1.2	1.1	1.0	1.0	0.91	0.85	0.80	0.75	0.70	0.66	0.62	0.58	0.54	0.51	0.48	0.45	0.42
8.3	1.2	1.1	1.1	1.0	0.94	0.88	0.83	0.77	0.73	0.68	0.64	0.60	0.56	0.53	0.49	0.46	0.43	0.41	0.38	0.36
8.4	1.0	1.0	0.90	0.85	0.80	0.75	0.70	0.66	0.61	0.58	0.54	0.51	0.47	0.45	0.42	0.39	0.37	0.34	0.32	0.30
8.5	0.87	0.81	0.76	0.72	0.67	0.63	0.59	0.55	0.52	0.49	0.46	0.43	0.40	0.38	0.35	0.33	0.31	0.29	0.27	0.26
8.6	0.73	0.69	0.65	0.60	0.57	0.53	0.50	0.47	0.44	0.41	0.39	0.36	0.34	0.32	0.30	0.28	0.26	0.25	0.23	0.22
8.7	0.62	0.58	0.55	0.51	0.48	0.45	0.42	0.40	0.37	0.35	0.33	0.31	0.29	0.27	0.25	0.24	0.22	0.21	0.19	0.18
8.8	0.53	0.49	0.46	0.43	0.41	0.38	0.36	0.34	0.31	0.30	0.28	0.26	0.24	0.23	0.21	0.20	0.19	0.18	0.17	0.15
8.9	0.45	0.42	0.40	0.37	0.35	0.33	0.31	0.29	0.27	0.25	0.24	0.22	0.21	0.19	0.18	0.17	0.16	0.15	0.14	0.13
9.0	0.39	0.36	0.34	0.32	0.30	0.28	0.26	0.25	0.23	0.22	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11

SOURCE: EGLE, accessed August 2019