Herring Lakes Watershed Protection Plan

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Herring Lakes Watershed Protection Plan Partners:

Benzie Conservation District (BCD), Benzie County (BC), Benzie County Road Commission (BCRC), Benzie Leelanau Health Department (BLHD), Conservation Resource Alliance (CRA), Grand Traverse Regional Land Conservancy (GTRLC), Michigan Department of Environmental Quality (MDEQ), Michigan Department of Natural Resources (MDNR), Natural Resources Conservation Service (NRCS), NW Michigan Council of Governments (NWCOG), Grand Traverse Regional Land Conservancy (GTRLC), and Michigan State University Extension (MSUE).

The Herring Lakes Watershed Protection Plan can be downloaded at the following website:
www.benziecd.org

INTRODUCTION

A watershed is an area of land that drains to a common point. On a very broad scale, imagine a mountain, and think of the highest ridges on the mountain as the boundaries of the watershed. Rain, melting snow, and wind carry pollutants from the ridges and sides of the mountains into the water in the valley. Watersheds are inherently defined by topography as water always follows the path of least resistance (U.S. EPA 2008).

The rationale for watershed management is that if we responsibly manage land activities, we will protect the water within that watershed. All activities within a watershed affect the quality of water as it percolates through and runs across natural and developed landscapes. Watershed planning brings together the people within the watershed to address those activities, regardless of existing political boundaries. By working together, individuals within the watershed can design a coordinated watershed management plan that builds upon the strengths of existing programs and resources, and addresses the water quality concerns in an integrated, cost effective manner (see U.S. EPA 2008).

The Herring Lakes Watershed Protection Plan is a comprehensive document that coordinates local lake associations and other group's ongoing efforts to protect water quality with other watershed-wide stakeholder groups to achieve designated and desired goals. The first efforts to develop a comprehensive watershed management plan began in late 2014 under a Stormwater /Asset Management/Wastewater (SAW) grant received by the Benzie Conservation District which retained Grobbel Environmental Planning and Associates to complete the plan project. A ten (10) member steering committee was formed in January of 2015 and represented most all stakeholder groups in the watershed to guide the watershed management planning effort. On March 6, 2019 the Michigan Department of Environmental Quality (MDEQ) and United States Environmental Protection Agency (U.S. EPA) formally approved the Herring Lakes Watershed Management Plan, and the steering committee members began working immediately to implement some of the pollution reduction tasks proposed in this plan.

In 2014 the Benzie Conservation District and Upper and Lower Herring Lakes Associations initiated an update to the original watershed plan to make it comply with the EPA 9 elements criteria in addition to the MDEQ's criteria on which it was originally based. The updated plan incorporates pollutant load reduction coefficients for watershed land uses along with estimation of pollutant load reductions to be achieved from Best Management Practice implementation. In addition, a robust water quality data collection program was initiated to help future planning efforts to effectively calculate pollutant loading estimations specific to the Herring Lakes watershed. One of the main goals of the updated plan is to better access the impacts of local agricultural practices on nutrient and sediment loading into tributary streams. In addition, this updated plan attempts to prioritize road stream crossings that have been identified as contributing an excessive amount of sediment (and nutrients) along with blocking aquatic organism movement both up and downstream.

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CHAPTER 1: EXECUTIVE SUMMARY

Purpose

The Herring Lakes Watershed Protection Plan (HLWPP) is a comprehensive document that coordinates the ongoing efforts of various partners to protect water quality with those of other watershed-wide stakeholder groups to achieve designated and desired goals. These goals are addressed in a consolidated task implementation chart designed to achieve and maintain the high water quality. It is important to note that this document is a planning framework that prescribes tasks designed to achieve watershed goals, however it is not regulatory in nature. The plan itself and the Steering Committee are nonpolitical entities and neither have regulatory powers.

Background

The Herring Lakes watershed community has become increasingly interested in water resource issues. Notable examples are the ongoing efforts by the Upper and Lower Herring Lake Associations, Benzie Conservation District, and Grand Traverse Regional Land Conservancy. The quality of life derived from healthy ecosystems and the numerous forms of high quality outdoor recreation that they provide makes the Herring Lakes Watershed a very desirable area for residents and visitors alike. In order to maintain the quality of this resource, local governments, concerned citizens, and numerous agencies all need to work together towards a common goal – protecting the entire watershed from poor management decisions to prevent any further water quality degradation. Watershed protection means conscientious stewardship of all water and land within the watershed. A Herring Lakes Watershed plan was completed in 2003. To update the plan with this 2018 watershed protection plan, the Herring Lakes Protection Plan steering committee met at least monthly from January 2015 to February 2017, held a number of public outreach sessions and stakeholder meetings, and disseminated a questionnaire via Survey Monkey through the Benzie Conservation District website (*www.benziecd.org*). This watershed protection plan summarizes existing watershed conditions, identifies and prioritizes major watershed pollutants and proposes specific tasks, project partners and costs to reduce the impact and amount of pollution entering the system. The HLWPP also outlines the implementation and evaluation strategies as well as resources for the local units of government including township planning and zoning boards.

Watershed Characteristics

The Herring Lakes Watershed drains a land area of roughly twenty-five square miles in southwestern Benzie County. The primary water bodies are Upper Herring Lake, Lower Herring Lake, Herring Creek and extensive wetlands. Herring Creek and its tributaries drain a large area of the watershed which includes forest land, agricultural crop land, orchards and livestock farmland.

Priority and Critical Areas

Although watershed management plans address the entire watershed, there are certain areas within the Herring Lakes Watershed that warrant more extensive management or specific protection consideration. Areas that are most sensitive to impacts from pollutants are considered **Priority Areas.** Areas that require focused monitoring, restoration, remediation and/or rehabilitation are considered **Critical Areas**.

Priority Areas

Priority areas in the Herring Lakes Watershed are defined as the geographic portions of the watershed that are most sensitive to impacts from pollutants and environmental stressors. The priority areas for the Herring Lakes Watershed are divided into three different tiers of protection priorities (High, Medium and Low Priority) that cover six geographic portions of the watershed. The priority areas and tiers are described below.

Priority Area Descriptions

Area 1 - The eastern portion of the HL Watershed

Area 2 - Herring Swamp in the center of the watershed

Area 3 - Herring Creek, lower portion downstream of M-22 Highway

Area 4 - Lower Herring Lake Outlet

Area 5 - Upper and Lower Herring Lakes

Area 6 - Shoreline and small lot development—private septic disposal systems in high density residential development areas

Tier 1 (Highest Priority):

- Habitat for or areas with threatened, endangered or species of special concern
- Existing public or protected land within the state, conservancies and or natural areas and preserves
- Herring Lakes Swamp and eastern wetland
- Exotic/invasive species
- High-risk erosion areas

Tier 2 (Medium Priority):

- Surface water bodies (i.e., lakes and streams), shorelines, wetlands and land within 500' of them
- Land protection areas and preserves
- Groundwater recharge areas

Tier 3 (Lower Priority):

- Steep slopes
- Wildlife corridors

Critical Areas

Critical Areas are specific sections of the watershed that are suspected to contribute a significant amount of pollutants or have been documented as impacted by stressors or pollutants and require restoration to achieve designated or desired uses. Critical Area designation indicates that implementation of identified tasks will be needed to achieve load reductions identified in the plan. The critical areas for the Herring Lakes Watershed include the following areas:

1. Upper and Lower Herring Lakes
2. High Density Residential Shoreline Development Areas
3. Michigan Department of Natural Resources (MDNR) Boat Launches
4. Herring Lake Swamp
5. Tributaries/Road Crossings and Culverts

6. Boo Hoo View Road End
7. Lower Herring Lake Outlet

Designated and Desired Uses

Identified designated uses and water quality standards for Michigan surface waters were used to assess the condition of the watershed. Michigan's surface waters are protected under Water Quality Standards for specific designated uses (R323.1100 of Part 4, Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended). These standards and designated uses are designed to: 1) protect the public health and welfare; 2) to enhance and maintain the quality of water; and 3) to protect the state's natural resources. Protected designated uses as defined by Michigan's Department of Environmental Quality associated with the Herring Lakes Watershed include: agricultural, industrial water supply, navigation, warm water and/or cold water fishery, other indigenous aquatic life and wildlife, fish consumption, and partial and total body contact recreation.

None of the designated uses for the Herring Lakes Watershed are impaired on a watershed wide scale. The steering committee and stakeholder input verified the need to establish specific desired uses particular to the Herring Lakes Watershed that are not addressed by designated uses based on state water quality standards. Desired uses can be defined as the ways in which people use the watershed and how they would like to manage and protect the watershed to ensure the sustainability of those uses for future generations. Desired uses for the Herring Lakes Watershed include uses for recreational, aesthetic, human health, and ecosystem preservation.

Pollutants, Sources and Causes

Designated and desired uses may be negatively affected by a number of different pollutants and environmental stressors in the Herring Lakes Watershed. The term environmental stressor is used to describe factors that have a negative effect on the ecosystem or water quality, but are not accurately categorized as a specific pollutant. The Herring Lakes Watershed is subject to pollutant threats from excessive nutrients, sedimentation of stream channels, improper septic waste disposal, as well as environmental stressors such as habitat loss and invasive species proliferation. Excessive phosphorus loading and sedimentation are the two primary impacts to the water quality with loss of habitat and invasive species proliferation being additional issues of concern. Other issues that threaten designated and desired uses within the Herring Lakes Watershed include toxic substances, pathogens, and thermal pollution. Table 39 identifies known or suspected sources and causes of pollutants and environmental stressors that impact specific designated or desired uses. Excessive nutrient loading of the Herring Lakes and its tributaries in the past has likely resulted in the degradation of the water quality and biological community of the Herring Lakes. Reduction of excessive nutrient and sediment loads to tributary streams and the Herring Lakes itself has been found to be the most effective way of achieving a proper nutrient balance for the Herring Lakes.

Watershed Goals:

The following goals for the Herring Lakes Watershed were developed by the Steering Committee to protect the designated and desired uses of the watershed:

- ✓ Goal 1: Protect aquatic and terrestrial ecosystems
- ✓ Goal 2: Protect the quality and quantity of water resources
- ✓ Goal 3: Preserve high quality recreational opportunities in the watershed
- ✓ Goal 4: Implement and promote educational programs that support stewardship and watershed planning goals, activities, and programs
- ✓ Goal 5: Protect the health and safety of watershed users, residents and stakeholders
- ✓ Goal 6: Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected

Each goal generally has multiple objectives that outline specific elements required to meet the goal. Tasks are then assigned to address the individual goals and multiple objectives. The detailed task implementation chart describes the task, provides interim milestones, approximates projected costs and assigns a plausible timeline for completion. The implementation tasks in Chapter 9 are designed to address individual watershed objectives under each main goal. Some of the tasks are designed to address multiple objectives.

Information and Education Strategy

Chapter 9 outlines an Information and Education Strategy that addresses the communication necessary for implementing the watershed protection plan. These outreach efforts are important because developing and carrying out a vision for stewardship of the Herring Lakes Watershed will require the public and community leaders to become knowledgeable about the issues and solutions, engaged and active in implementing solutions and committed to both individual and societal behavior changes necessary.

Evaluation Procedures

An evaluation strategy will be used to measure progress during the Herring Lakes Watershed Protection Plan's implementation and to determine whether or not water quality is improving. The timeline for the evaluation is approximately every five (5) years, with ongoing evaluation efforts completed yearly. The main purpose of the evaluation strategy is to measure how well we are doing at actually *implementing* the watershed management plan and to assess if project milestones are being met. Measuring accurate pollutant load reductions is the most essential element of the evaluation strategy since it will provide objective, quantified results. The evaluation strategy will also focus on public education of watershed issues and will monitor success of the Information and Education Strategy by looking at public perception of watershed issues over time.

CHAPTER 2: HERRING LAKES WATERSHED DESCRIPTION

2.1 Location and Size

The majority of the Herring Lakes Watershed is contained within Benzie County in Michigan's northwest Lower Peninsula. The total drainage area is approximately 25.3 square miles and the primary Herring Lake Valley is about 4.6 miles in length and 6.5 miles in width. The entire watershed covers approximately 16,201 acres. However, the length of the entire watershed that extends along Lake Michigan is 10.3 miles. The watershed intersects with the jurisdictions of five townships, but the majority of the watershed is within three townships located in Benzie County (Blaine, Gilmore, and Joyfield townships). The southern extent of the watershed also intersects with northern Manistee County and touches two townships (Arcadia and Pleasanton townships) (Figure 1-Base Map). The Herring Lakes Watershed contains no villages. Joyfield Township forms the eastern limit of the watershed.

Note: two "wings" along Lake Michigan north and south of the actual drainage area of the Herring Lakes Watershed were "claimed" and included in this watershed protection plan as both locations had been left out of watershed planning projects north and south of the Herring Lakes Watershed. These coastal "wings" primarily consist of sandy beaches, bluffs and dunes and are interpreted to primarily drain directly to Lake Michigan.

Elberta Dunes, Elberta Michigan within the northern "wing" of the Herring Lakes watershed

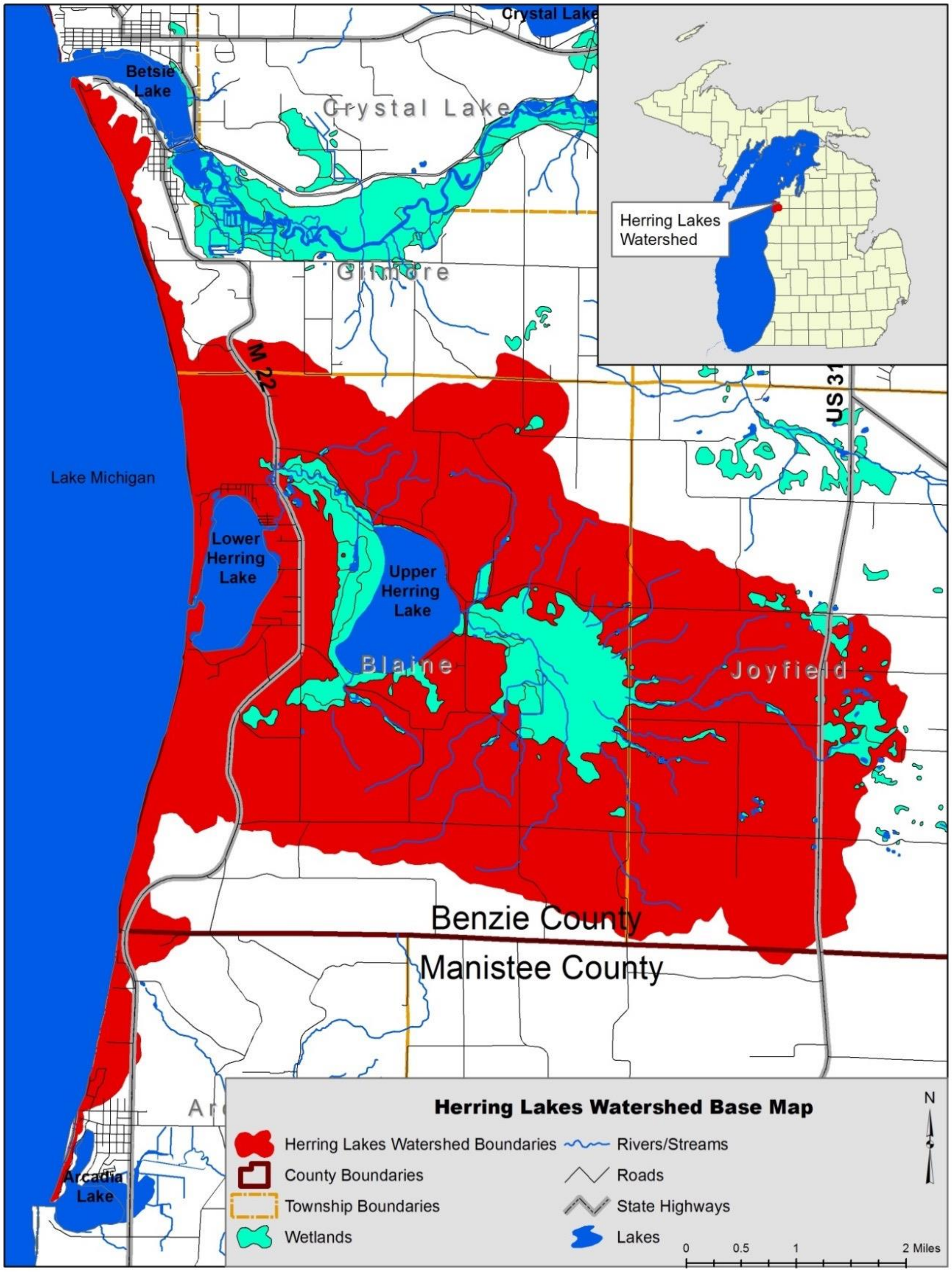


Figure 1: Herring Lakes Watershed – Base Map

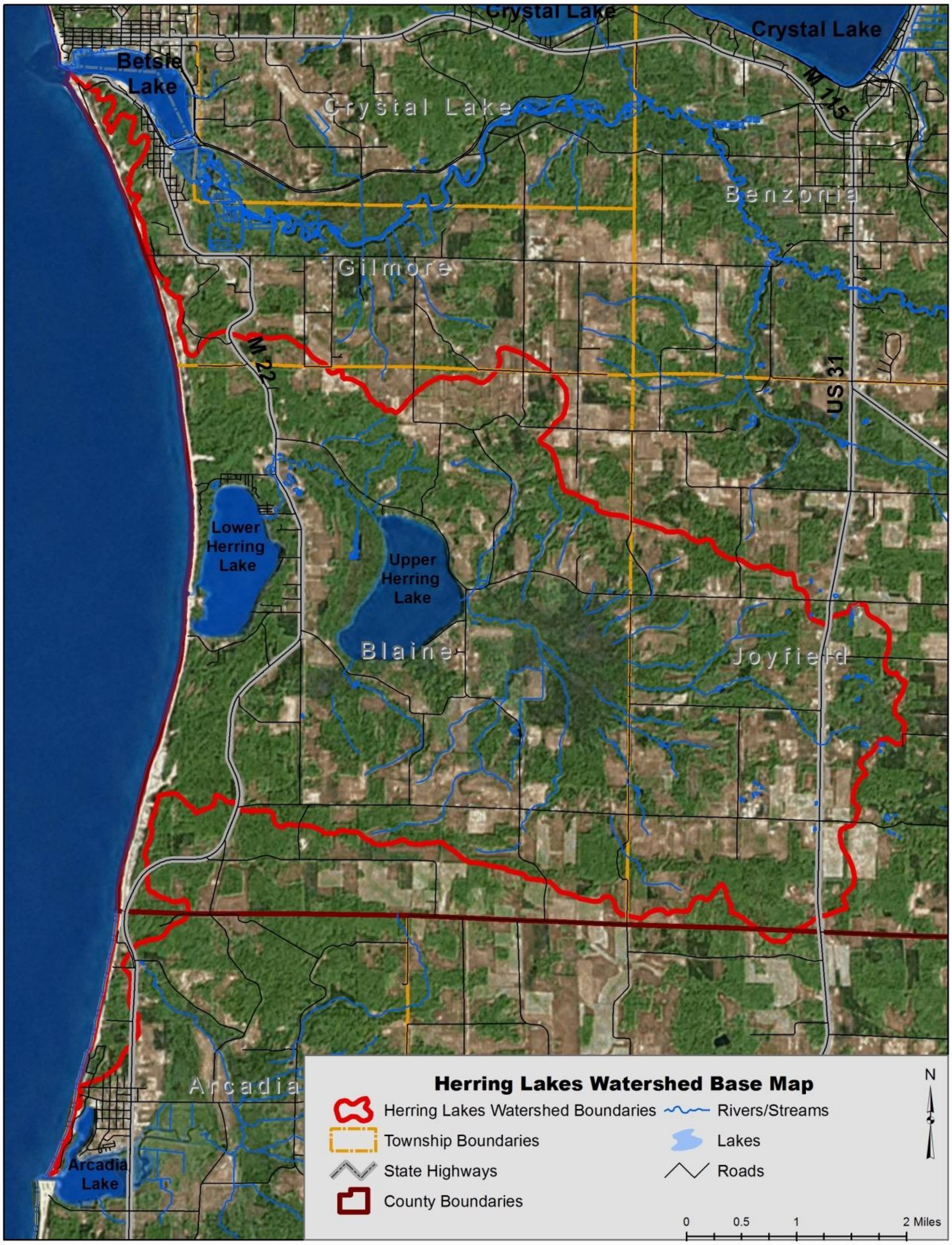
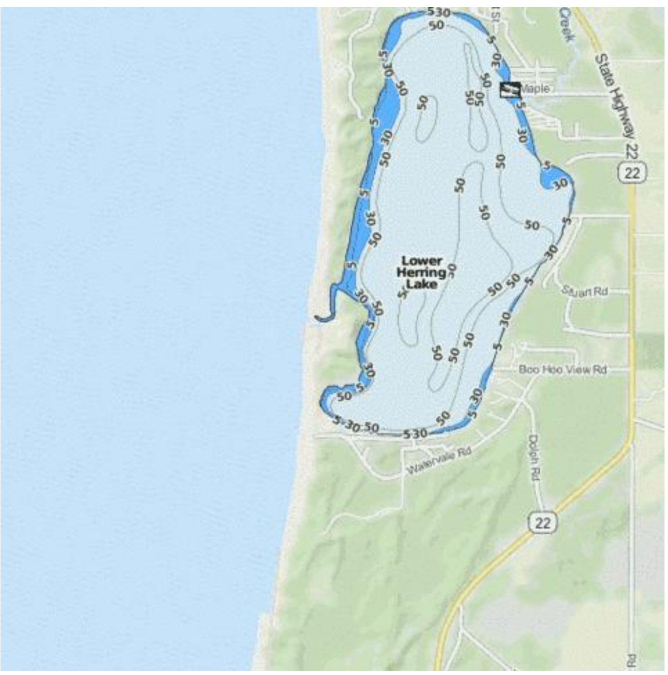
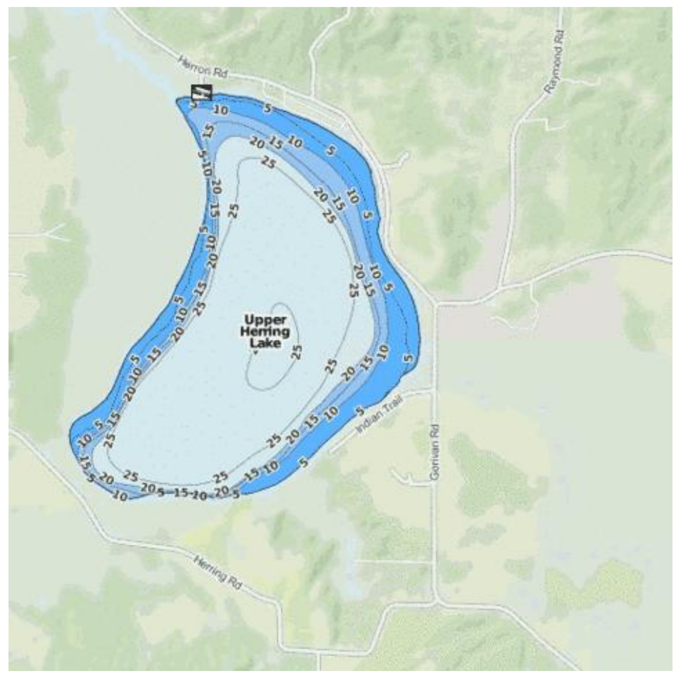


Figure 2: Herring Lakes Watershed – Aerial Photo Map

2.2 Hydrology and Groundwater Recharge

Upper and Lower Herring lakes are the two main water bodies in the watershed. The water bodies have a total surface area of 1,081 acres or 6.3% of the total watershed surface area. Precipitation and snowmelt that falls across the forested and agricultural uplands located north, east and south of Upper Herring Lake percolates through to porous sandy soils, thereby recharging local groundwater aquifers. Groundwater then emerges from forested valleys and gives rise to several streams that supply the majority of the surface flow for the entire watershed. Herring Creek, a second order perennial stream, is the main tributary stream flowing from east to west into Upper Herring Lake. This creek is fed by numerous unnamed first order groundwater tributaries and intermittent streams flowing from the adjacent hillsides north and south of the main Herring Creek valley. Additional perennial first and





second order streams and intermittent streams flow into the south and north shores of Upper Herring Lake as well as the north bank of Herring Creek as is flows between Upper and Lower Herring lakes.

Upper Herring Lake is the largest water body in the watershed, covering 572.5 acres and with just over 4 miles of shoreline and covering a surface area of 0.9 square miles. Upper Herring Lake has a maximum depth of 26 feet and average depth of 22 feet. Upper Herring Lake elevation is 592 feet or 13 feet above the level of Lake Michigan. Lower Herring Lake is slightly smaller in area covering 445.7 acres with nearly 4 miles of shoreline. Lower Herring Lake has a maximum depth of 61 feet and average depth of

45 feet. Lower Herring Lake's legally established elevation is 580.5 feet—only a few inches above Lake Michigan—and relatively high levels of Lake Michigan during 2016-2018 have significantly influenced its discharge.

Lower Herring Lake is surrounded by forested hillsides that are predominately stabilized sand dunes. The absence of first order tributary streams on Lower Herring Lake seems to indicate that groundwater recharge in this portion of the watershed primarily flows directly toward Lake Michigan itself. The lake's outlet, Lower Herring Creek, is a warm water, second order stream that drains from western boundary flowing westward through forested sand dunes into Lake Michigan.

Herring Lakes Watershed Hydrology

A discharge control structure or "dam" exists at the outlet of Lower Herring Lake at the Lake Michigan shoreline. The discharge elevation of the control structure is fixed at 580.33 feet. The water from Lower Herring Lake that discharges at the outlet flows within a wide, shallow channel approximately 550 feet to Lake Michigan. This structure was constructed in 1935, and improved with the addition of side pillions in 1958. An earthen and log dam existed at this location before 1935. The control structure was undermined and washed out by Lower Herring Lake discharge and subsequently repaired in 1963.

Since 2016 the flow control structure has overtopped on several occasions due to high water levels of Lake Michigan. These recent Lake Michigan water levels have caused the periodic sedimentation/sand in-fill and closing off the discharge at Lake Michigan below the dam. Significant concern exists with raising water levels of Lower Herring Lake, and the potential for the introduction of exotic/invasive species from Lake Michigan during such overtopping events.

The channel between the flow control structure is vulnerable to flow alteration and/or blockage from shifting Lake Michigan shoreline sands and fluctuating water levels. In late 2017 and early 2018 the Lower Herring Lake Association has twice used heavy equipment to re-open the outlet of Lower Herring Lake pursuant to an after-the-fact MDEQ/U.S. ACE permit. The Lower Herring Lake Association and regulators were exploring and studying long-term solutions to this problem at the time of this writing.

Lower Herring Lake dam/outlet and discharge channel to Lake Michigan.

Herring Lakes Discharge Measurements — Inlets/Outlets

The discharge in cubic feet per second (i.e., cfs) was monitored monthly at four (4) locations during the water quality assessment period of the Herring Lakes Watershed Protection Planning project. Discharge and relative elevations or "levels" were monitored at the time of water quality sampling events at WS-1 (i.e., the Lower Herring Lake outlet), WS-2 (i.e., Lower Herring Lake inlet at Buena Vista Road), WS-3 (i.e., Upper Herring Lake outlet) and WS-4 (i.e., Upper Herring Lake inlet at Gorivan Road). Discharge, i.e. flows and levels, measurement locations are depicted in Figure 9 below. Precipitation recorded at Frankfort, Michigan was used to characterize precipitation trends within the Herring Lakes Watershed during the project period, i.e., from April 2015 through August 2016 (see Figure 3).

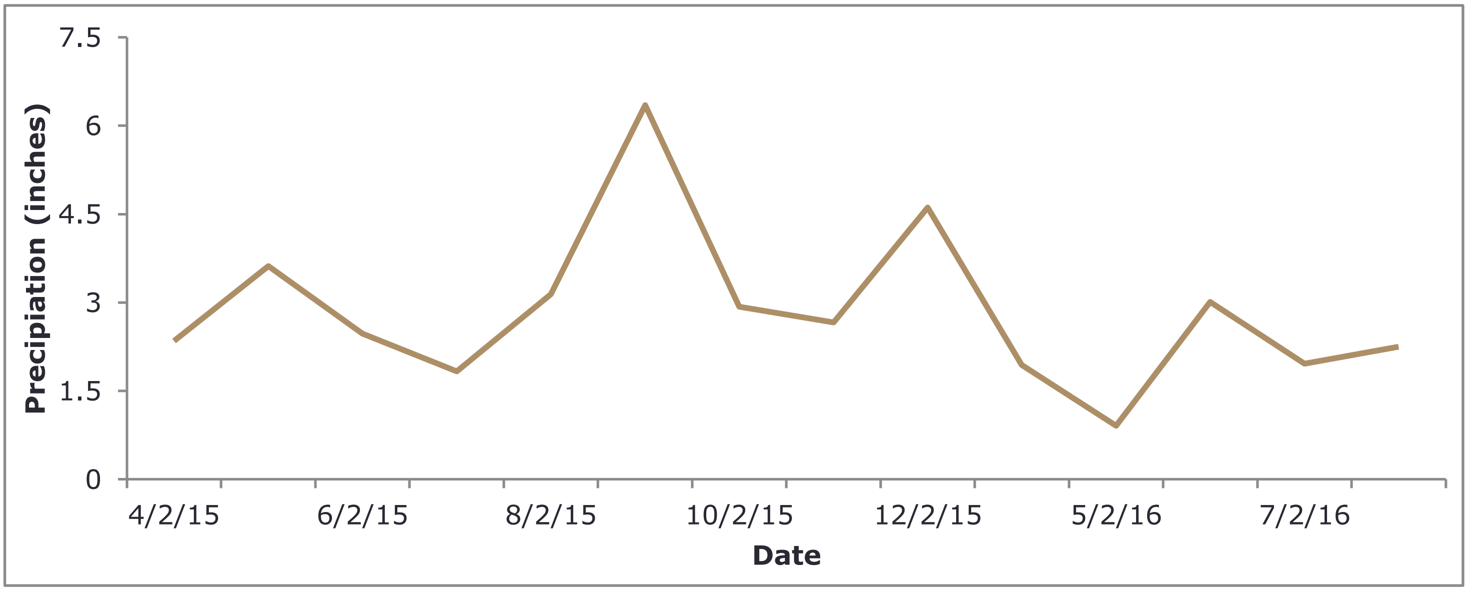


Figure 3: Precipitation Trends – Herring Lakes Watershed, 2015-2016, taken from Frankfort Weather Station

Source: www.usclimatedata.com/climate/frankfort/michigan/united-states/usmi

Discharge at the Lower Herring Lake outlet (i.e., WS-1) at the dam/discharge control structure ranged from 0.0 cubic feet per second (cfs, i.e., at times when the outlet was closed from sediment deposition at the Lake Michigan shoreline) to 85.8 cfs. The average low at the Lower Herring Lake outlet (i.e., WS-1) was 47.9 cfs (see Figure 4 below).

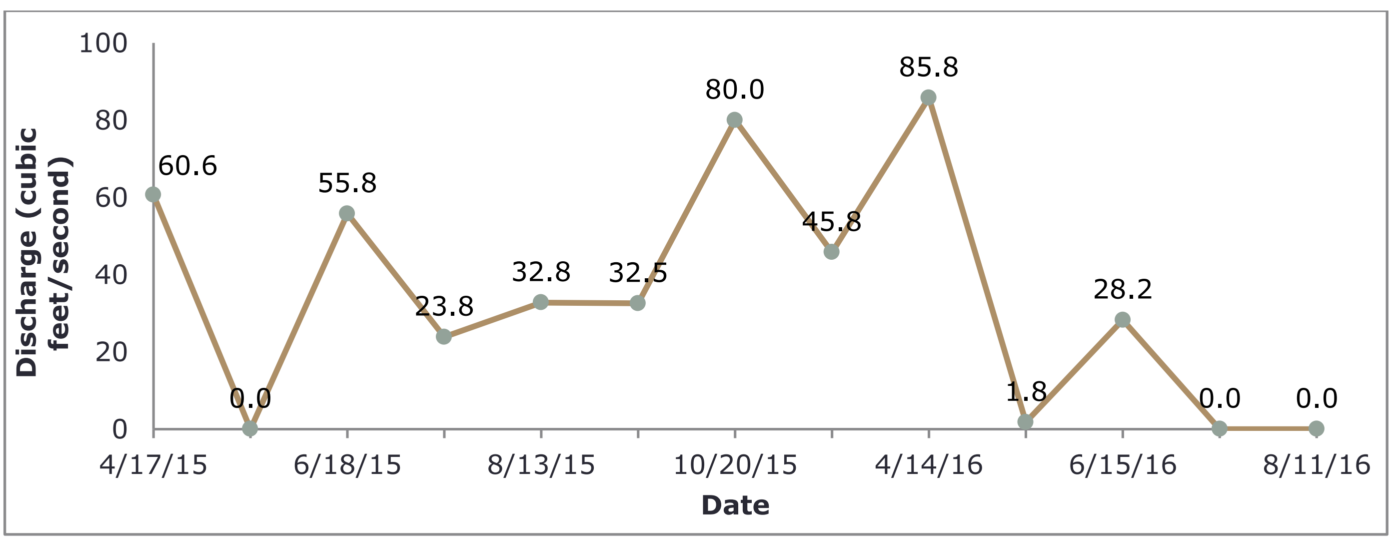


Figure 4: Discharge (cfs) at Lower Herring Lake Outlet (WS-1), 2015-2016

Discharge at the Lower Herring Lake inlet (i.e., WS-2) at the Elberta Resort Road ranged from 28.9 cfs to 78.4 cfs. The average discharge at the Lower Herring Lake inlet (i.e., WS-2) was 48.16 cfs (see Figure 5 below).

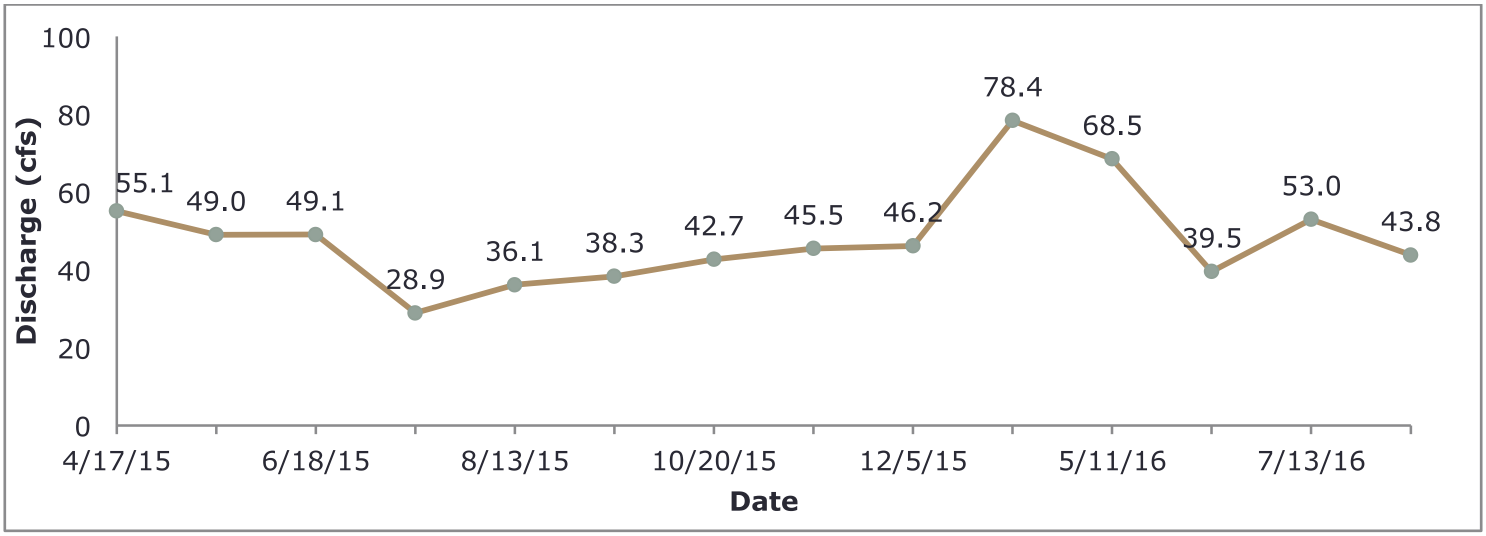
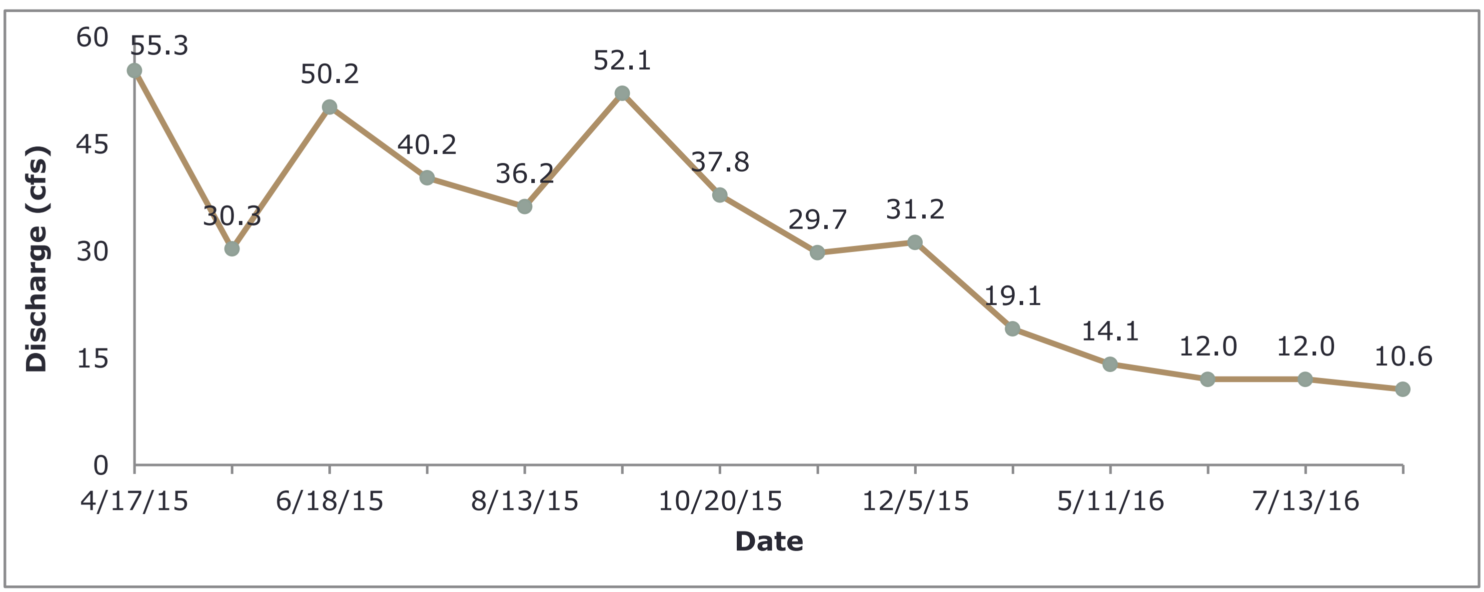


Figure 5: Discharge (cfs) Lower Herring Lake Inlet (WS-2), 2015-2016

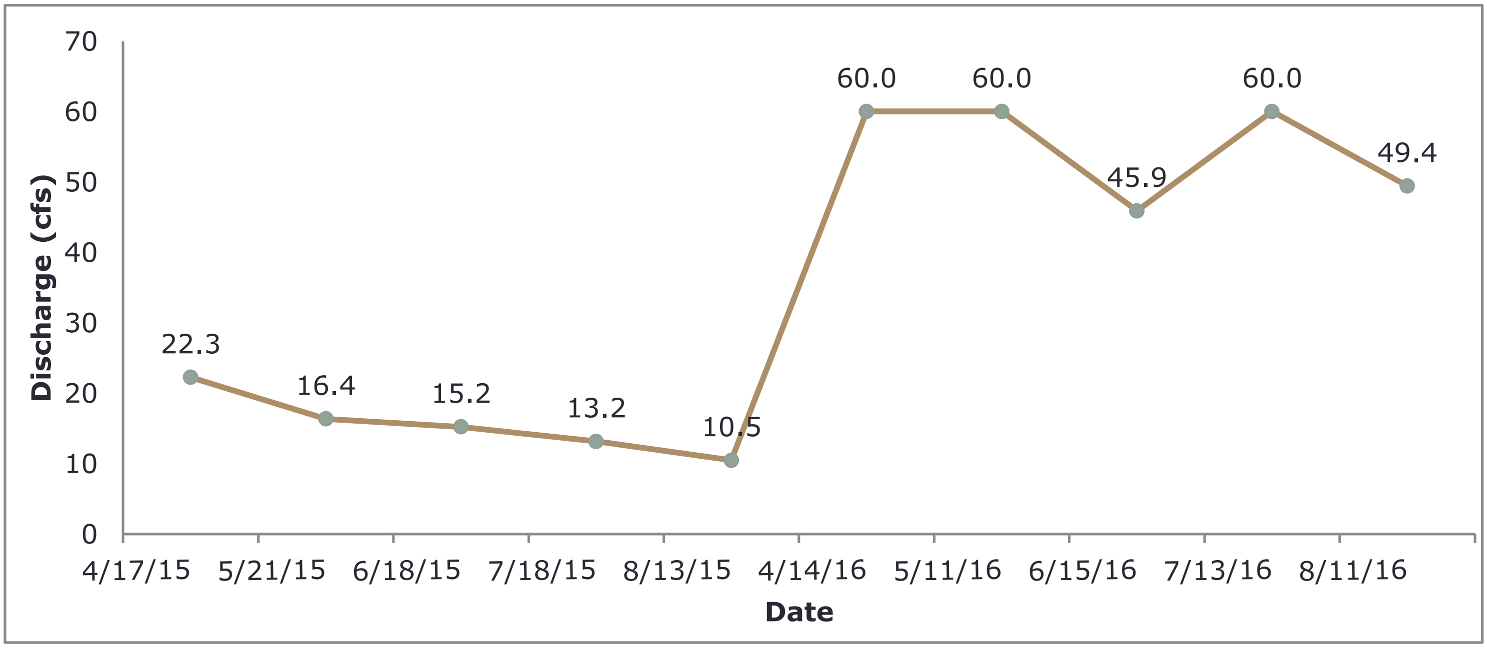
Discharge at the Upper Herring Lake outlet (i.e., WS-3) ranged from 10.48 cfs to 60.0 cfs. The average



discharge at the Upper Herring Lake outlet (i.e., WS-3) was 30.32 cfs (see Figure 6 below).

Figure 6: Discharge (cfs) Upper Herring Lake Outlet (WS-3), 2015-2016

Discharge at the Upper Herring Lake inlet at Gorivan Road (i.e., WS-4) ranged from 12.0 cfs to 55.9 CFOs. The average discharge at the Upper Herring Lake inlet (i.e., WS-4) was 30.8 cfs (see Figure 7



below).

Figure 7: Discharge (cfs) Upper Herring Lake Inlet (WS-4), 2015 - 2016

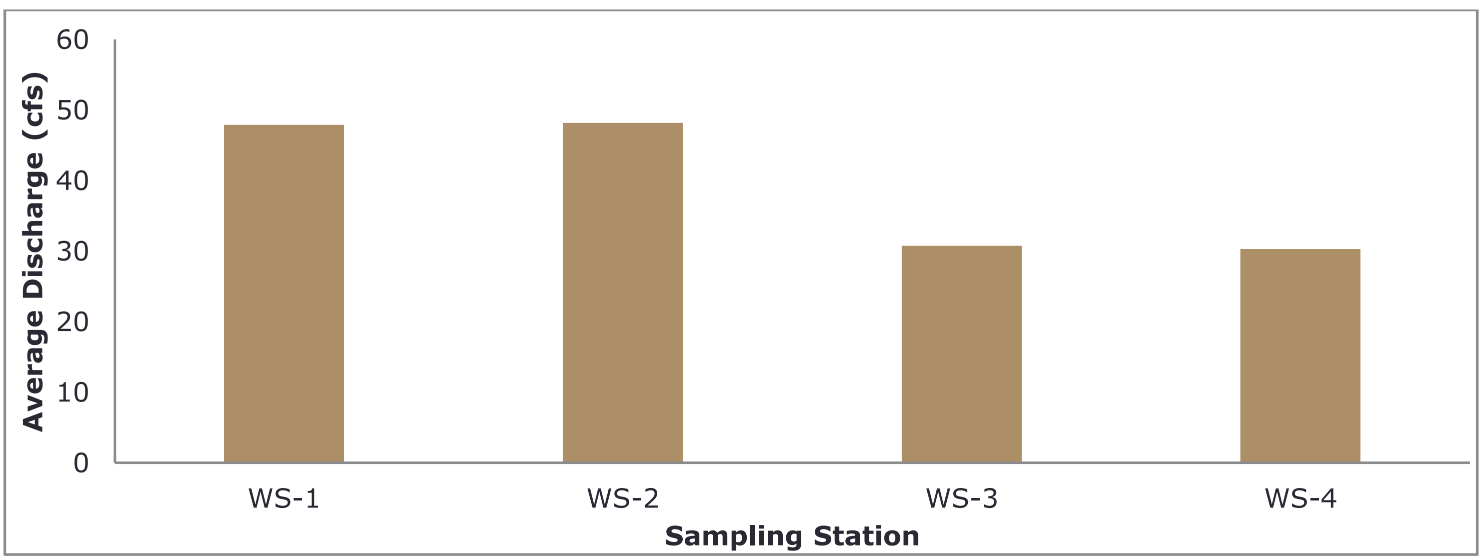


Figure 8: Average Discharge (cfs) Herring Lakes Inlets/Outlet, 2015 - 2016

The "flashiness" of waterway or water body describes the relative speed or rapidity at which discharges and levels increase following a precipitation event. As expected the outlet at Lower Herring Lake (i.e., WS-1) is the flashiest water body in the Herring Lakes Watershed during this study, followed by the Lower Herring Lake inlet (i.e., WS-2), the Upper Herring Lake outlet (i.e., WS-3) and the Upper Herring Lake inlet (i.e., WS-4), respectively. In other words, waterways within the Herring Lakes Watershed demonstrate a relatively slow release response to significant precipitation events based on other factors not mentioned here. Major tributaries within the watershed possess permanent flow and are depicted in Figure 9 below.

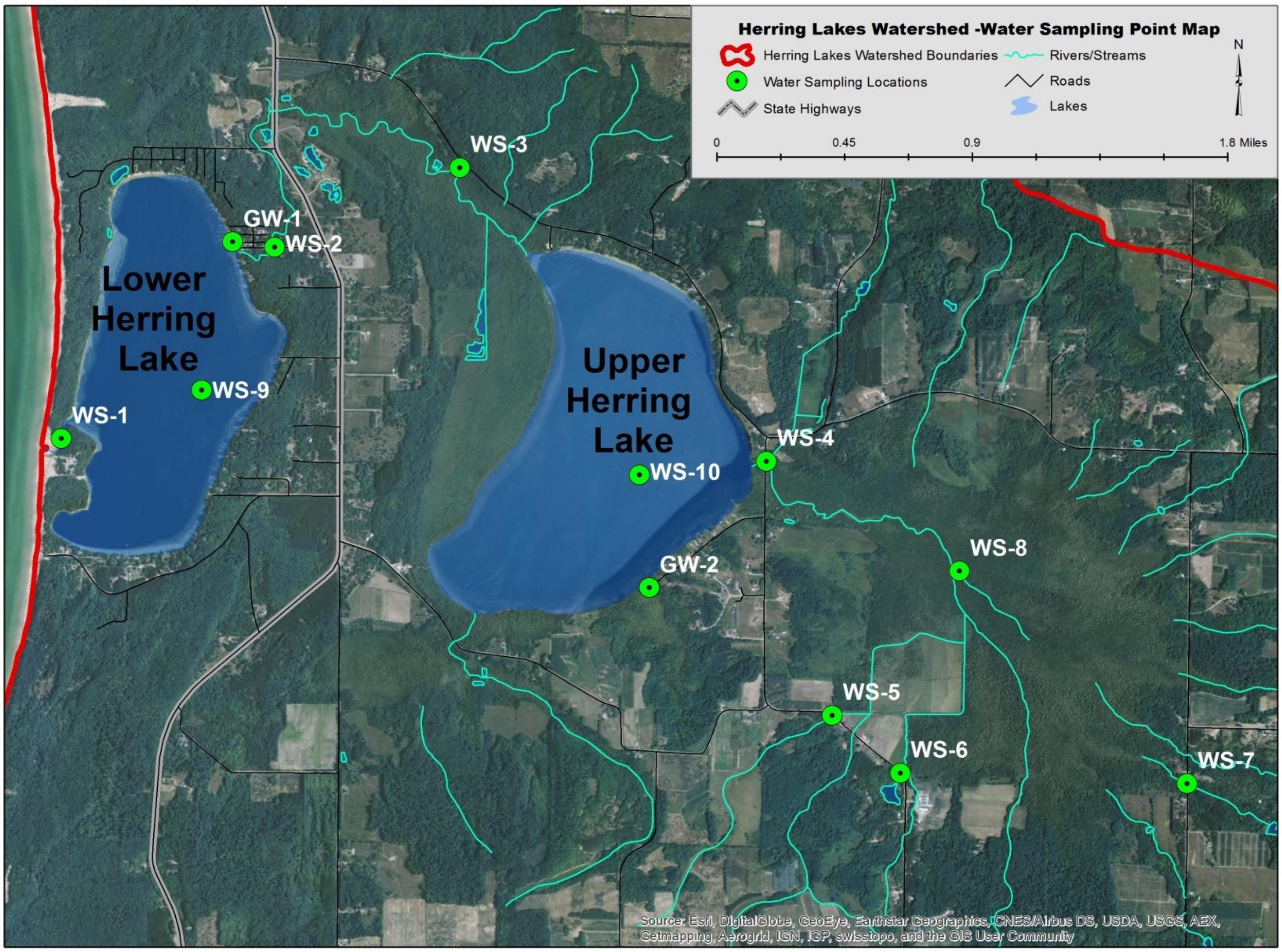


Figure 9: Water Sample/Flow Measurement Locations, Herring Lakes Watershed

Wetlands

Wetlands comprise a vital link in the preservation of high water quality and important wildlife habitat in the Herring Lakes Watershed. Riparian wetlands located along the tributary streams and lakeshore, combined with the larger wetland complex east of Upper Herring Lake protect groundwater springs and tributary stream water quality by filtering out sediment and temporarily storing nutrients from surface run-off before they reach the stream channels or the lakeshore directly (see Figure 3).

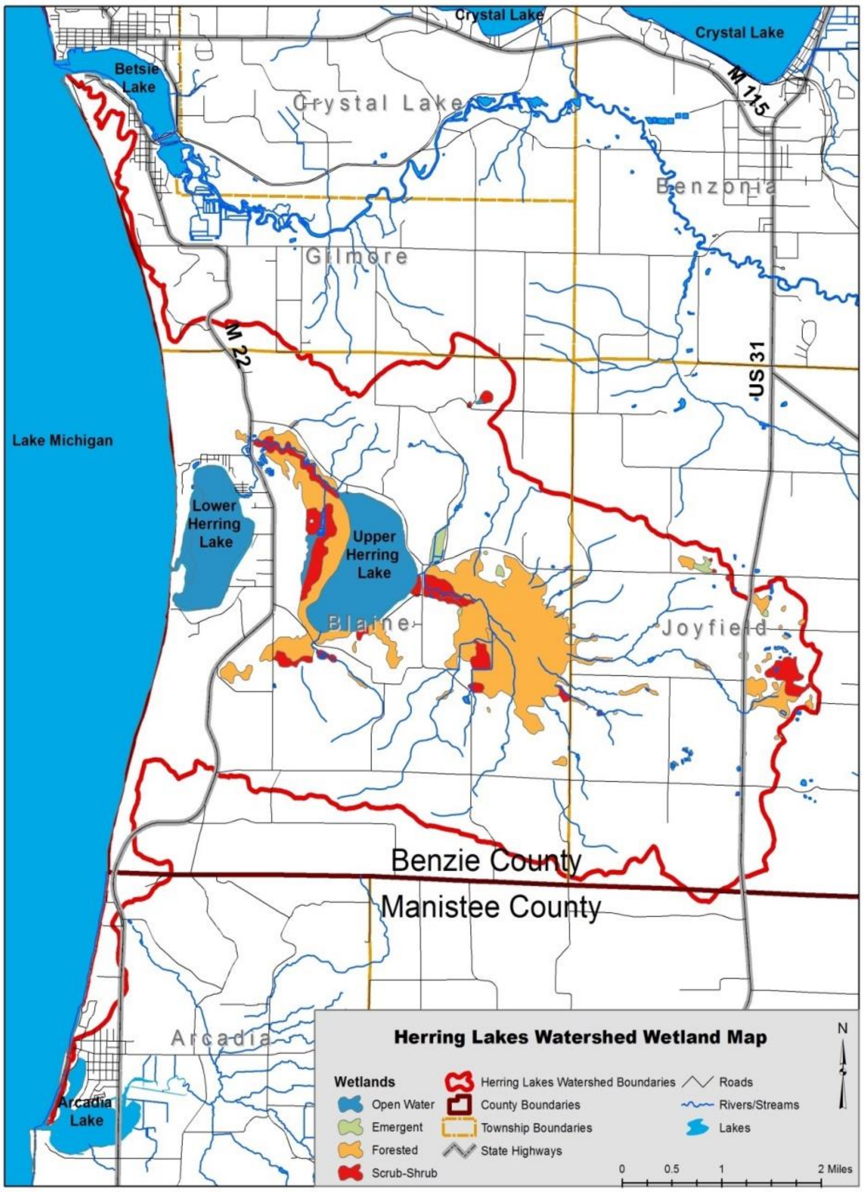


Figure 10: Herring Lakes Watershed Wetland Map

Additionally, both Upper and Lower Herring lakes have healthy pockets of emergent and submergent wetlands along their shorelines and near-shore waters that provide critical habitat for aquatic and wetland species. Currently the Federal Army Corps of Engineers and/or the State of Michigan regulate wetlands that are within 500 feet of inland waters, 5 acres or greater in highly populated counties, and/or within 1,000 feet of the Great Lakes. Additionally, the State of Michigan also protects wetlands under state law P.A. 451 of 1994 if they meet any of the following conditions:

- Located within 1,000 feet of one of the Great Lakes or Lake St. Clair
- Connected to an inland lake, pond, river, or stream
- Located within 500 feet of an inland lake, pond, river or stream
- Not connected to one of the

Great Lakes or Lake St. Clair, or an inland lake, pond, stream, or river, and less than 5 acres in size, but the DEQ has determined that these wetlands are essential to the preservation of the state's natural resources and has notified the property owner

A study to identify potential wetland areas, combining different sources of wetland information using Geographic Information Systems (GIS) software, was completed in early 2000 by the Northwest Michigan Council of Governments (NWMCOG) through the Special Wetland Area Management Project (SWAMP), coordinated by the Michigan Department of Environmental Quality (MDEQ). The dataset is a composite of three sources of wetland information:

1. The National Wetland Inventory (NWI), conducted by the U.S. Fish and Wildlife Service

2. The U.S. Soil Conservation Service Soil Survey, which identifies hydric soils and soils with hydric inclusions and/or components

3. The Michigan Resource Inventory System (MIRIS) land cover interpretation from aerial photographs

Wetlands according to the National Wetlands Inventory in the Herring Lakes Watershed cover 2,734.2 acres or 12.6 % of the total watershed area (see Table 1 and Figure 3). The majority of the wetlands in the Herring Lake watershed are forested (48.5%). The second most common wetland community in the watershed is scrub-shrub, which is highlighted by the large wetland complex east of Upper Herring Lake, i.e., the Herring Swamp.

These approximate wetland boundaries provide a useful planning tool in determining the general location and amount of probable wetland areas, but the data has not been field checked. Localized groundwater fluctuations from fluctuating Lake Michigan levels, disturbed hydrologic functions, unusual precipitation patterns and other external influences drastically alter the location of the wetland/upland boundary, thereby shrinking or growing wetland communities annually as the local groundwater table and lake levels change.

Table 1: Composite Wetland Areas in the Herring Lakes Watershed

Type of Wetland	*Acres*	*% of Wetlands*
Emergent	45.9	1.7
Forested	1,326.0	48.5
Open Water/Unknown Bottom	1,030.7	37.7
Scrub-Shrub	331.7	12.1
Total	**2,734.2**	**100%**

2.3 Geology and Soils

Geology/Hydrogeology

The Herring Lakes Watershed is truly shaped as a basin sloping, generally to the west toward its outlet at Lake Michigan. The Herring Lakes Watershed is relatively flat and gently sloping in its center and lower reaches at elevations of 600 feet (183 meters) above mean sea level (m.s.l.) to 617 feet (187 meters) m.s.l., and is significantly steeply sloping along its margins at elevations of 836 feet (255 meters) 853 feet (260 meters) m.s.l. An extensive relatively flat wetland exists east of Upper Herring Lake at approximately 607 feet (185 meters) m.s.l. Numerous tributaries flow generally radially toward Upper Herring Lake at elevations of 623 feet (190 meters) m.s.l. Lower Herring and Upper Herring lakes are generally groundwater fed at elevations of 580.5 feet (177 meters) and 590.4 feet (180 meters) above m.s.l., respectively. Given area hydrology and geomorphology, near surface and deeper regional groundwater are interpreted to flow generally westerly toward Herring Creek and Lake Michigan.

Copies of residential water well logs were obtained and reviewed from the MDEQ's Residential Water Well Record Retrieval System for recorded residential well logs in areas draining directly to the Herring Lakes (see Figure 11). The review of one hundred and sixty-nine (169) available well logs from within the watershed was undertaken from Blaine and Joyfield townships, Benzie County. Site and vicinity residential wells are relatively shallow and entirely completed or “screened” within glacial drift at depths averaging 56.5 feet below ground surface (b.g.s.), with the shallowest vicinity residential well at approximately 30 feet b.g.s. Area well logs suggest that glacial stratigraphy at and near the subject parcel and their vicinity consists of a thick, surficial sand layer to an average depth of 42.7 feet b.g.s., which is underlain by a thin confining clay layer, below which is a sandy aquifer providing potable water to the vast majority of residential wells in the area and supplying wetlands, tributaries, Herring Creek and both Herring lakes. The average water table or “static water level” within the area drinking water aquifer is 14.3 feet b.g.s.

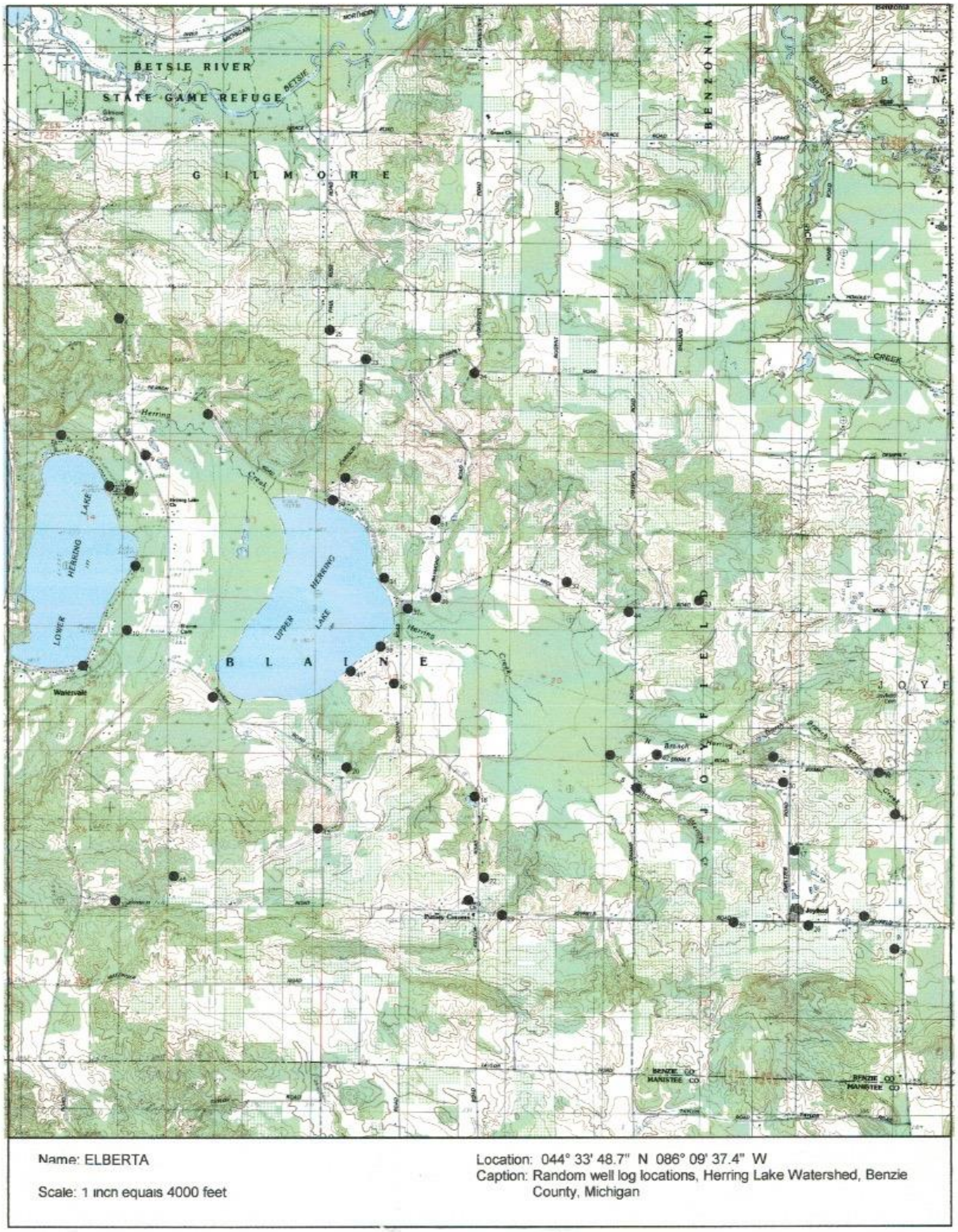


Figure 11: Herring Lakes Watershed Well Log Map

Soils

The Herring Lakes Watershed is gently sloping with soils that range from mucky to well drained. The Herring Lakes Watershed is bordered to the north and south by east and west running, streamlined hills known as moraines formed by retreating glaciers. These hills, called drumlins, are composed of sandy and coarse loam soils that are well drained and conducive to agriculture (see Figure 12). There are four main soil associations in the Herring Lakes Watershed:

The Kalkaska-Leelanau-Emmet association makes up the majority of the soil associations comprising 69% and the Tawas-Roscommon-Cathro comprise 15%, the Deer Park-Upidsamments-Eastport 10%, and the Rubicon-East Lake-Eastport association comprises 5% (see Figure 13).

Nearly level to strongly sloping sandy soils on outwash plains characterize the Kalkaska-Leelanau association. The Rubicon soils are deep, excessively drained sandy soils on nearly level to steep topography. The Deer Park association is made up of sandy soils that are well drained and strongly sloping to very steep.

Climate[1]

The average annual total precipitation within the Herring Lakes region of Benzie County is 35.13 inches. Of this, about 19.67 inches (i.e., 56%) usually falls in May through October. The growing season for most crops falls within this period. The heaviest 1-day rainfall during the period of record was 4.08 inches at Frankfort on August 17, 1995. Thunderstorms occur on about 37 days each year, and most occur between May and September.

The average annual number of days with any measurable precipitation is 83, and on average there are 164 sunny days per year. The average number of days with at least 1 inch of snow on the ground is 109 days. The average July high is around 79 degrees, and the January low is 17. In winter, the average temperature is 24.6 degrees F and the average daily minimum temperature is 19.0 degrees. The lowest temperature on record, which occurred at Frankfort on January 17, 1982 was negative 15 degrees. In summer, the average temperature is 65.7 degrees, and

[1] Natural Resource Conservation Service, National Weather and Climate Center, weather station Frankfort 2NE, for the years 1971 - 2000.

the average daily maximum temperature is 75.0 degrees. The highest temperature, which occurred at Frankfort on August 16, 1988 was 95 degrees.

Although data for the Herring Lakes was not available, first ice cover is interpolated for January 14 and last ice on March 15, for an average, long-term ice cover duration of 90 days.[2]

Table 2: Herring Lakes Watershed Regional Climate

Month	Temperature (F ave)	Precipitation (inches)
January	22.4	2.77
February	24.2	1.98
March	31.9	2.34
April	42.6	2.59
May	53.8	2.69
June	62.5	3.24
July	67.7	3.04
August	67.0	3.49
September	59.8	4.03
October	49.4	3.18
November	37.3	2.98
December	27.3	2.80
	Annual Average 45.5	**Total 35.13**

[2] NOAA Technical Memorandum GLERL-125, GREAT LAKES ICE COVER, FIRST ICE, LAST ICE, AND ICE DURATION: WINTERS 1973-2002, Raymond A. Assel, NOAA, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan, September 2003.

The average seasonal snowfall is 115.0 inches. The greatest snow depth at any one time during the period of record was 48 inches recorded on February 3, 1994. On average, 109 days per year have at least 1 inch of snow on the ground. The heaviest 1-day snowfall on record was 16.0 inches recorded on December 22, 1989. The average relative humidity in mid-afternoon is about 64 percent. Humidity is higher at night, and the average at dawn is about 81 percent. The sun shines 62 percent of the time in summer and 31 percent in winter. The prevailing wind is from the southwest. Average wind speed is highest, around 12 miles per hour, from November to April.

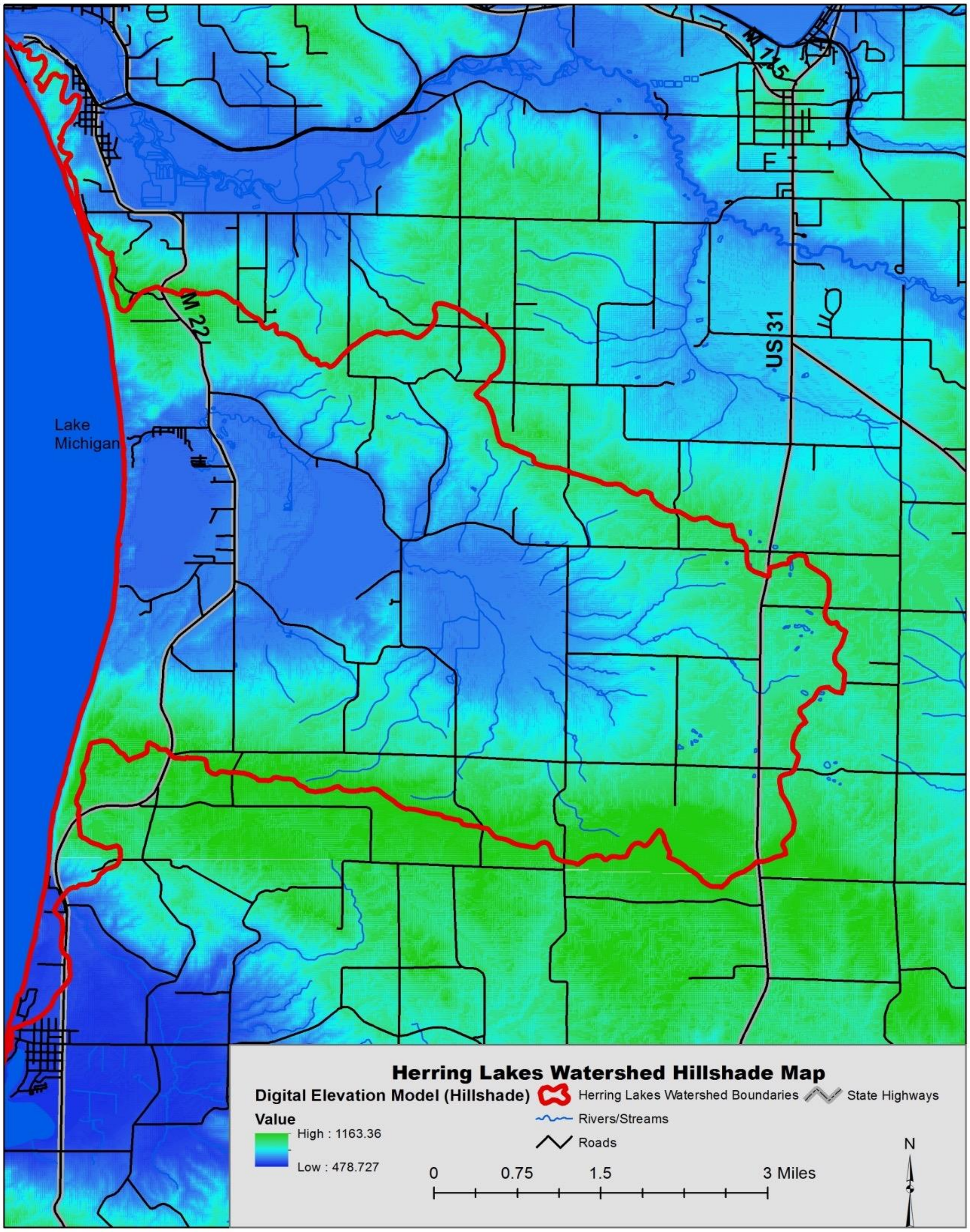


Figure 12: Herring Lakes Watershed Topographic Shade Map

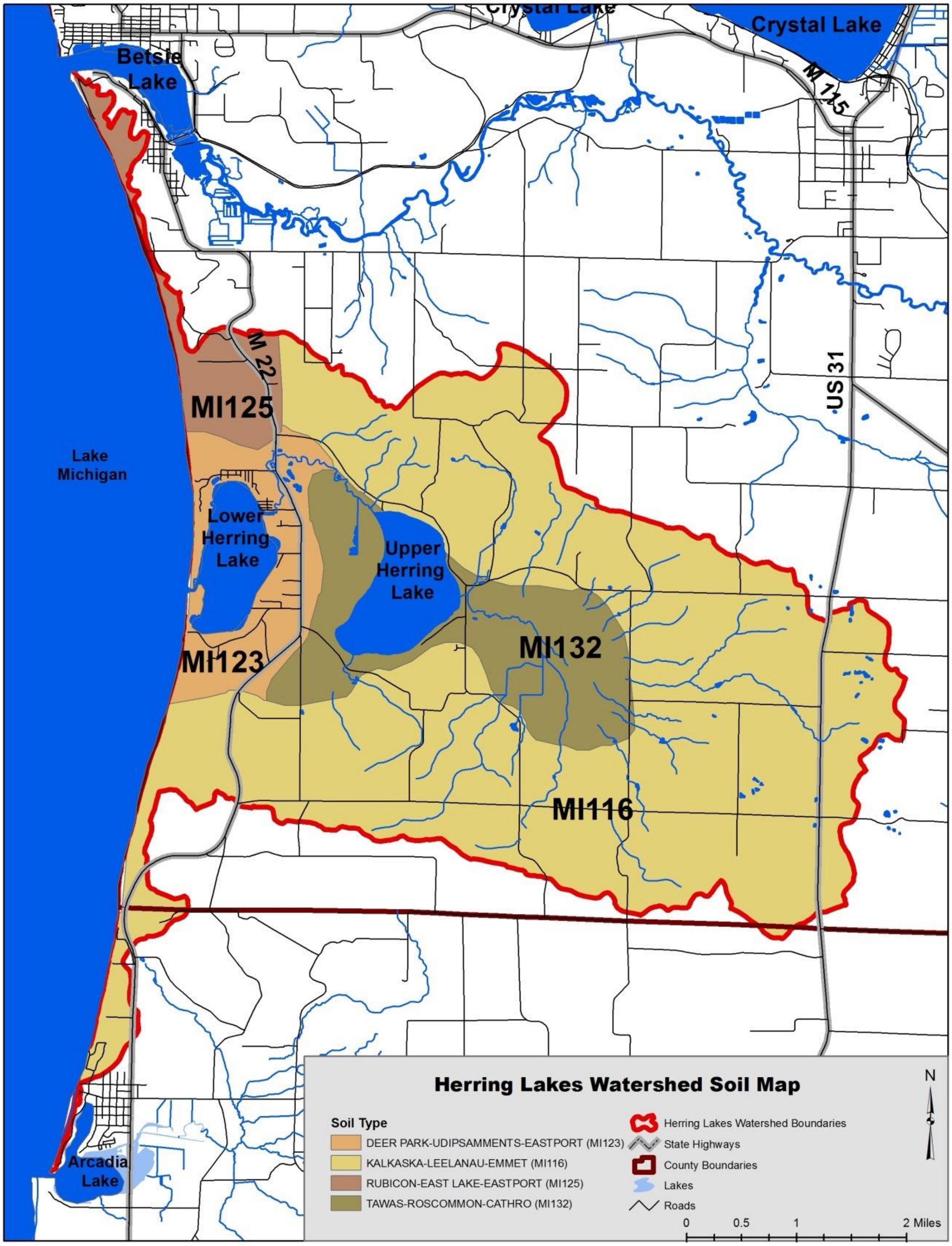


Figure 13: Soil Associations of the Herring Lakes Watershed

2.4 Jurisdictions

The Herring Lakes Watershed is comprised of portions of five (5) townships within two counties. The majority of the watershed is within Benzie County (i.e., 97.9%) and a small portion of Manistee, only covering 2.1% of the watershed (see Figure 1, Tables 2 and 3). The majority of the property in the watershed is in private ownership (i.e., 78%). The Grand Traverse Regional Land Conservancy owns or manages about 1670 acres (or 10%) of Natural Areas and Preserves which are open to the public, while the State of Michigan State Forest comprises only 0.3% of the watershed (see Figure 14, Table 5).

Table 3: Percent of Each County within the Watershed

County	*Total Acres in the Watershed*	*% of County in Watershed*
Benzie County	15,857.9	97.9 %
Manistee County	343.07	2.1 %

Table 4: Percent of Each Township within the Watershed

Township	*County*	*Acres in Watershed*	*% of Acres Watershed*	*% of Township in Watershed*
Arcadia	Manistee	328.9	2.0	0.50
Blaine	Benzie	10,965.0	67.7	81.6
Gilmore	Benzie	465.9	2.9	0.7
Joyfield	Benzie	4,427.1	27.3	34.6
Pleasanton	Manistee	14.1	0.1	0.02
Total		16201.0	100.0	

Table 5: Public and Private Land in the Herring Lakes Watershed

Jurisdiction	***Acres***	***% of Watershed***
Private Land	12,684.8	78.3
Privately Protected Land (conservation easements- CE's)	781.5	4.8
GTRLC Public Parks/Natural Areas/BCD Land	1,668.5	10.3
State Land	48.0	0.3
Water (Lakes)	1,018.2	6.3
Total	16,201.0	100

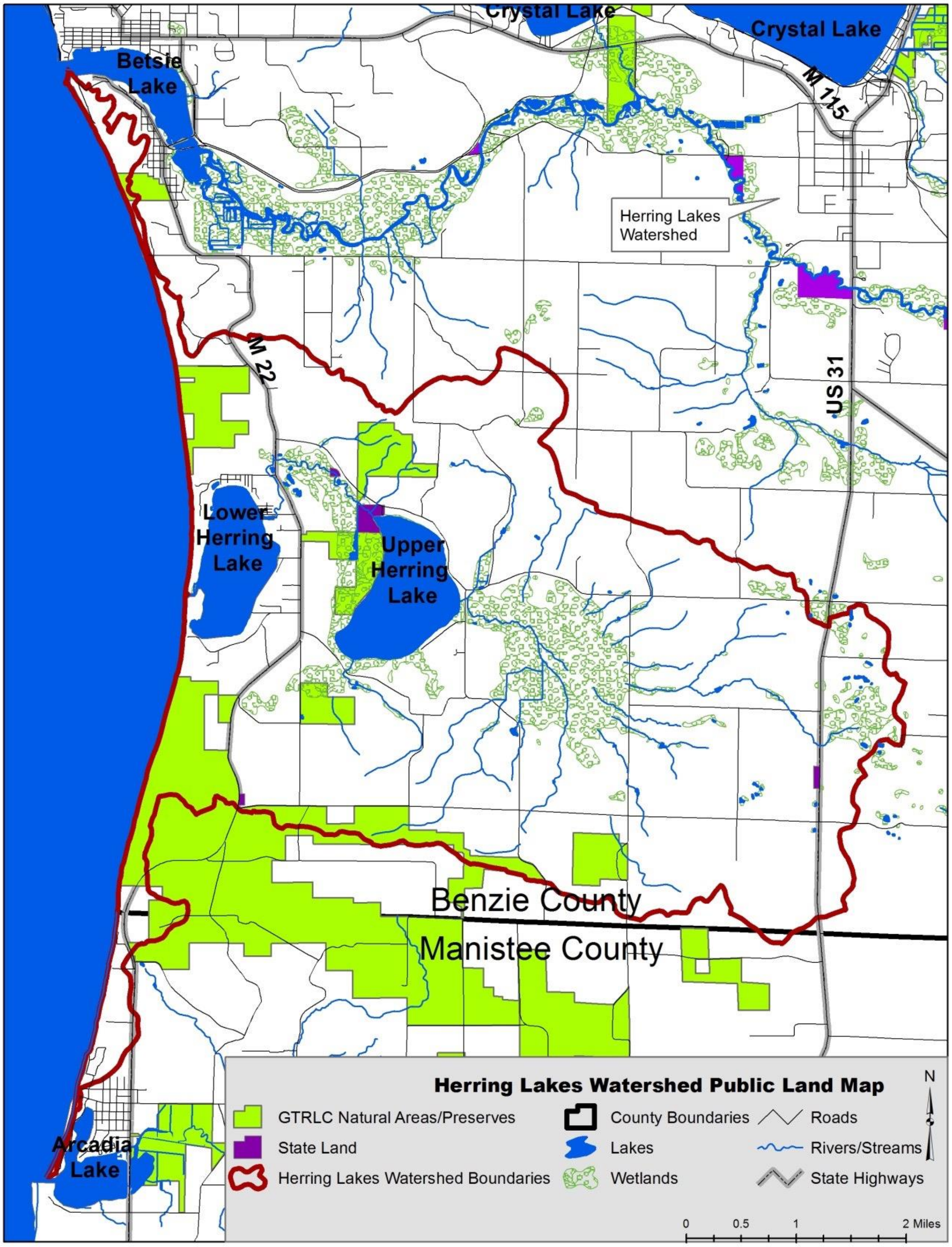


Figure 14: Public/Protected Lands in the Watershed

2.5 Population

Rich in land and water resources, the Herring Lakes Watershed is home to both seasonal and year-round residents living mostly in Benzie County and covering three (3) townships (see Table 5). Only 2% of the watershed is in Manistee County. Since watershed boundaries do not directly follow census boundaries, it is difficult to evaluate demographic characteristics of the exact population within the watershed. According to the last census, Benzie County grew at one of the fastest rates in northwest Michigan. From 2000 to 2010 the area's population rose 10% (see Table 6) and future projections indicate a steady growth rate for years to come.

Benzie County has the sixth smallest year-round population among counties in Michigan. The Benzie County population was 11,205 in 1980, and 12,200 in 1990 and 17,525 in 2010 (see Table 6). In fact, Benzie County's population grew by 31% from 1990-2000, the 4th fastest in Michigan (see Benzie County Open Space and Natural Resources Protection Plan).

The greatest individual township population increases between 2000 and 2010 were found in Blaine Township, which encompasses 67% of the watershed (12.2%). Benzie County's population doubles during summer months to nearly 26,000 persons (LLMP 2009). These increases in population and future development have the potential to impact the entire watershed through non-point source pollutants, increased storm-water runoff, loss of wetlands, land fragmentation and potential degradation of important groundwater recharge areas. Since the mid-2000s, however, population growth in many communities has slowed or in some cases reversed, as families left the region during the recession and new residential construction ground nearly to a halt throughout the region. However, recent upticks in the real estate market across all of northwest Lower Michigan indicate that this area is poised to experience another surge of development pressure in the near future.

Table 6: Population and Population Change by Township

Township	*County*	*1990*	*2000*	*% Change (1990-2000)*	*2010*	*% Change (2000-2010)*
Arcadia	Manistee	553	621	12.3	639	2.9
Blaine	Benzie	424	491	15.8	551	12.2
Gilmore	Benzie	794	850	7.1	821	-3.4
Joyfield	Benzie	626	777	24.1	799	2.8
Pleasanton	Manistee	573	817	42.6	818	0.1

Table 7: Population and Population Change by County

County	*1990*	*2000*	*% Change (1990-2000)*	*2010*	*% Change (2000-2010)*
Benzie	12,1200	15,998	31.1	17,525	9.5
Manistee	21,265	24,527	15.3	24,733	0.8

Estimate – Population Division, U.S. Census Bureau

2.6 Land Use/Land Cover

The land area within the watershed is dominated by 41.8% forested lands, (i.e., 36.3% deciduous and 5.5% coniferous), 25.2% is covered by agriculture (i.e., 9.19% cropland, 14.7% orchards and vineyards), and 1.32% permanent pasture or other agriculture, followed by 6.3% water and 7.5% wetlands, and Low Density Residential (LDR) comprising 1.7% (see Figure 15, Tables 7 and 8).

The Herring Lakes Watershed is fortunate to have almost half of its land in a forested condition (see Tables 7 and 8). Deciduous forest stands comprise the single largest land use of the watershed, and with sustainable management, provide an economic resource. Well-managed hardwood forests also provide important habitat and promote groundwater recharge. Area forests have been significantly impacted by the emerald ash borer (*Agrilus planipennis*) and may be threatened at present by the American beech blight aphid (i.e., *Grylloprociphilus imbricator*). Wetlands (i.e., 7.5%) and shrub and herbaceous rangeland (i.e., 10.1% & 4.5%) cover the majority of the remaining portions of the watershed (see Table 8). These undeveloped areas (i.e., forests, herbaceous rangeland and wetlands) comprise 63.9% of the watershed land use, which helps maintain the high water quality and groundwater dominated aquatic systems.

Residential homes or Low Density Residential (LDR) area, which comprises 1.9% of the watershed currently, is likely to increase as regional real estate sales continue to increase. The majority of new residential development in the watershed is targeted at second home buyers that are looking for vacation or retirement properties. The lack of commercial development combined with a forested, scenic landscape adjacent to Lake Michigan makes Herring Lakes a desirable tourist and retirement location. The demand for seasonal and retirement homes located on and nearby Herring Lakes is only expected to increase as the adjacent and more developed watersheds experience continued residential and commercial growth. The agricultural land use of the watershed (i.e., 25.2%) is occupied by primarily permanent orchards, commodity crops (i.e., corn, wheat, beans) and pasture land.

Since the majority of watershed lands are in private ownership (nearly 90%), the most popular recreation activities are invariably focused on the two main lakes, Upper and Lower Herring. Fishing, swimming, water skiing and pleasure boating are the most popular passive recreation activities in the watershed.

(Source Land Use Land Cover Layer - 2000, Michigan Geographic Data Library, http://www.mcgi.state.mi.us/mgdl/?action=thm)

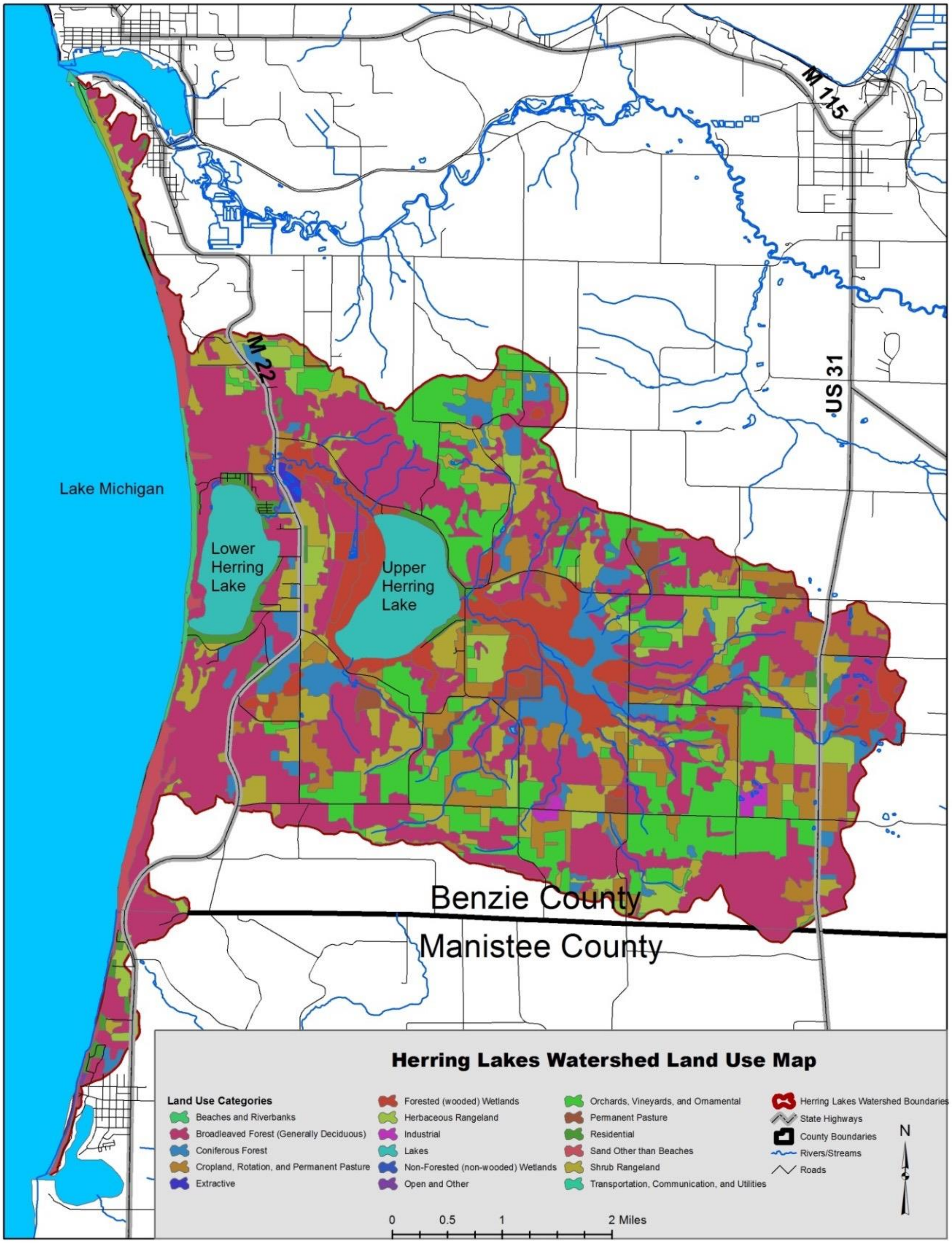


Figure 15: Land Use/Land Cover in the Watershed

Table 8: Land Use/Cover in the Herring Lakes Watershed

Land Use/Cover	*Acres*	*% Total*
Beaches and Riverbanks	102.1	0.63
Coniferous Forest	896.9	5.54
Cropland, Rotation, & Permanent Pasture	1,488.6	9.19
Deciduous Forest	5886.4	36.33
Extractive	37.1	0.23
Forested (wooded) Wetlands	1,202.2	7.42
Herbaceous Rangeland	731.8	4.52
Industrial	59.6	0.37
Lakes	1,018.9	6.29
Non-Forested (non-wooded) Wetlands	5.0	0.03
Open and Other	11.0	0.07
Orchards, Vineyards, and Ornamental	2,376.5	14.67
Permanent Pasture	217.7	1.34
Residential	279.6	1.73
Sand Other than Beaches	251.3	1.55
Shrub Rangeland	1,632.5	10.08
Transportation, and Utilities	4.2	0.03
Total	**16,201**	**100%**

Table 9: Grouped Land Use/Cover

*Land Use/Cover Category**	*Acres*	*% Total*
Barren	364.4	2.2
Commercial	100.9	0.6
Cropland/Pasture	1,706.4	10.5
Forested	6783.3	41.9
Residential	279.6	1.7
Orchards	2,376.5	14.7
Rangeland	2,364.3	14.6
Water	1,018.9	6.3
Wetlands	1,207.2	7.5
Total	**16,201**	**100**

2.7 Threatened and Endangered Species

Table 9 is a list of all known occurrences of the Endangered (E), Threatened (T), and probably Extirpated (X) plant and animal species of Michigan, and high quality natural communities occurring within the Herring Lakes Watershed. The species and community information is derived from the MNFI database. The watersheds are based on the 14-digit Hydraulic Unit Codes (HUC).

The species on this list are protected under the Endangered Species Act of the State of Michigan (i.e., Part 365 of P.A. 451, 1994 Michigan Natural Resources and Environmental Protection Act). The current list became effective on April 9, 2009, after extensive review by technical advisors to the MDNR and the citizenry of the state. Also included in this list are natural communities, and plant and animal species of special concern. While not afforded legal protection under the Act, many of these species are of concern because of declining or relict populations in the state. Should these species continue to decline, they would be recommended for T or E status. Protection of special concern species now, before they reach dangerously low population levels, would prevent the need to list them in the future by maintaining adequate numbers of self-sustaining populations within Michigan. Some other potentially rare species are listed as of special concern pending more precise information on their status in the state; when such information becomes available, they could be moved to threatened or endangered status or deleted from the list.

The listing is based on the polygon representation of the occurrences. Consequently, any single occurrence may span watershed boundaries and be listed in more than one watershed. This list is based on known and verified sightings of threatened, endangered, and special concern species and represents the most complete data set available. It should not be considered a comprehensive listing of every potential species found within a watershed. Because of the inherent difficulties in surveying for threatened, endangered, and special concern species and inconsistent of inventory effort across the state, species may be present in a watershed and not appear on this list.

This list was produced by the Endangered Species Program of the Michigan Department of Natural Resources and the Michigan Natural Features Inventory (MNFI website: http://mnfi.anr.msu.edu/data/county.cfm). Common names from published sources have been incorporated, when possible, to promote public understanding of and participation in the Endangered Species Program. To comment on the list or request additional copies, or for information on the Endangered Species Program, contact the Endangered Species Coordinator, Wildlife Division, Michigan Department of Natural Resources, P.O. Box 30028, Lansing, MI 48909 (517-373-1263). To report occurrences of these species, please contact: mnfi@msu.edu.

Source: http://mnfi.anr.msu.edu/

Table 10: Herring Lakes Watershed Rare Plant & Animal Species/ Natural Communities List

Scientific Name	*Common Name*	*Federal Status*	*State Status*
Accipiter gentilis	Northern goshawk		SC
Alasmidonta viridis	Slippershell		T
Ammodramus savannarum	Grasshopper sparrow		SC
Berula erecta	Cut-leaved water parsnip		T
Botrychium campestre	Prairie Moonwort or Dunewort		T
Buteo lineatus	Red-shouldered hawk		T
Calypso bulbosa	Calypso or fairy-slipper		T
Charadrius melodus	Piping plover	LE	E
Cirsium pitcheri	Pitcher's thistle	LT	T
Cistothorus palustris	Marsh wren		SC
Coregonus artedi	Lake herring or Cisco		T
Cypripedium arietinum	Ram's head lady's-slipper		SC
Dendroica discolor	Prairie warbler		E
Emydoidea blandingii	Blanding's turtle		SC
Gavia immer	Common loon		T
Glyptemys insculpta	Wood turtle		SC
Haliaeetus leucocephalus	Bald eagle		SC
Ixobrychus exilis	Least bittern		T
Lanius ludovicianus migrans	Migrant loggerhead shrike		E
Lepisosteus oculatus	Spotted gar		SC

Ligumia nasuta	Eastern pondmussel		E
Ligumia recta	Black sandshell		E
Microtus pinetorum	Woodland vole		SC
Mimulus michiganensis	Michigan monkey flower	LE	E
Myotis sodalist	Indiana bat		E
Mimulus michiganensis	Northern long-eared bat		T
Orobanche fasciculata			T
Panax quinquefolius	Ginseng		T
Pandion haliaetus	Osprey		SC
Physella magnalacustris	Great Lakes physa		SC
Pyganodon lacustris	Lake floater		SC
Sistrurus catenatus catenatus	Eastern massasauga	C	SC
Stenelmis douglasensis	Douglas stenelmis riffle beetle		SC
Terrapene carolina carolina	Eastern box turtle		SC
Toxolasma parvus	Lilliput		E
Trimerotropis huroniana	Lake Huron locust		T

SC = Special Concern

T= Threatened

E= Endangered

LE= Listed Endangered

C= Concern

2.8 Master Plans and Zoning Ordinances

Master Plans and Zoning Ordinances

Land use within a watershed has a significant impact on water quality and overall watershed protection. Benzie County relies on individual townships for their zoning. There is a master plan for the county; however, each township has its own zoning ordinance and individual master plan. In 2006 P.A. 110, the Michigan Zoning Enabling Act was signed into law. This act consolidates the laws regarding local units of government regulating the development and use of land. It also provides for the adoption of zoning ordinances; provides for the establishment in counties, townships, cities, and villages of zoning districts; prescribes the powers and duties of certain officials; provides for the assessment and collection of fees; authorizes the issuance of bonds and notes; and prescribes penalties and remedies. In 2008, P.A. 33, entitled Michigan Planning and Enabling Act, was signed into law. This law consolidates previous planning acts under one statute, creating a standard structure for all local planning commissions and one set of requirements that apply to the preparation of all master plans. Since protecting water quality requires looking at what happens on land, zoning is an important watershed management tool.

Zoning administrators and planning officials should recognize that water quality is directly impacted by adjacent land use with the amount of impervious surfaces being particularly important. Land use planning techniques should be applied that preserve sensitive areas, redirect development to those areas that can support it, prevent unnecessary increases in impervious surface cover (i.e., roads, driveways and parking lots), and reduce or eliminate non-point sources of pollution.

Zoning's effectiveness to protect water quality depends on many factors, such as the restrictions in the language, the enforcement, and public support. Many people assume existing laws protect sensitive areas, often only to find otherwise when development is proposed. However, with proper foresight, zoning can be used very effectively for managing land uses in a way that is compatible with watershed management goals. A wide variety of zoning and planning techniques can be used to manage land use and impervious cover in the watershed. Some of these techniques include: watershed-based zoning, overlay zoning, limiting impervious surfaces, incentive zoning, performance zoning, urban growth boundaries, large lot zoning, infill/community redevelopment, infrastructure extensions, and many more. Local officials face complex choices when deciding which land use planning techniques are the most appropriate to modify current zoning. See Table 10, adapted from the Center for Watershed

Protection's *Rapid Watershed Planning Handbook,* provides further details on land use planning techniques and their utility for watershed protection (CWP 1998). While most of these techniques are for watersheds much larger and more developed than the Herring Lakes Watershed, this handbook still presents many applicable land use planning techniques. In addition, the MDEQ has published *Filling the Gaps: Environmental Protection Options for Local Governments* that equips local officials with important information to consider when making local land use plans, adopting new environmentally focused regulations, or reviewing proposed development (see Ardizone, Wyckoff, and MCMP 2003). An overview of federal, state, and local roles in environmental protection is provided, as well as information regarding current environmental laws and regulations including wetlands, soil erosion, inland lakes and streams, natural rivers, floodplains, and more. The book also outlines regulatory options for better natural resources and environmental protection at the local level. A copy of this guidebook is available via the DEQ website: ***www.michigan.gov/deq* → *WATER* → *SURFACE WATER PROGRAMS* → *NONPOINT SOURCE POLLUTION (LOOK UNDER INFORMATION/EDUCATION HEADING; OR TYPE IN THE TITLE UNDER SEARCH).*** The development of a Herring Lakes Watershed Protection Plan was identified as a high priority in the Blaine Township Master Plan adopted in 2014.

Table 11: Land Use Planning Techniques

Land Use Planning Technique	*Description*	*Utility as a Watershed Protection Tool*
Watershed-Based Zoning	Watershed and sub-watershed boundaries are the foundation for land use planning.	As implement by a joint plan and planning commission at the watershed level, this can be used to protect receiving water quality on the sub-watershed scale.
Overlay Zoning	Superimposes additional regulations for specific development criteria within	Can require development restrictions or allow alternative site design techniques in specific areas.
Limits on Impervious Surfaces	Zoning standards that limit total impervious surfaces.	Can be used to protect receiving water quality at both the sub-watershed and site level.
Site Plan Review	Including water quality protection in all planning and zoning.	Requiring an strengthening water quality protection in site plan reviews, e.g., secondary containment, innovate storm water treatment and disposal, etc.
Incentive Zoning	Applies bonuses or incentives to encourage creation of amenities or environmental	Can be used to encourage development within a particular sub-watershed or to obtain open space in exchange for a density bonus at the site level.
Performance Zoning	Specifies a performance requirement that accompanies a zoning district.	Can be used to require additional levels of performance within a sub-watershed or at the site level.
Urban Growth Boundaries	Establishes a dividing line that defines where a growth limit is to occur and where	Can be used in conjunction with natural watershed or sub-watershed boundaries to protect specific water bodies.
Large Lot Zoning	Zones land at very low densities.	May be used to decrease impervious cover at the site or sub-watershed level, but may have an adverse impact on regional or watershed imperviousness.

Infill/ Community Redevelopment	Encourage new development and redevelopment within existing developed areas.	May be used in conjunction with watershed based zoning or other zoning tools to restrict development in sensitive areas and foster development in areas with existing infrastructure.
Transfer of Development Rights (TDRs)	Transfers potential development from a designated "sending area" to a designated "receiving area."	May be used in conjunction with innovative planned unit developments on watershed-based zoning to restrict development in sensitive areas to areas capable of accommodating increased density.
Infrastructure Extensions	Limiting new infrastructure (e.g., public sewer, water, or roads) to avoid increased development in some areas.	May be used as a temporary method to control growth in targeted areas. Can delay development until the economic or political climate changes. May also include sewer extension to lakeshore parcels.

Table adapted from Center for Watershed Protection's Rapid Watershed Planning Handbook – page 2.4-5 (CWP 2001)

Township zoning supersedes county zoning, without regard to which is more stringent. City and village zoning are not subject to township or county zoning, and local zoning is likely more stringent than state statutes, but less stringent. For certain land uses, state law supersedes local zoning, i.e., state mental health facilities, campgrounds, manufactured home parks, prisons/jails, schools, etc. In any case, all applicable state laws must be followed. Most of the townships located in the Herring Lakes Watershed have both a Master Plan and Zoning Ordinance (see Tables 11 and 12). Assisting local governments in updating and enacting strong zoning ordinances to protect water quality and secure natural areas is extremely important in the Herring Lakes Watershed and is a high priority for implementation efforts (see Chapter 8). Master plans and zoning ordinances have great potential to affect water quality. Zoning ordinances have a direct role in determining the type and density of land use allowed. They regulate permitted uses of the land, for example, setting minimum/maximum lot sizes and setback requirements (i.e., from neighbors, roads, water bodies). Overall, zoning ordinances are enacted to ensure that the use of private property does not negatively affect the public's safety, health, and welfare.

Examples of zoning to protect water quality include requiring vegetative buffer zones along bodies of water, requiring greenbelt areas, protecting the integrity of soil by having filtered views along stream corridors (i.e., protects banks from erosion), or protecting wetlands.

Networks Northwest did a review of Benzie County Master Plans in 2015 (April 2015 memo). Their findings, as they pertain to watershed planning, are summarized below.

Priority Areas

A number of clear consensus areas emerged throughout all local plans, reflecting community priorities and values:

- Scenic character was a goal and priority in 100% of local plans. Within that category, design guidelines and/or signage guidelines were heavily emphasized, with 100% of plans including goals around this issue. Open space was also a focus of scenic character, with goals/objectives around the preservation of open space included in 92% (i.e., 12 out of 13 plans) of local plans.
- The preservation and conservation of natural resources was addressed in 100% of local plans. Detailed goals and objectives around sensitive environments were found in 85% of plans.
- Water quality was included as a goal in 92% of local plans and in many cases was addressed with extensive goals and objectives. Water quality considerations ranged from watershed management (i.e., goals in 31% of plans), storm water considerations (i.e., 46%), and pollutants/erosion impacts (i.e., 39%). Several plans also addressed shoreline considerations and greenbelts in goals and objectives.

Changing Trends & Conditions

Since the Benzie County Master Plan was adopted in 2000, many trends have changed, in some cases dramatically. At the time the plan was developed, the county was growing rapidly and experiencing significant amounts of development pressure. Since the mid-2000s, however, population growth in many communities has slowed or in some cases reversed, as families left the region during the recession and residential construction ground nearly to a halt throughout the region. As such, some issues that were front and center in 2000 are no longer of paramount concern.

- ***Development pressure*** is not emphasized in local plans to the extent that it is in the county plan. Rather, the focus is on appropriately-located and designed development: 77% of plans specify that new residential development should be ***located in proximity to existing public services and facilities,*** and 100% of local plans include goals and objectives relative to ***design guidelines***.

- ***Mineral extraction***, including oil, gas, sand, and gravel, was discussed in the 2000 Benzie County Master Plan. No local plans, however, addressed mineral resources or extraction either as a planning consideration or in goals and objectives, likely due in part to limited extraction or mining activity in Benzie County in recent years.

- ***Forestry*** was also highlighted as an issue in 2000. While forest cover and impacts were addressed to some extent in local plans, fewer than half of local plans (i.e., 46%) included forestry-specific goals and objectives, particularly in relation to the issues highlighted in 2000, such as fragmentation and forest diversity.

- In 2000 agricultural goals focused on the ***preservation of agricultural lands*** and ***conflicts between agricultural land and residential development***. In 2015, ***agricultural land preservation*** is still considered a priority in many communities, with 62% of local plans addressing farmland preservation, but creating and supporting a viable agricultural economy was emphasized as a key component of that effort, with 54% of local plans also including goals around ***local and regional food systems or economies***. Only four (4) plans (i.e., 31%) identified goals relating to ***agricultural/residential conflict***.

- The goal and ideal of ***intergovernmental cooperation*** and ***coordinated planning and zoning*** are visible both in local plans and in practice. Multiple communities have partnered together to develop coordinated master plans, and, in some cases, joint master plans: Colfax Township, Weldon Township, and the Village of Thompsonville have developed a joint master plan, as have Homestead and Inland townships; Benzonia and Platte townships have created the West Benzie Joint Planning Commission; and Joyfield, Gilmore, Blaine, and Crystal Lake townships, together with the Village of Honor and communities in Manistee County, have worked together through the Lakes to Land Regional Initiative to develop a coordinated approach to planning, recreation, and zoning in their communities.

Lakes to Land Regional Initiative

The Lakes to Land Regional Initiative was completed in 2012 and 2013, and is a unique joint planning effort among the northwestern Michigan townships of Arcadia, Blaine, Crystal Lake, Gilmore, Bear Lake, Joyfield, Lake, Manistee, Onekama, and Pleasanton; the villages of Honor, Onekama, Bear Lake, and Elberta; the cities of Frankfort and Manistee; and the Little River Band of Ottawa Indians. It brought together voices from throughout the region and created a vision for the region's future. This process resulted in a series of nine master plans[3], adopted in 2014-2015, which include a detailed assessment of

[3] Master plans resulting from the effort were adopted in Crystal Lake Township, Blaine Township, Arcadia Township, Gilmore Township, Joyfield Township, Pleasanton Township, the Village of Honor, and the Village of Bear Lake.

the community, coming to consensus on a shared vision, and translating this vision into policy and action statements.

The communities have now begun collaborating on a clear set of strategies for achieving that vision, erasing municipal boundaries to view the region as a whole. Two zoning templates have been written to address common regional themes. A Food and Farm System Assessment was undertaken to provide a comprehensive understanding of the substantial agricultural outputs of the region. The Arcadia-Pierport Watershed Committee has formed to protect the water quality that emerged as a priority in nearly all of the visioning sessions. Each of these efforts grew from a wider understanding of the common challenges and opportunities experienced by participating communities, and has been fueled and supported by the relationships developed over the course of over two years of intense planning work.

2000 Benzie County Master Plan Goals[4]

Based on the extent to which the goals, objectives, and priorities found in local plans addressed issues and policies of the 2000 County Master Plan, the master plan review process determined that local plans are consistent with, and in many cases implement, overall County Master Plan goals or policies, which are as follows:

1. Scenic character should be preserved or enhanced wherever feasible in the County.
2. Natural resources in the County should be protected from inappropriate use or conversion.
3. The pristine natural environment of the County should be protected from degradation.
4. An economy built on renewable natural resources is sustainable and should continue to be the principal economic base for the future.

[4] Benzie County has held a final public hearing on a 2017 Master Plan, but it had not been adopted at the time of this report writing.

Table 12: Master Plan and Zoning Ordinance Status Summary for Local Governments in Watershed

County	*Township*	*Master Plan*	*Zoning*
Benzie County		Y (2000), Updated in 2015	N (by Township)
	Blaine	Y, 6-2014	Y, 10-2012
	Gilmore	Y, 5-2014	Y, 4-2010
	Joyfield	Y, 7-2014	NA
Manistee County			
	Arcadia	Under Development	Amended 2010
	Pleasanton	Under Development	Adopted March 12, 1991, Revised November 11, 2003

Benzie County Soil, Erosion, Sedimentation, and Storm Water Control Ordinance

Benzie County has a Soil, Erosion, Sedimentation and Storm Water Control Ordinance that was adopted in 2002 and amended/approved in 2005. The purpose is to prevent the pollution, impairment or destruction of a natural resource or the public trust in Benzie County. There are fifteen (15) specific objectives outlined in the ordinance which are designed to protect surface and ground water quality, to promote adequate design of systems and prevent storm water runoff resulting from earth movement. The Benzie County Building Codes Department is responsible for enforcing the ordinance. There is a permit and approval process and information the landowner is responsible for such as if they have an environmentally sensitive site. A full copy of the ordinance can be found on the Benzie County website: http://www.benzieco.net/document_center/Building/Soil_Erosion_Ordinance.pdf

Table 13: Herring Lakes Watershed 2015 Master Plan Assessments

MASTER PLAN ASSESSMENT										
Unit of government	***Plan Reviewed ("NA" indicates no plan) and "NP" indicates plan not provided by project deadline)***	***Master Plan Goals/ Narrative Address:***								
		Maintain/ Promote Community Character	**Land use limitations for environ-mental constraints**	**Protect Shore-line/ Herring Lakes**	**Protect Wetlands**	**Preserve and protect Streams/ Surface Water/ Groundwater**	**Soil erosion/ Storm water Measures**	**Protect Dunes/ Hills/ Slopes**	**Protect Forests/ Agriculture/ Open Space**
Benzie County	X	X	X	X	X	X	X	X	X
Blaine Twp	X	X	X	X	X	X	X	X	X
Gilmore Twp	X				X	X			X
Joyfield Twp	X					X			X
Manistee County	Limited geographic extent, not reviewed								
Arcadia Twp	Limited geographic extent, not reviewed								
Pleasanton Twp	Limited geographic extent, not reviewed								

Table 14: Herring Lakes Watershed 2015 Zoning Ordinance Assessments

	ZONING ORDINANCE ASSESSMENT								
Unit of government	***Ordinance Reviewed ("NA" =no plan and "NP"= plan not provided)***	***Ordinance Regulations Include:***							
		Special Districts for Environ-mentally Sensitive Areas	**Approval or Permits for Environ-mentally Sensitive Areas or Uses**	**Require-ments for Shore-line/ Riparian Areas**	**Require-ments for unreg-ulated Wetland Areas**	**Provisions to Protect Streams/ Surface Water/ Ground water**	**Soil Erosion/ Storm water Prov-isions**	**Sewer/ Water Prov-isions**	**Open Space Require-ments**
Benzie County	No Zoning	---	---	---	---	---	---	---	---
Blaine Twp	X	X	X			X		X	X
Gilmore Twp	X			X		X		X	X
Joyfield Twp	X								
Manistee County	Limited geographic extent, not reviewed								
Arcadia Twp	Limited geographic extent, not reviewed								
Pleasanton Twp	Limited geographic extent, not reviewed								

Specific water quality protection provisions in watershed township zoning ordinances include:

- Blaine and Gilmore townships requires the retention of shoreline vegetation, especially trees; stormwater standards; limitations on earth fill and grading; proper handling and storage of hazardous substances; requires environmental impact assessment and review for Special Land Uses; viewshed protection; limitations on flood plain development; prohibitions on nuisance noise; and exterior lighting regulations to protect the dark night sky.
- Joyfield Township has provisions protecting wetlands, steep slopes/viewsheds, conserved lands, migratory birds and endangered species; prohibitions on nuisance noise; requirements of the environmental impact assessments of special land uses; and exterior lighting regulations to protect the dark night sky.

2.9 Fisheries

Herring Lakes Watershed has a long history of sport fishing by local residents and vacationing tourists. Early management reports from the Michigan Department of Conservation, Institute for Research (now Division of the Michigan Department of Natural Resources) indicated that landowners on both lakes reported good pan fish, walleye and bass fishing back in the 1930s, '40s and early '50s. Stocking records date back to 1929 for Upper Herring Lake and 1938 for Lower Herring Lake. The Department focused on stocking bluegill, walleye, largemouth bass, smallmouth bass, and occasionally perch until the mid '40s. Upper Herring Lake is much shallower and more eutrophic than Lower Herring Lake and therefore supports a more robust pan fish (i.e., bluegill, black crappie, rock bass, pumpkinseed sunfish) and largemouth bass population.

In 1955 the Department of Conservation conducted an extensive survey of both lakes. The study determined that Upper Herring Lake populations were stable and growing at statewide averages for most desirable species; however, bluegill and largemouth bass were not as abundant as expected. Lower Herring Lake was found to have a high species diversity, but low numbers of desirable sport fish. Walleye in particular were found in much lower numbers than desired. At that time management agencies were having little success with sustaining walleye by planting spring fry. The study did note that the water control structure located at the outflow of Lower Herring Lake was known by locals to block migrations of walleye to and from Lake Michigan. Lower Herring Lake has always enjoyed a very diverse fish population due to its connectivity with Lake Michigan. Walleye, smelt, northern pike, yellow perch, suckers, cisco, rainbow trout and salmon (i.e., since the 1960s) have all been documented to migrate between the lakes, thereby augmenting the resident lake populations and fishing opportunities. The extent of fish movement between Upper and Lower Herring lakes is not well known, however rainbow trout (i.e., steelhead) and Coho salmon have been documented spawning in Herring Creek above Upper Herring Lake, so at least some movement does occur with these species.

Despite periodic letters to State managers and public officials from landowners along Lower Herring Lake that reported a steady decline in sport fishing success from the mid '50s through the 1960s, management efforts were unable to implement a satisfactory response. The Department attempted to create a brown trout fishery in Lower Herring Lake for a few years in the middle 1960s, only to abandon the program in 1967 after finding poor returns. In 1963 the state constructed a fishing access site and boat launch on Lower Herring Lake and the following year on Upper Herring Lake.

Starting in the 1960s the focus of local residents and management shifted to the emerging alewife population in Lake Michigan and subsequent stocking of Pacific salmon in attempt to control the ballooning alewife numbers. The Lower Herring Lake Association was very active in communicating this issue with the Department of Conservation starting in 1965 and continuing for many years. The Association was particularly concerned about potential alewife introduction into Lower Herring Lake from Lake Michigan along with the blockage of spring walleye migrations into the lake. Many members felt that blockage of walleye spawning migrations into Lower Herring Lake was the primary cause for reduced angler success as compared to what they experienced in the 1930s and '40s. The Association asked the Department to investigate the potential of installing a fish ladder or similar passage structure in the outlet dam. Ultimately, by 1970 managers determined that the potential harm from alewife introduction outweighed the potential benefit of improving the walleye fishery and discontinued any efforts to design a fish passage structure.

A 1975 survey of Upper Herring Lake found a well-balanced warm water fish population with no management recommendations required. The 1973 survey of Lower Herring Lake once again found much lower numbers of desirable species (i.e., walleye, perch, bluegill, smallmouth bass, northern pike) and high populations of rough fish (i.e., suckers, carp, chubs). In 1986 both lakes were surveyed again with a focus on determining the status of the walleye populations. Upper Herring Lake was found to have a fair number of walleye, but few fish in the larger size classes. Lower Herring Lake was found to have a fair population as well, however very few of the younger year classes were present, with mostly older, larger fish. A fall-fingerling stocking program was implemented on Upper Herring Lake in 1987 and Lower Herring Lake in 1990. Both lakes have been restocked every 1-3 years since that time. Management has had greatly improved success with management of inland walleye since switching to stocking fall fingerlings instead of spring fry. Herring Lakes Watershed is a prime example of this strategy paying out. Recent surveys (i.e., 2015) found good walleye populations in both lakes. In addition, managers have found young-of-the-year walleye from years where no walleye were stocked indicating successful natural reproduction is occurring. In addition, angler success has been reported to be quite high with many satisfied local and visiting anglers. The 2015 surveys found populations of other desirable sport fish were also doing well with average size distributions.

2.10 Human History[5]

Lumber, farming, summer resorts and logging railroads were a defining influence on the Herring Lakes Watershed – the small settlements grew as they were nourished by the economic lifeblood around sawmills, train stops, and resort areas. As the fortunes of these enterprises went up or down, so did the fate of a few of the settlements.

Descriptions of two “ghost towns” in Benzie County date back to the year 1877. Gilmore was settled in 1890 and was located in Blaine Township on the shore of Lake Michigan, 12 miles southwest of Benzonia. The community shipped logs and wood products, provided a stage to Frankfort and Pier Port three times weekly, and boasted a post office and general store. A post office in Joyfield Township was described as “located on a fruit belt, mail by stage four times weekly. Amazia Joy, was the postmaster and pastor of the Baptist Church.”

Numerous narrow gauge railways were constructed in the region to carry logs to shoreline piers on Lake Michigan. Regional timber products were reportedly extensively shipped to rebuild Chicago in the wake of its tragic 1891 fire. Lumbering took most of the white pine, maple, ash, oak, elm, basswood, hemlock and beech trees in the area, and the small settlements were mostly abandoned by 1910. In addition to timber, farm products including potatoes, butter and sugar were also shipped from area farms, and stage travel included routes to Manistee, Benzonia and Traverse City. Phone service made its

[5] Sources: Glarum, Sivert N. 1983. *Our Land and Lakes. Michigan, Benzie County, Lower Herring Lakes.* West Graf, J.B. Publications, Manistee, Michigan; Wolin, J. 1996. “Late Holocene lake-level and lake development signals in Lower Herring Lake, Michigan.” *Journal of Paleolimnology,* Vol. 15, pp. 19-45; and *Lower Herring Lake Ecological Assessment*, Mark R. Luttenton, PhD, December 1, 2009)

way along the Arcadia and Betsie River Railway in 1917, “connecting” the area by phone to far flung population centers.

Blaine Township

Blaine Township was founded in 1851 at the location of the Loyed & Thomas sawmill near Lower Herring Lake. Tragedy struck the Loyed & Thomas mill in 1862, however, when extraordinarily high water levels undermined a dam at Lower Herring Lake’s outlet at Lake Michigan, draining the lake by three feet across Herring Creek and rendering the mill unusable. Blaine Township continued to grow despite this mishap, and was officially organized in 1867, including the area that is today Gilmore Township. A substantial commercial fishery was established by John Babinaw about one-half mile south of Lower Herring Lake, shipping thousands of tons of whitefish, herring and lake trout on lake ice to Chicago and Milwaukee.

Joyfield Township

Township namesake Rev. Amariah Joy, a Baptist minister from Putney, Vermont filed Benzie County’s first homestead claim in Joyfield Township on July 11, 1863 consisting of 160 acres. Rev. Joy quickly encountered the realities of the area, which was little populated and relatively inaccessible with few roads. Rev. Joy went on to become the first postmaster and township supervisor. He was succeeded by his son and one year later by Charles H. Palmer, a New York teacher who had travelled to Ecuador and California before enlisting into service of the Union during the Civil War. After the Civil War Palmer establish his homestead by a claim in November 1866, and resumed his teaching post while clearing his land for agriculture. Eventually the Palmer Farm consisted of 30 acres in production, including 1,500 fruit trees and specialty nuts.

Major ecological impacts to the Herring Lakes began in 1845 with the deforestation of the watershed from logging operations and significant amounts of sediment being washed from these deforested lands into Upper and Lower Herring lakes and connecting waterways (see Glarum 1983). Due to the significant amount of logging waste left in the forest, the entire Herring Lakes basin experienced a major fire in 1867. Since World War II, cottages and single-family homes have been established on both lakes, and the Watervale Resort community has been in operation on Lower Herring Lake since approximately 1900.

Watervale Resort[6]

The Leo Hale lumber company built the lumber town of Watervale in 1892. With a railroad that ran from Upper Herring to the great pier on Lake Michigan, the town ran as a lumber mill for just a few years until the company was bankrupted in the Panic of 1893 and the town was abandoned. Dr. Oscar Kraft purchased Watervale in 1917 as a gathering spot for his extended family. This gathering spot evolved into a summer resort with guest registers dating from 1918. Dr. Kraft's niece, Vera and her husband Vernon Noble, purchased Watervale in 1960 and owned it until her death in 2005. Vera and Vernon's three children now own Watervale and continue the tradition of bringing families together to this idyllic place on earth.

Watervale Inn, circa 1925.

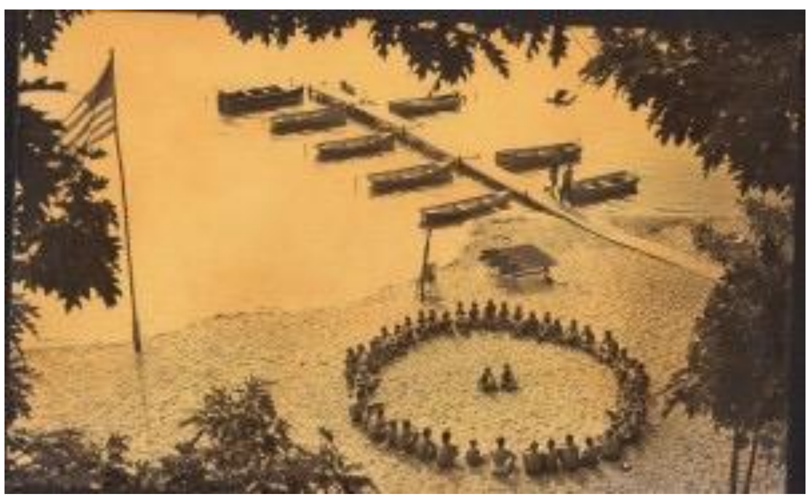
[6] Adapted from the Watervale Inn website, watervaleinn.com.

Playing on the Pilings, Watervale Inn.

Camp Lookout[7]

According to Glarum, the site where Camp Lookout presently exists had its beginnings in 1917 when the land was purchased from the Stubbs family by the Christ's Church of Winnetka, Illinois. "The choir director of the church, Ellis Chase," writes Glarum," had spent summers in the area and convinced officials of the church to establish a camp at that location where he could bring his choir boys for summer vacations to reward them for their efforts and where he could continue their training through the summer."

[7] Adapted from the Camp Lookout website, lookoutsummer.com.



1950s campers gathered on the Lower Herring beachfront
before the outlet dam was built.

According to Glarum, "(e)very evening during the camping period, weather permitting, the boys would gather on the shore of the lake and sing. The voices coming across the water were a great treat for the people around the lake."

A view up the "Steps of Woe"

According to Benzie County records, the operation of the camp by the church ended following the stock market crash of the 1929, and the property was sold to Verne Handley and Roy E. Robinson in 1934. The new owners operated it as a private summer camp for boys, called Camp Lookout. Robinson sold his interest to Handley who continued operation through 1954. From 1955 to 1961 the camp was operated by Byron and Winifred Neidhamer, and then by Arthur and Marian Davis during the years 1962 to1976.

View from the top of Old Baldy

In 1976 Elizabeth Howard purchased the camp and opened it as Camp Marameg for Girls. Ms. Howard ran Camp Marameg until 1990 when Dave Reid, Kathi Houston and Fred Oeflein purchased the property, and Dave Reid and Kathi Houston re-opened Camp Lookout as a camp for both boys and girls. Dave and Kathi successfully ran both Camp Lookout and Crystalaire Camp simultaneously until

Crystalaire Camp closed in 2007. Camp Lookout still has strong ties and deeply planted roots with many Crystalaire Camp families.

2.11 Economy, Tourism, and Recreation

The Herring Lakes Watershed has a tourism and agricultural based economy with the majority of businesses being associated with service industries associated with the tourism infrastructure. The lack of industrial activity or intense commercial development has helped to sustain high water quality and beautiful natural resources along the Lake Michigan lakeshore, which are significant components of the draw for the areas tourism. Both Upper and Lower Herring lakes were popular destinations for early vacationers with cottages and resorts that catered to fisherman and provided popular retreats for summer vacationers in the area. Since the turn of the century Lower Herring Lake has been steadily developed with shoreline cottages along much of the lakeshore, while Upper Herring has been buffered along the western shore by wetlands that have prevented residential development along most of that shoreline. The lack of intense shoreline development has helped to maintain a strong inland fishery which has been a significant part of the tourism and recreation draw for both lakes over the past century.

Additional recreation opportunities have been created by the Grand Traverse Regional Land Conservancy with the acquisition of Arcadia Dunes: C.S. Mott Nature Preserve, which offers several miles of hiking and mountain biking trails in addition to hunting. Nearly $7.5 million dollars were raised by the local community to ensure the GTRLC purchase of the Acadia Dunes Preserve. The mountain biking trails in particular draw riders from all across Northwest Lower Michigan and beyond. The watershed's unspoiled natural resources have continued to draw visitors and attract residents for over 100 years.

CHAPTER 3: INVENTORIES CONDUCTED IN THE HERRING LAKES WATERSHED

3.1 Upper and Lower Herring Lake Shoreline Survey[8]

A shoreline survey was conducted on both Upper and Lower Herring lakes during the late summer and fall of 2015. The survey evaluated shoreline conditions at 191 properties (i.e., 82 on Upper Herring Lake, and 109 on Lower Herring Lake). All properties were surveyed with data recorded on survey sheets, including GPS readings and photos taken. The data gathered included assessments and scoring of the following criteria: water frontage, shoreline development, shoreline condition, shoreline access, structures, slope, erosion, vegetative cover, turf (grass) cover, green belt length and depth, vertical structure (ground cover, shrubs, trees), density of vegetation, and species diversity.

The purpose of the survey was to evaluate the current condition of the existing shoreline and to establish a baseline of shoreline conditions for future evaluations. Therefore, this shoreline greenbelt survey will serve as a baseline of information in determining recommendations and actions as part of water quality protection planning. Other watershed plans have established that major threats to high water quality are sediment deposition to the near shore lake environment from upland erosion, nutrient runoff from upland fertilizer use, direct storm water runoff, and improperly functioning or obsolete septic effluent treatment systems.

Upper Herring Lake Shoreline Survey Summary

A slight majority of shoreline properties on Upper Herring Lake were assessed and recorded as being "developed" (i.e., 55%), while 46% were considered to be primarily "undeveloped." Properties were given a score for each category. The total score for the Shoreline Survey for Upper Herring Lake properties ranged from 24 to -4. Scores were broken up into categories (i.e., "Very High" to "Very Low"). Very high scores were the highest scoring properties and very low were the lowest scoring with

[8] Project Team members Bill Henning and Dave Long completed the shoreline surveys of both lakes in the summer and fall of 2015. Copies of raw data sheets are available from the Benzie Conservation District if desired for review.

some scores in the negative. The majority of properties around Upper Herring Lake scored in the medium to high category with total scores of 33% developed and 37% highly developed, respectively, and 19.6% and 13.7% of the properties scored low and very low development status (Figure 16). The scores reflect overall shoreline health. The lower the score, the more best management practices would be needed to address the shoreline health.

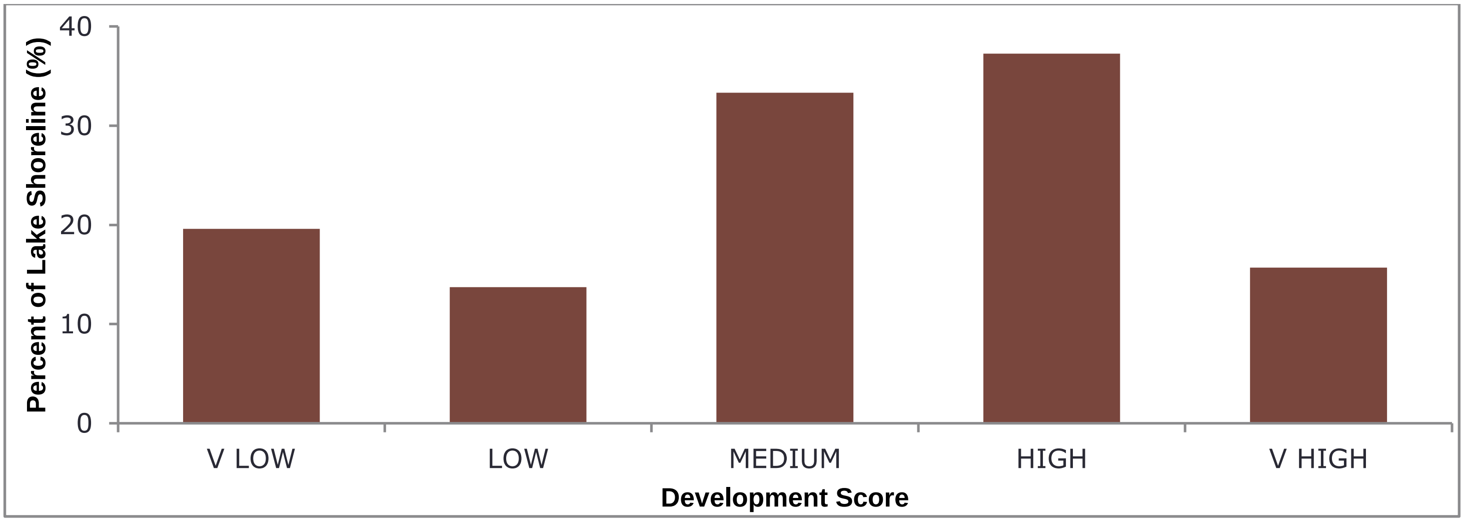


Figure 16: Upper Herring Lake Shoreline Parcel Development Score (%)

The Upper Lake shoreline survey also showed that 43% of shoreline properties have less than 100 feet of lake frontage, and 16.7 % of Upper Herring Lake shoreline parcels have over 500 feet of lake frontage. The Upper Herring Lake shoreline was also assessed and recorded as "grassy," "sandy" or "steep slopes." The majority of the properties were described as having steep slopes, ranging from very steep to gentle to flat. 62% of the properties were considered to be very steep and only 14% considered to be flat.

On Upper Herring lake properties either had no lawn - just under 50% of Upper Herring Lake shoreline properties lack a lawn or turf (49%), but approximately 34% are mostly more covered with lawn or turf >75% (Figure 17). 18% of Upper Herring Lake shoreline properties were evaluated as possessing vegetative "groundcover," "over story," and "understory" plants. 36% of Upper Herring Lakes shoreline properties possessed over story vegetation only, and 26% possessed just groundcover. Only 3% of these shoreline properties showed "no vertical plant structure," and 16% possessed only vegetative "understory" (i.e., a shrub layer). The density of vegetation was recorded mostly as "medium" to "dense" (i.e., 37% and 46%, respectively). Only a few Upper Herring Lake shoreline properties scored "sparse" vegetation or "no vegetation" (i.e., 11% and 4% respectively).

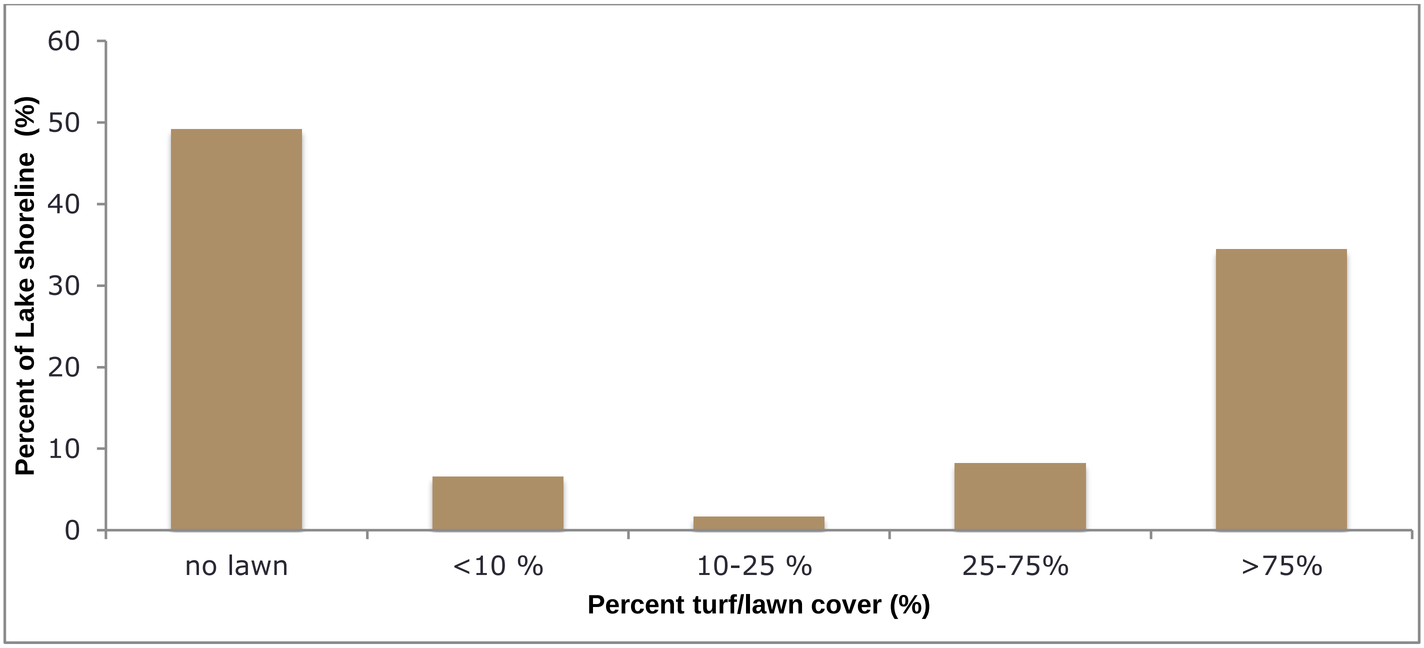


Figure 17: Upper Herring Lake Shoreline Survey - % turf (or lawn) cover

Nearly 70% of Upper Herring Lakes shoreline properties possessed a vegetative greenbelt along the majority of their shorelines (i.e., 68.5%), and 24% possessed no shoreline vegetative greenbelt. 49% of Upper Herring Lakes properties possessed a shoreline vegetative greenbelt with a depth of more than 40 feet.

Almost 50% of Upper Herring Lake shoreline properties lacked any emergent aquatic vegetation (i.e., 49%), while 13% showed more than 75% shoreline bottomland in emergent vegetation cover. 30% of Upper Herring Lake shoreline properties showed more than 25% submerged vegetation shoreline bottomland cover. The predominant emergent aquatic plants species observed included: cattails, yellow water lily, bulrushes Northern water-milfoil, Chara, American pondweed, large leaf pond weed, purple loosestrife, wild celery, clasping leaf pondweed, flat stem pond weed, sago pondweed, and spatter dock.

Upper Herring Lake Shoreline Survey Summary

Upper Herring Lake is almost 50% undeveloped, but the majority of the lakefront properties are developed. The lake has a significant vegetative greenbelt cover along the shoreline of lake front properties with a variety of vegetation cover. However, the Upper Herring Lake shoreline is steep in many areas, and shoreline soil erosion and sedimentation into nearshore environment is a threat. The results of the Upper Herring

Lake 2015 shoreline survey show areas where concern exists for the lack of vegetative greenbelt coverage and the potential for erosion and sedimentation. This is therefore a topic that lends itself to potential improvement through outreach to and education of lakefront property owners, as identified as a task in this plan.

Below are some photos of the shoreline along Upper Herring Lake.

Example of natural shoreline

Example of retaining wall

Example of native plant vegetative buffer with dock

Example of mixed shoreline (natural and grass)

Lower Herring Lake Shoreline Survey

The Lower Herring Lake shoreline is relatively evenly divided between "developed" (i.e., 51%) and "undeveloped" (i.e., 49%) parcels. Lower Herring Lake shoreline parcel assessment scores ranged from 19 to -2, and was divided into categories ranging from "High" to "Very Low." The majority of properties around scored in the medium category (i.e., 52%), but 23% and 20% of the properties scored low and very low (see Figure 18). The scores reflect overall shoreline health. The lower the score, the more best management practices would be needed to address the shoreline health.

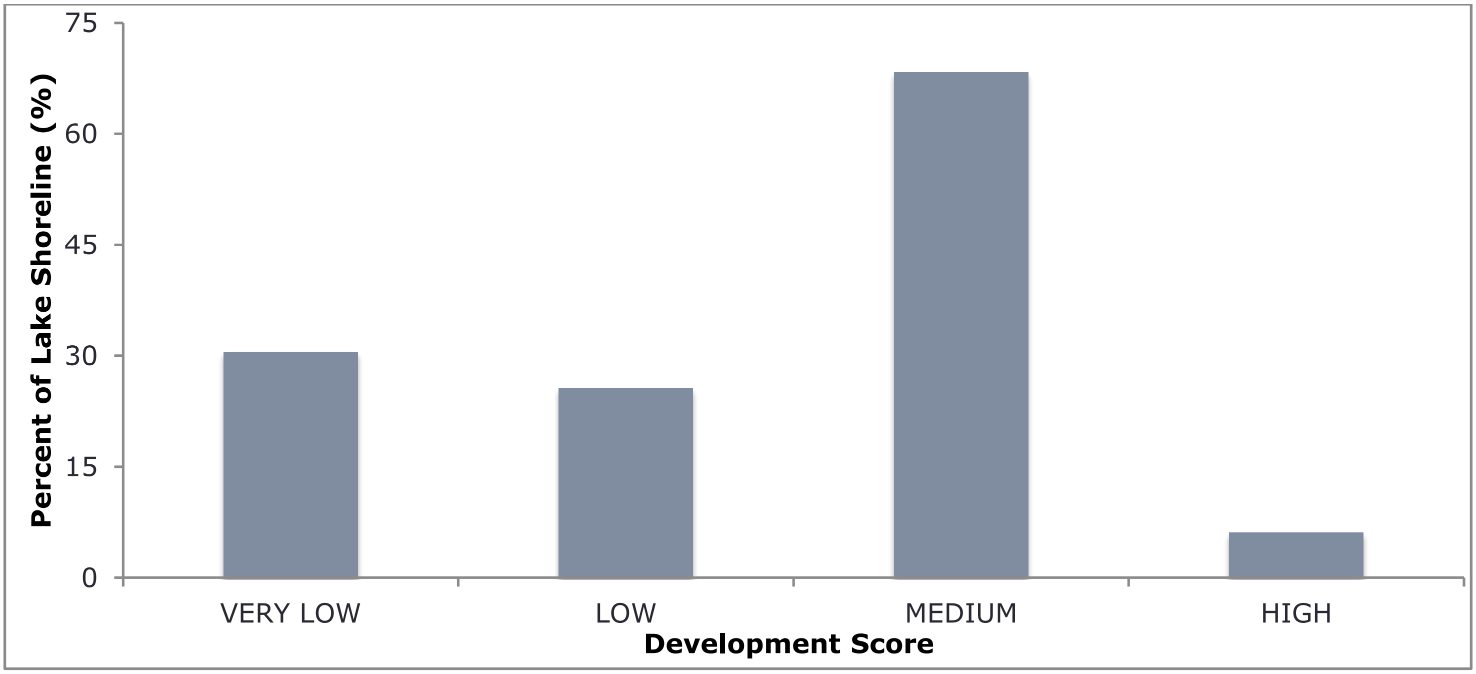


Figure 18: Lower Herring Lake Shoreline Parcel Development Score

The Lower Herring Lakes shoreline survey also showed that over one-half (i.e., 59%) of the parcels have less than 100 feet of lake frontage, and merely 8% have more than 300 feet of lake frontage. The Lower Herring Lake shoreline was also assessed and recorded as "grassy," "sandy" or "steep slopes." The majority of the properties were described as having sandy shorelines, and ranging from very steep to gentle to flat. 24% of these properties were considered to be "very steep (i.e., slopes >25%)," 25% of the properties were considered to be "steep (i.e., slopes 18-25%," and 46% of Lower Herring Lake shoreline properties were considered to be "gently sloping (i.e., slopes <18 %)." Many of the steep to very steeply sloping parcels were relatively flat along the shoreline but rise significantly landward of the lakeshore. 54% of Lower Herring Lake shoreline parcels lack any turf or lawn (54%), but approximately 25% have shorelines predominantly in lawn or turf. 54% of Lower Herring Lake shoreline parcels possess ground cover, and 13% have a mix of over story, understory and ground cover. The density of vegetation was mostly “medium” to “dense” (i.e., 30% and 45%, respectively) with only a few properties scoring “sparse” or with “no vegetation” (i.e., 16% and 10%, respectively) (see Figure 19).

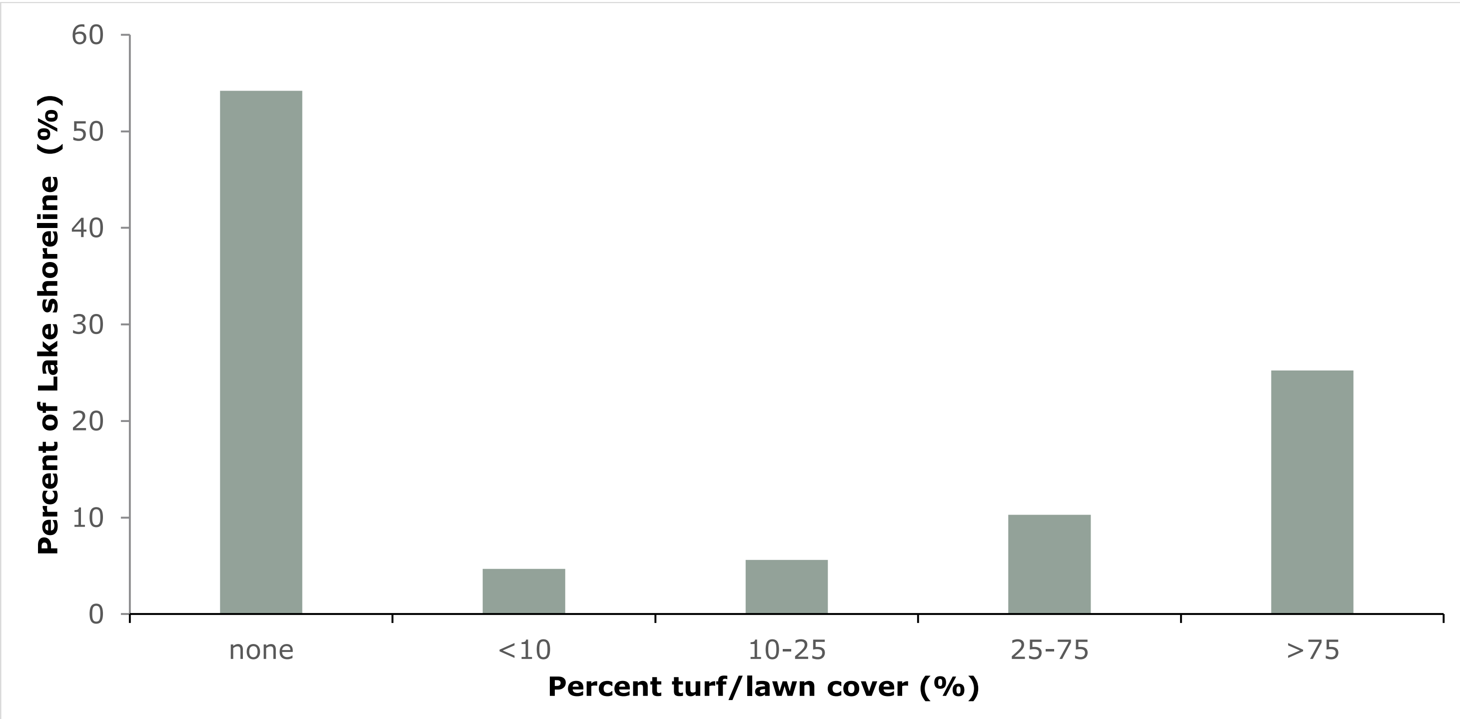
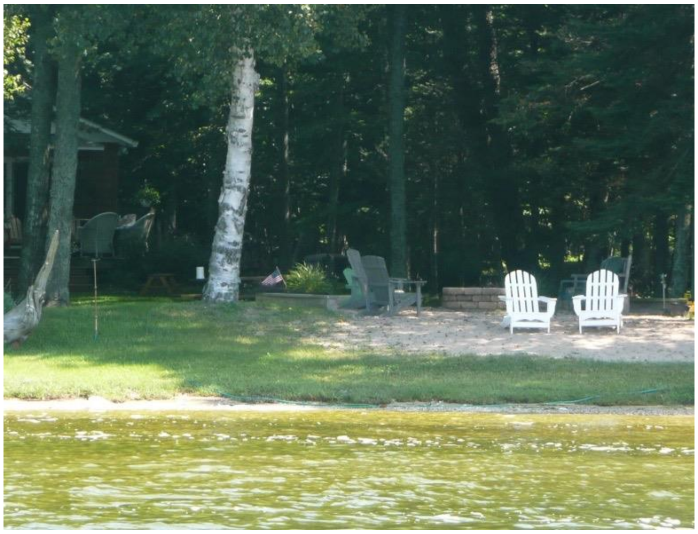


Figure 19: Lower Herring Lake Shoreline Survey - % turf/lawn cover

56% of Lower Herring Lake shoreline parcels possess a greenbelt along the majority of their shorelines, however 26% of Lower Herring Lake shoreline parcels do not possess a shoreline vegetated greenbelt. 35.5% of Lower Herring Lake shoreline properties possess a shoreline vegetative greenbelt with a depth greater than 40 feet.

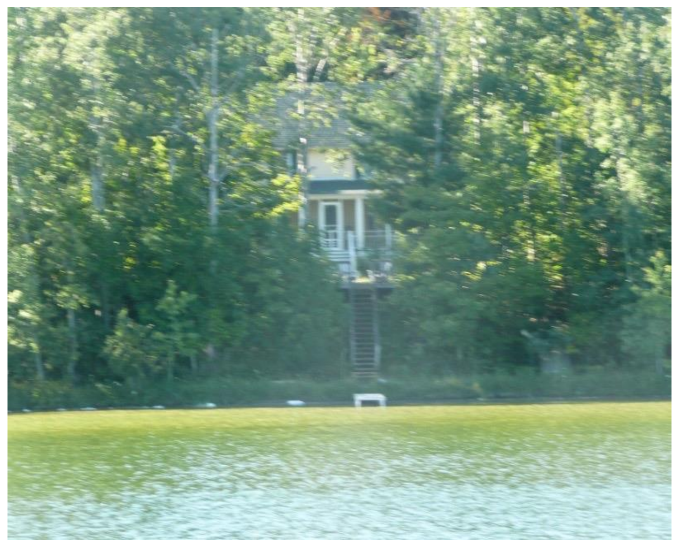
58% of Lower Herring Lake shoreline properties do not possess any nearshore emergent vegetation cover, or 42% of these properties do possess emergent vegetation cover. Predominant submerged aquatic vegetation along Lower Herring Lake’s shorelines include: cattails, yellow water lily, bulrushes, Northern water-milfoil, Chara, American pondweed, large leaf pond weed, loosestrife, wild celery, clasping leaf pondweed, flat stem pond weed, sago pondweed, and spatter dock.

Following are some photos of Lower Herring Lake shoreline.



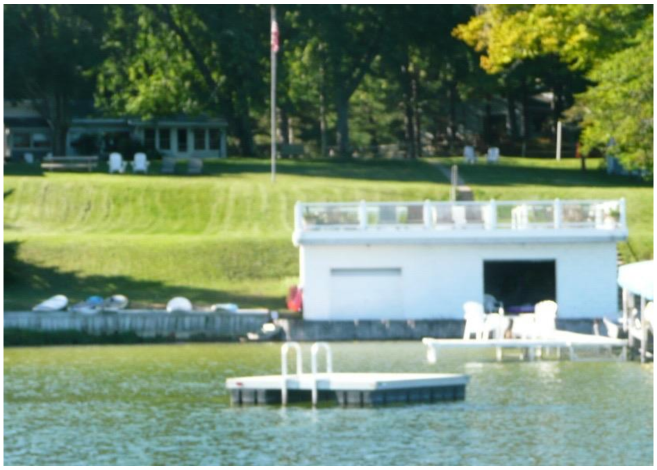
Northeast shore, sand added, grass almost to shoreline

Northeast shore, partially develop lot



West shore undeveloped land steep slope

East shore, developed lot, steep slope to shoreline with stairs



Watervale area with boat house and grass up to sea wall

Lower Herring Lake Shoreline Survey Summary

A slight majority of shoreline parcels on Lower Herring Lake are developed (i.e., 51%). Lower Herring Lake parcels possess a significant amount of vegetated shoreline greenbelts with a variety of vegetation cover. However, the shoreline of Lower Herring Lake was evaluated as "steep," and there are a significant number of sandy shorelines. Erosion seems to be less of a concern on Lower Herring Lake, with only minor to moderate erosion noticed. The results of the shoreline survey show areas where there are concerns over greenbelt coverage and the potential for erosion and nearshore deposition. As stated above and as identified as a task in this plan, this is a topic that lends itself to potential improvement through outreach to and education of lakefront property owners.

3.2 Upper Herring Lake Macrophyte Survey[9]

A macrophyte survey of Upper Herring Lake was conducted in the summer of 2012, 2013 and 2015 in an effort to identify potential aquatic invasive plants. The survey sampled seven known weed bed locations around the lake (see Figure 20). At each site the surveyors dragged a sampling rake through macrophyte beds and collected the attached plant material for identification. Plants were identified to species and recorded by their common names. Northern milfoil was the only species present at all sampling locations. The sites located near the Herring Creek outlet contained the highest species diversity in 2015,

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[9] Project team members Bill Henning and Dave Long completed the macrophyte survey of both lakes in the summer and fall of 2015. Copies of raw data sheets are available from the Benzie Conservation District if desired for review.

with eleven (11) species being recorded. These species included yellow water lily, Northern water-milfoil, Chara, American pondweed, large leaf pond weed, loosestrife, wild celery, clasping leaf pondweed, flat stem pond weed, sago pondweed, and spatter dock. All of the identified samples were native species.

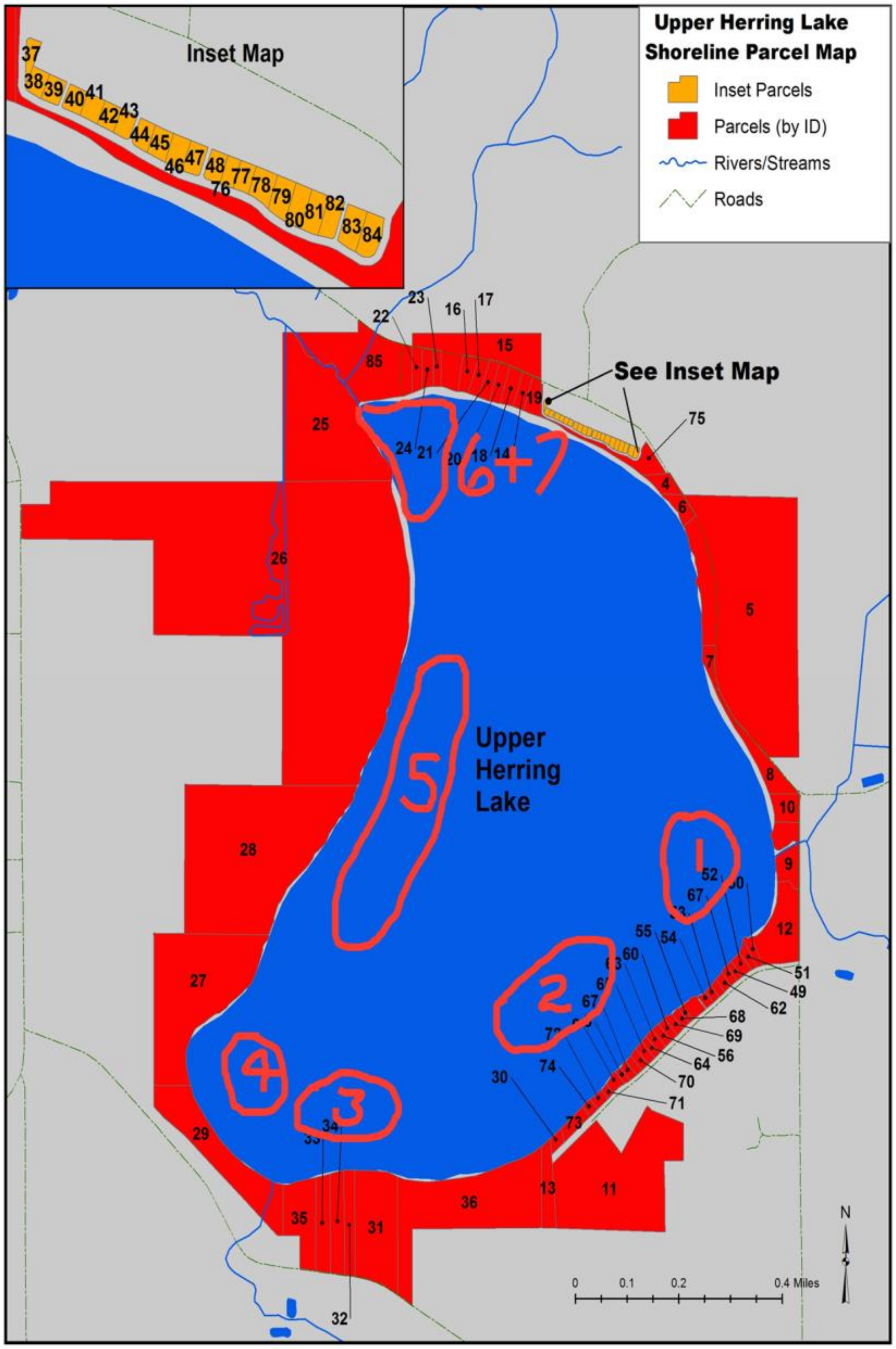

Figure 20: Upper Herring Lake Macrophyte Sampling Locations

3.3 Herring Lake Watershed Road and Stream Crossing Survey[10]

A road/stream crossing survey of the Herring Lakes Watershed was conducted over five separate sampling dates from December 11, 2015 to July 18, 2016. The survey documented the condition of 26 separate crossing sites throughout the entire watershed (see Figure 21). The survey identified three (3) new sites and ten (10) priority crossing sites, i.e., with active erosion and sedimentation to tributaries, that should be considered for future restoration efforts. All of the priority sites also suffer from perched culverts on the downstream side. Fish passage is the main impact identified at each site with mild or moderate erosion being listed at a handful of these locations. Only one site, an unnamed stream crossing Putney Rd. (i.e., HRS-23), was identified to have severe erosion in addition to a perched culvert. The surveyors determined that cattle walking along and in the stream corridor were causing the significant erosion issues observed at this site.

[10] Project team members John Ransom and Christopher Grobbel completed the road stream crossing inventory and rated them as active or inactive sources of sedimentation to waterways. Copies of raw data sheets are available from the Benzie Conservation District if desired for review.

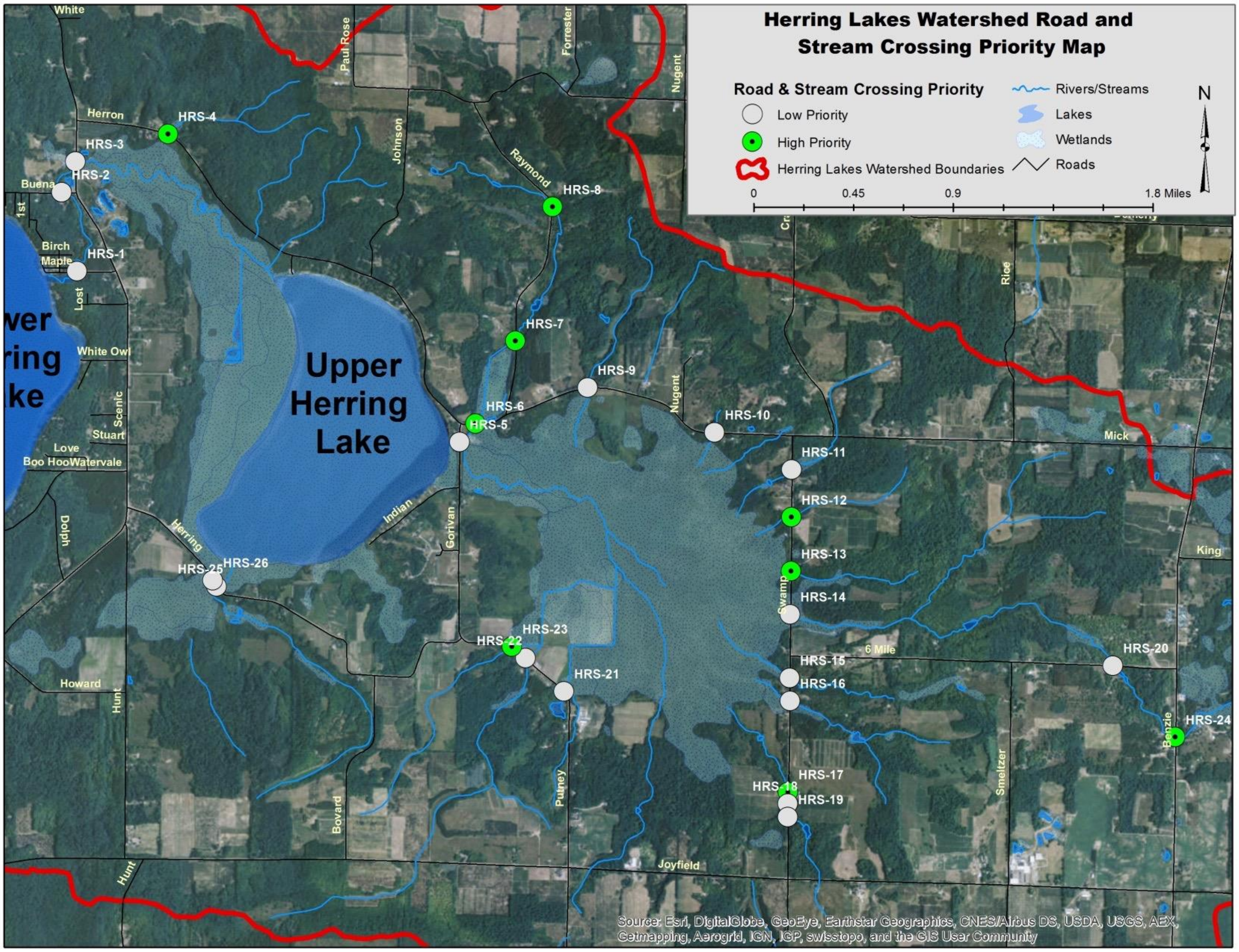

Figure 21: Road and Stream Crossing Inventory locations

3.4 Herring Lake Watershed Dam and impoundment Inventory[11]

A dam/impoundment inventory was conducted in the summer of 2016. Twelve (12) of the thirteen (13) sites were visited. The primary concerns with impoundments include the warming of tributaries and barriers to fish passage. The locations are shown on the Figure 22 on the next page, and site details and notes are included in Table 15 below.

Table 15: Dam Inventory Site Information

Site #	Longitude	Latitude	Size m^2	Comments
1	-86.220754603	44.560456170		At outlet dam
2	-86.170607391	44.559672268		At Gorivan Rd crossing
3	-86.161114039	44.542786704	8,664	Charolette's pond just upstream of WS6 - Charlotte Putney property
4	-86.133446498	44.540244843	3,182	Kim House Property - South Branch Herring Creek
5	-86.123258856	44.548063085	3,850	Smeltzer property - on North Branch Herring Creek
6	-86.138754287	44.533823687	2,716	Mead Property - just upstream of southern most Swamp Road stream crossing
7	-86.154198862	44.535461888		Unchecked - likely impoundment on Putney property
8	-86.163113498	44.569027349	2,790	Loy Putney property - upstream of Raymond Road crossing
9	-86.167163037	44.561356657		No connection to Herring Creek

[11] Project team member John Ransom completed the dam and impoundment inventory during the summer of 2016. Copies of raw data sheets are available from the Benzie Conservation District if desired for review.

10	-86.173190692	44.577525432		Middle impoundment in a series of three on this stretch of creek including upstream @ 44.578131, -86.174326 and downstream @ 44.576545, -86.167127
11	-86.190557710	44.568575057		No flow at the outlet on 10/13/2015 - access from GTRLC preserve trail
12	-86.103226765	44.541826174		Two impoundments just upstream of the US31 crossing on the North Branch Herring Creek
13	-86.110173125	44.544854255	686	Just south of the six mile road crossing on the North Branch of Herring Creek

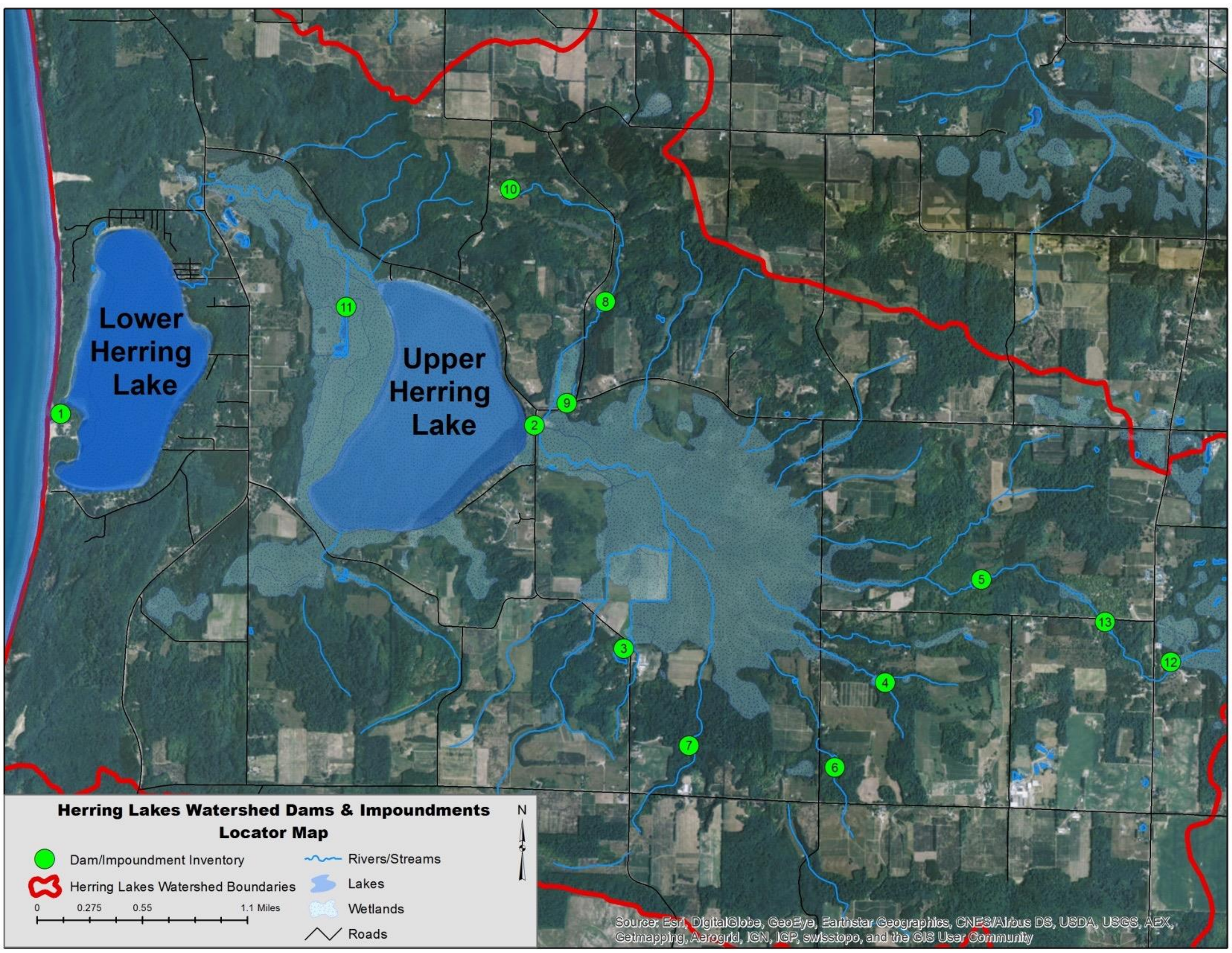

FIGURE 22: HERRING LAKE WATERSHED DAM INVENTORY SITE MAP

CHAPTER 4: EXISTING WATER QUALITY INFORMATION AND RESULTS FOR THE HERRING LAKES WATERSHED

Upper and Lower Herring Lakes and their main tributary, Herring Creek, presently exhibit some concern with the water quality based on the 2015-2016 testing results. Increased aquatic weed growth in the lakes is one indicator of polluted runoff occurring within the watershed. High levels of coliform bacteria have also been detected in Herring Creek at several locations including the inlet to Upper Herring Lake. The presence of bacteria at the levels measured within tributaries in the study may at certain times, i.e., late summer and early fall months, and at certain locations, i.e., tributaries to Upper Herring Lake, pose a risk to human health.

This chapter is broken up into two sections with many subsections. Below is an overview of this chapter:

4.1 Herring Lakes Watershed Water Quality Information

Historic water quality data and reports

Previous studies have been conducted in the past decade that contributed to our current scientific understanding of water quality issues in the Herring Lake Watershed. Section 4.2 is a summary of findings of previous studies completed within the Herring Lake Watershed. Below is a summary of the water quality parameters collected and the standards for each parameter.

Nutrients (Phosphorus and Nitrogen)

Nutrients, such as nitrogen and phosphorus, are essential for plant and animal growth and nourishment, but the overabundance of certain nutrients in water can cause a number of adverse health and ecological effects. Phosphorous and nitrogen are considered "limiting nutrients" in freshwater aquatic systems. These nutrients are required for biological growth but slight increases can lead to water quality degradation, change from cold water to warm water aquatic biological systems and toward higher lake trophic or productivity levels. An example would be going from an oligotrophic or low productivity associated with low phosphorous and nitrogen concentrations to mesotrophic (i.e., moderate productivity associated with medium phosphorous and nitrogen concentrations) or eutrophic (i.e., high productivity associated with high phosphorous and nitrogen concentrations) status.[12] Eutrophic and high nutrient regimes in freshwaters are generally considered being less desirable for recreation and lower quality waters.

Phosphorus (P)

Phosphorus (P) is an essential nutrient for all life forms, and is the eleventh-most abundant mineral in the earth's crust. It is needed for plant growth and is required for many metabolic reactions in plants and animals. Organic phosphorus is a part of living plants and animals, their by-products, and their remains. Generally, phosphorus is the limiting nutrient in freshwater aquatic systems. That is, if all phosphorus is used, plant growth will cease, no matter how much nitrogen is available. Phosphorus

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[12] Wetzel, Robert G., Limnology, Lake and River Ecosystems, 1.3 the Phosphorous Cycle, The Importance of Nutrient Loading to Aquatic Ecosystems, Third Edition, Academic Press, 2001, pp. 274-275.

typically functions as the "growth-limiting" factor because it is usually present in very low concentrations. The natural scarcity of phosphorus can be explained by its attraction to organic matter and soil particles. Any unattached or "free" phosphorus is rapidly removed from the aquatic system by algae and larger aquatic plants. Excessive concentrations of phosphorus can quickly cause extensive growth of aquatic plants and algal blooms. Several detrimental consequences may result.

Phosphorus may accumulate in bottom sediment, both in deposited clays and silts and deposited organic matter. In such cases, phosphorus and other nutrients may be released from the sediment in the future. This results in an internal phosphorus loading. Because of this phenomenon, a reduction in phosphorus inputs may not be effective in reducing algal blooms for a number of years.

Phosphorus enters surface waters from both point and nonpoint sources. A primary point source of phosphorus is on-site septic treatment and disposal systems. Additional phosphorus originates from the use of home products, such as toothpaste, pharmaceuticals, and food preservation compounds. Nonpoint sources of phosphorus include both natural and human sources. Natural sources include: 1) phosphate deposits and phosphate-rich rocks which release phosphorus during weathering, erosion, and leaching; and 2) sediments in lakes and reservoirs which release phosphorus during seasonal overturns. The primary human nonpoint sources of phosphorus include runoff from: 1) land areas being mined for phosphate deposits; 2) agricultural areas; and 3) urban/residential areas.

Finally, high nutrient concentrations interfere with recreation and aesthetic enjoyment of water resources by causing reduced water clarity, unpleasant swimming conditions, objectionable odors, blooms of toxic and nontoxic organisms, interference with boating, and "polluted appearances." The economic implications are significant for many communities.

Water Quality Standards for Phosphorus[13]

Rule 60 of the Michigan Water Quality Standards (Part 31 of Act 451) limits phosphorus concentrations in point source discharges to 1 mg/L of total phosphorus as a monthly average. The rule states that other limits may be placed in permits when deemed necessary. The rule also requires that nutrients be limited as necessary to prevent excessive growth of aquatic plants, fungi or bacteria, which could impair designated uses of the surface water. The Michigan Department of Environmental Quality, Part 201

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[13] michigan.gov/documents/deq

Cleanup Criteria state the groundwater surface water interface standard for total phosphorous in surface waters is 1 mg/L.[14]

Nitrogen[15]

Nitrogen, in the forms of nitrate, nitrite, or ammonium, is a nutrient needed for plant growth. About 78% of the air that we breathe is composed of nitrogen gas, and in some areas of the United States, particularly the northeast, certain forms of nitrogen are commonly deposited in acid rain.

Although nitrogen is abundant naturally in the environment, it is also introduced through sewage and fertilizers. Chemical fertilizers or animal manure is commonly applied to crops to add nutrients. It may be difficult or expensive to retain on site all nitrogen brought on to farms for feed or fertilizer and generated by animal manure. Unless specialized structures have been built on the farms, heavy rains can generate runoff containing these materials into nearby streams and lakes. Wastewater-treatment facilities that do not specifically remove nitrogen can also lead to excess levels of nitrogen in surface and/or groundwater.

Nitrate can get into water directly as the result of runoff of fertilizers containing nitrate. Some nitrate enters water from the atmosphere, which carries nitrogen-containing compounds derived from automobiles and other sources. More than 3 million tons of nitrogen is deposited in the United States each year from the atmosphere, derived either naturally from chemical reactions or from the combustion of fossil fuels, such as coal and gasoline. Nitrate can also be formed in water bodies through the oxidation of other forms of nitrogen, including nitrite, ammonia, and organic nitrogen compounds such as amino acids. Ammonia and organic nitrogen can enter water through sewage effluent and runoff from land where manure has been applied or stored.

Nitrate (NO3), Nitrite (NO2), and Ammonia (NH3) are considered inorganic forms of nitrogen and are analyzed separately in water quality monitoring to determine the total inorganic nitrogen (TIN).[16] Total

[14] MDEQ: Table 1. Groundwater. Residential and Non-residential Part 201 Generic Cleanup Criteria and Screening Levels/ Part 213 Risk-based Screening Levels, December 30, 2013, Footnote (EE), R299.49.

[15] USGS article Nitrogen and Water http://water.usgs.gov/edu/nitrogen.html

[16] Nitrite (NO2-) + nitrate (NO3-) + Ammonium (NH4+) = Total Inorganic Nitrogen (TIN).

Kjehldahl nitrogen (TKN) is the combination of organically bound nitrogen and ammonia in wastewater. Total nitrogen is the combination of organic nitrogen and TIN.

Water Quality Standards for Nitrogen

There is no specific Michigan water quality standard for nitrogen in surface waters. However, when a lake or stream does not meet designated uses, a Total Maximum Daily Load (TMDL) may be developed to determine the maximum daily load of a pollutant that a water body can assimilate and meet water quality goals. This load is then allocated to point source discharges, nonpoint source discharges, and a margin of safety reserve (i.e., to account for technical uncertainties). Water quality goals relating to nutrients state that "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.[17]"

TMDL development is a public process that works best with the involvement of all affected parties. This is particularly important during the discussion on allocation and implementation issues. Participation by local communities and landowners leads to more representative TMDLs that can be readily implemented, which can lead to faster improvements in water quality.

Following development of a draft TMDL, the document is noticed for public comment. After appropriate modifications are made in response to public comments, the TMDL is sent to the U.S. Environmental Protection Agency for approval. Upon approval, the state is required to implement the TMDL so the water body will meet applicable WQS. The TMDL is implemented through existing programs, such as the National Pollutant Discharge Elimination System permits for point source discharges and nonpoint source control programs, to achieve the necessary pollutant reductions for meeting the goal established in the TMDL.

Through 2013, fifteen (15) TMDLs have been written to address nutrient impairments in southern Lower Michigan waters. In Michigan, total phosphorus (TP) is most often the nutrient causing nuisance plant based water quality impairment and most of nutrient TMDLs address TP loads. These TP TMDLs add

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17 Michigan Department of Environmental Quality, Nutrient Framework to Reduce Phosphorous and Nitrogen Pollution, October 2013.

up to a total reduction of approximately 150,000 pounds of phosphorus per year. To date there has not been a need for a TMDL on any water bodies in the Herring Lakes Watershed.

Chloride

Most waters contain some chloride. It can be caused by the leaching of brine from dust control operations on gravel roads, from road de-icing during winter, and industrial or domestic salt usage or wastes. Chloride concentrations in excess of about 250 mg/l usually produce a noticeable taste in drinking water. An increase in chloride content may indicate possible pollution from sewage sources, particularly if the normal chloride content is known to be low. Where only waters of very high natural chloride content are available, reverse osmosis or electrodialysis units may be used to produce potable water. Chloride (Cl-) is completely soluble and very mobile. Chloride is toxic to aquatic life and impacts vegetation and wildlife. There is no natural process by which chlorides are broken down, metabolized, taken up, or removed from the environment.

Contaminates from road salt enter water resources by infiltration to groundwater, runoff to surface water and through storm drains. The chloride discharged into these waters remains in solution and is not subject to any significant natural removal methods; only dilution can reduce its concentration. The statewide median value for chlorides in surface waters is 18 mg/L, and values range from 1 mg/L within northern lower Michigan to 429 mg/L in a tributary to the Rouge River.[18] Chloride level also can increase during winter and spring and during times of low surface water flow in the summer and fall. The accumulation and persistence of chloride poses a risk to the water quality and the plants, animals, and humans who depend upon it.

Water contaminated with NaCl creates a higher water density and will settle at the deepest part of the water body where current velocities are low such as in ponds and lakes. This can lead to a chemical stratification which can impede turnover and mixing, preventing the dissolved oxygen within the upper layers of the water from reaching the bottom layers and nutrients within the bottom layers from

[18] Michigan's Water Chemistry Monitoring Program: A report of Statewide Spatial Patterns 2005-2009 and Fixed Station Status and trends 1998-2008, Water Chemistry Monitoring Program, Surface Water Assessment Section, Water Resources Division, Michigan Department of Environmental Quality, February 2013, MI/DEQ/WRD-13/005, revised February 22, 2013.

reaching the top layers. This leads to the bottom layer of the water body becoming void of oxygen and unable to support aquatic life.[19]

Water Quality Standards for Chloride[20]

Michigan does not possess a water quality criterion for Cl, but the US EPA has a recommended chronic criterion for Cl for aquatic life of 230 mg/L.

Bacteria[21]

Bacteria are among the simplest, smallest, and most abundant organisms on earth with a reproduction or "re-generation" rate as short as 20 minutes for some bacteria species (e.g., *Escherichia coli or E. coli*). While the vast majority of bacteria are not harmful, certain types of bacteria cause disease in humans and animals. Concerns about bacterial contamination of surface waters led to the development of analytical methods to measure the presence of waterborne bacteria. Since 1880, coliform bacteria have been used to assess the quality of water and the likelihood of pathogens being present. Although several of the coliform bacteria are not usually pathogenic themselves, they serve as an indicator of potential bacterial pathogen contamination. It is generally much simpler, quicker, and safer to analyze for these organisms than for the individual pathogens that may be present. Fecal coliforms are the coliform bacteria that originate specifically from the intestinal tract of warm-blooded animals (e.g., humans, water fowl, deer, beavers, raccoons, etc.).

Bacteria sources

Human sources of bacteria can enter water via either point or nonpoint sources of contamination. Point sources are those that are readily identifiable and typically discharge water through a system of pipes. Nonpoint sources are those that originate over a more widespread area and can be more difficult to trace back to a definite starting point. Failed on-site wastewater disposal systems (i.e., septic systems) in residential or rural areas can contribute large numbers of coliforms and other bacteria to surface water and groundwater.

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[19] http://des.nh.gov/organization/divisions/water/wmb/was/salt-reduction-initiative/impacts.htm

[20] michigan.gov/documents/deq

[21] michigan.gov/documents/deq

Animal sources of bacteria are often from nonpoint sources of contamination. Concentrated animal feeding operations, however, are often point source dischargers. Agricultural sources of bacteria include livestock excrement from barnyards, pastures, rangelands, feedlots, and uncontrolled manure storage areas. Storm water runoff from residential, rural, and urban areas can transport waste material from domestic pets and wildlife into surface waters. Land application of manure and sewage sludge can also result in water contamination, which is why states require permits, waste utilization plans, or other forms of regulatory compliance. Bacteria from both human and animal sources can cause disease in humans.

Bacteria laden water can either leach into groundwater and seep, via subsurface discharge, into surface waters or rise to the surface and be transported by overland discharge. Bacteria in overland discharge can be transported freely or within organic particles. Overland discharge is the most direct route for bacteria transport to surface waters. Underground transport is less direct, because the movement of water and bacteria is impeded by soil porosity and permeability constraints.

Water Quality Standards for Bacteria

Rule 62 of the Michigan Water Quality Standards (i.e., Part 31 of Public Act 451 of 1994, as amended) limits the concentration of microorganisms in surface waters of the state and surface water discharges. Waters of the state which are protected for total body contact recreation must meet limits of 130 *E. coli* per 100 milliliters (ml) water as a 30-day average and 300 *E. coli* per 100 ml water at any time. The limit for waters of the state which are protected for partial body contact recreation is 1,000 E. coli per 100 ml water.

Discharges containing treated or untreated human sewage shall not contain more than 200 fecal coliform bacteria per 100 ml water as a monthly average and 400 fecal coliform bacteria per 100 ml water as a 7-day average. For infectious organisms which are not addressed by Rule 62, the Department of Environmental Quality has the authority to set limits on a case-by-case basis to assure that designated uses are protected.

Turbidity

Turbidity is basically a measure of the amount of light intercepted by a given volume of water due to the presence of suspended and dissolved matter and microscopic biota. Increasing the turbidity of the water decreases the amount of light that penetrates the water column, which can then cause changes in the aquatic ecosystem. These changes could include a result in a reduction in photosynthetic activity of phytoplankton, algae, and macrophytes, which would reduce the primary productivity of the system and may result in causing less favorable Cyanobacteria (i.e., blue green algae) to become established. Turbidity can also result in the reduction of dissolved oxygen, destroying the habitat of macroinvertebrates, and cause gill damage/abrasion.[22]

General Water Quality Parameters: (Temperature, Dissolved Oxygen, Conductivity, and pH)

pH[23]

Water contains both hydrogen (H+) and hydroxyl (OH-) ions. The pH of water is a measurement of the concentration of H+ ions, using a scale that ranges from 0 to 14. A pH of 7 is considered "neutral," since concentrations of H+ and OH- ions are equal. Liquids or substances with pH measurements below 7 are considered "acidic," and contain more H+ ions than OH- ions. Those with pH measurements above 7 are considered "basic" or "alkaline," and contain more OH- ions than H+ ions.

Fresh waters usually have a pH between 6.5 and 8.5. While there are natural variations in pH, many pH variations are due to human influences. Fossil fuel combustion products, especially automobile and coal-fired power plant emissions, contain nitrogen oxides and sulfur dioxide, which are converted to nitric acid and sulfuric acid in the atmosphere. When these acids combine with moisture in the atmosphere, they fall to earth as acid rain or acid snow. In some parts of the United States, especially the Northeast, acid rain has resulted in lakes and streams becoming acidic, resulting in conditions which are harmful to aquatic life. For example, the shells on clams and crayfish may be softened due to acid conditions. The problems associated with acid rain are lessened if limestone is present, since it is alkaline and neutralizes the acidity of the water.

Most aquatic plants and animals are adapted to a specific pH range, and natural populations may be harmed by water that is too acidic or alkaline. Immature stages of aquatic insects and young fish are extremely sensitive to pH values below 5. Even microorganisms which live in the bottom sediment and decompose organic debris cannot live in conditions which are too acidic. In very acidic waters, metals which are normally bound to organic matter and sediment are released into the water. Many of these metals can be toxic to fish and humans. Below a pH of about 4.5, all fish die.

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[22] Stream Assessments, Biological Monitoring, Remote Data Logging

http://www.water-research.net/index.php/water-treatment/water-monitoring/stream-water-quality-and-monitoring

[23] michigan.gov/documents/deq

Michigan Water Quality Standards for pH

Rule 53 of the Michigan Water Quality Standards (Part 4 of Public Act 451 of 1994, as amended) states that the hydrogen ion concentration expressed as pH shall be maintained within the range of 6.5 to 9.0 in all waters of the state.

Dissolved Oxygen[24]

Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water. Oxygen enters the water as rooted aquatic plants and algae undergo photosynthesis, and as oxygen is transferred across the air-water interface. The amount of oxygen that can be held by the water depends on the water temperature, salinity, and pressure. Gas solubility increases with decreasing temperature (i.e., colder water holds more dissolved oxygen). Gas solubility increases with decreasing salinity (i.e., freshwater holds more dissolved oxygen than salty water).

Once absorbed, oxygen is either incorporated throughout the water body via internal currents or is lost from the system. Discharging water is more likely to have high dissolved oxygen levels compared to stagnant water because the water movement at the air-water interface increases the surface area available to absorb the oxygen. Oxygen losses readily occur when water temperatures rise, when plants and animals respire (breathe), following extended periods of ice cover, and when aerobic microorganisms decompose organic matter.

Oxygen levels are also affected by a daily (i.e., “diurnal”) cycle. Plants, such as rooted aquatic plants and algae produce excess oxygen during the daylight hours when they are photosynthesizing. During the dark hours they must use oxygen for life processes.

Dissolved oxygen may play a large role in the survival of aquatic life in temperate lakes and reservoirs during the summer months, due to a phenomenon called stratification (i.e., the formation of layers). Seasonal stratification occurs as a result of water's temperature-dependent density. As water temperatures increase, the density decreases. Thus, the sun-warmed water will remain at the surface of the water body (i.e., forming the epilimnion), while denser, cooler water sinks to the bottom (i.e., the hypolimnion). The layer of rapid temperature change separating the two layers is called the thermocline.

[24] michigan.gov/documents/deq

At the beginning of the summer, the hypolimnion of the lake will contain more dissolved oxygen because colder water holds more oxygen than warmer water. However, as time progresses, an increased number of dead organisms from the epilimnion sink to the bottom and are broken down by microorganisms. Continued microbial decomposition eventually results in an oxygen-deficient hypolimnion. If the lake has high concentrations of nutrients, this process may be accelerated. When the growth rate of microorganisms is not limited by a specific nutrient, such as phosphorus, the dissolved oxygen in the lake could be depleted before the summer's end.

The introduction of excess organic matter may result in a depletion of oxygen from an aquatic system. Prolonged exposure to low dissolved oxygen levels (less than 5 to 6 mg/l oxygen) may not directly kill an organism, but will increase its susceptibility to other environmental stresses. Exposure to less than 30% saturation (i.e., less than 2 mg/l oxygen) for one to four days may kill most of the aquatic life in a system.

Low dissolved oxygen levels may occur during warm, stagnant conditions that prevent mixing. In addition, high natural organic levels will often cause a depletion of dissolved oxygen.

Michigan Water Quality Standards for Dissolved Oxygen

Rule 64 of the Michigan Water Quality Standards (Part 4 of Public Act 451 of 1994, as amended) includes minimum concentrations of dissolved oxygen which must be met in surface waters of the state. This rule states that surface waters designated as cold water must meet a minimum dissolved oxygen standard of 7 mg/l, while surface waters protected for warm water fish and aquatic life must meet a minimum dissolved oxygen standard of 5 mg/l.

Temperature/Thermal Pollution[25]

Thermal pollution occurs when humans change the temperature of a body of water. Thermal pollution can be caused by storm water runoff from warm surfaces such as streets and parking lots. Soil erosion is another cause, since it can cause cloudy conditions in a water body. Cloudy water absorbs the sun's rays, resulting in a rise in water temperature. Thermal pollution may even be caused by the removal of trees and vegetation which normally shade water ways, such as creeks, drains, and streams.

[25] michigan.gov/documents/deq

Thermal pollution can result in significant changes to the aquatic environment. Most aquatic organisms are adapted to survive within a specific temperature range. As temperatures increase, cold water species, such as trout and stonefly nymphs, may be replaced by warm water species, like carp and dragonfly nymphs. Thermal pollution may also increase the extent to which fish are vulnerable to toxic compounds, parasites, and disease. If temperatures reach extremes of heat or cold, few organisms will survive.

In addition to thermal pollutions direct effects on aquatic life, there are numerous indirect effects. Thermal pollution results in lowered levels of dissolved oxygen, since cooler water can hold more oxygen than warmer water. Low dissolved oxygen levels will cause oxygen sensitive species to die.

Photosynthesis and plant growth increase with higher water temperatures, resulting in more plants. When these plants die, they are decomposed by bacteria that consume oxygen. This can result in a further drop in dissolved oxygen levels.

The metabolic rate of fish and aquatic organisms also increases with increasing water temperatures, and additional oxygen is required for respiration. Life cycles of aquatic insects may speed up in response to higher water temperatures. Animals that feed on these insects may be affected, especially birds that depend on aquatic insects emerging at specific times during their migratory flights**.**

Michigan Water Quality Standards for Temperature

Rules 69 through 75 of the Michigan Water Quality Standards (Part 31 of Public Act 451 of 1994, as amended) specify temperature standards which must be met in the Great Lakes and connecting waters, inland lakes, and rivers, streams and impoundments. The rules state that the Great Lakes and connecting waters and inland lakes shall not receive a heat load which increases the temperature of the receiving water more than three (3) degrees Fahrenheit above the existing natural water temperature (i.e., after mixing with the receiving water). Rivers, streams and impoundments shall not receive a heat load which increases the temperature of the receiving water more than two (2) degrees Fahrenheit for cold water, and 5 degrees Fahrenheit for warm water.

It is recommended that Michigan waters should not receive a heat load which increases the temperature of the receiving water above monthly maximum temperatures (i.e., after mixing). Recommended monthly maximum temperatures for each water body or grouping of water bodies are listed in the Part 31 rules. The rules state that inland lakes should not receive a heat load which would increase the temperature of the hypolimnion (i.e., the dense, cooler layer of water at the bottom of a lake) or decrease its volume. Further provisions protect migrating salmon populations, stating that warm water rivers and inland lakes serving as principal migratory routes should not receive a heat load which may adversely affect salmonid migration.

Specifically, Michigan water quality guideline's include that monthly maximum temperatures in inland lakes should not exceed 45 degrees (F) in January and February; 50 degrees (F) in March; 60 degrees (F) in April; 70 degrees (F) in May; 75 degrees (F) in June; 80 degrees (F) in July; 85 degrees (F) in August; 80 degrees (F) in September; 70 degrees (F) in October; 60 degrees (F) in November; and 50 degrees (F) in December.[26]

Michigan guideline's also include that monthly maximum temperatures in cold-water rivers and streams should not exceed 38 degrees (F) in January and February; 43 degrees (F) in March; 54 degrees (F) in April; 65 degrees (F) in May; 68 degrees (F) in June, July and August; 63 degrees (F) in September; 56 degrees (F) in October; 48 degrees (F) in November; and 40 degrees (F) in December.[27]

Michigan guideline's for monthly maximum temperatures in warm water rivers and streams north of a line between Bay City, Midland, Alma and North Muskegon should not exceed 38 degrees (F) in January and February; 43 degrees (F) in March; 54 degrees (F) in April; 65 degrees (F) in May; 80 degrees (F) in June; 83 degrees (F) in July; 81 degrees (F) in August; 74 degrees (F) in September; 64 degrees (F) in October; 49 degrees (F) in November; and 39 degrees (F) in December.[28]

Temperature and Dissolved Oxygen (DO) are intimately linked in northern temperate lakes such as the Upper and Lower Herring lakes, because of the formation of a vertical temperature gradient during summer periods. Because cooler water is denser than warm water it settles to the bottom of the lake. As the sun continues to heat the lake surface layer, the warm/cool water density gradient becomes too great to allow mixing of surface and bottom water. The upper layer of warm water is called the epilimnion, the transition zone is the thermocline, and the cooler bottom water the hypolimnion. This lack of vertical mixing creates environments where near-bottom oxygen can be reduced or depleted. Near-bottom oxygen depletion occurs in both Upper and Lower Herring lakes.

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[26] R 323.1075(1), Rule 72(c).

[27] R 323.1075(1), Rule 75(1).

[28] R 323.1075(1), Rule 75(3).

Conductivity[29]

Conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. Compounds that dissolve into ions are also known as electrolytes. The more ions that are present, the higher the conductivity of water. Likewise, the fewer ions that are in the water, the less conductive it is. Distilled or deionized water can act as an insulator due to its very low (i.e., if not negligible) conductivity value. Sea water, on the other hand, has a very high conductivity.

Conductivity is dependent on water temperature and salinity/TDS 38. Water flow and water level changes can also contribute to conductivity through their impact on salinity. Water temperature can cause conductivity levels to fluctuate daily. In addition to its direct effect on conductivity, temperature also influences water density, which leads to stratification. Stratified water can have different conductivity values at different depths.

Low conductivity (i.e., 0 to 200 μS/cm) is an indicator of pristine or background conditions. Mid-range conductivity (i.e., 200 to 1000 μS/cm) is the normal background for most major rivers. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or bugs. High conductivity (i.e., 1,000 to 10,000 μS/cm) is an indicator of saline conditions. Waters that have been heavily impacted by industry can fall into this range.[30]

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[29] http://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/#cond17

[30] http://www.enr.gov.nt.ca/sites/default/files/conductivity.pdf

4.2 Summary of Previous Water Quality Reports

Several studies have been conducted in the past decades that contribute to our current scientific understanding of water quality and environmental stressors within the Herring Lake Watershed. Following is a brief summary of findings from each study. These studies can be found in hard copy at the Benzie Conservation District (BCD) office.

1992 South Branch Herring Creek Study

This 1992 report provides the first resource management plan for the Herring Lakes Watershed, although it focuses only on the Upper Herring Lake drainage area. The study addresses concerns based largely on qualitative assessments of geology, land use databases, and observed problems rather than actual scientific data. The study however, accurately defines the primary nonpoint source pollution threats to water quality within the HLW, and proposes an implementation strategy to further study and strategies to address these concerns.

1992 MDEQ Biological Survey of Herring Creek

This survey covered the section of Herring Creek northeast of Putney Road within the Upper Herring Lake drainage area. Overall, the study rated this stream section as “fair” to “moderately impaired.” Conditions leading to this rating included a lack of bottom substrate suitable for fish and aquatic insects. This was attributed to heavy silt and sand deposits caused by an eroding stream bank upstream of one (1) sample location and stream channel erosion caused by cattle access at another. Excessive nitrogen and phosphorus was also detected thought water quality sampling and analysis. While measurable water quality and habitat degradation was revealed in this study, the presence of young trout and other fish species migrating from UHL indicates that some sections of the stream still served as spawning and nursery habitat.

1992 Lower Herring Lake Water Quality Report

Water quality samples were taken on LHL on October 6, 1992. The study completed by Dr. Wally Fusilier who reported the lake as having excellent water quality.

1996 MDNR FISH Survey Analysis Report

UHL and LHL have long been valued as sport fishing resources, with UHL having a better reputation than LHL. Since the 1930's, both lakes have been periodically stocked with bluegill, largemouth bass, smallmouth bass and walleye. The lakes are now managed by the Michigan Department of Natural Resources (MNDR) as a two-story cold water-warm water fishery. The unique ecology of these lakes makes this strategy possible, and supports a healthy and diverse fish community. According to the 1996 MDNR survey, the continued quality of the sport fishing resource may be threatened without deliberate action to preserve the elements contributing to a healthy lake fishery. Particularly, Herring Creek and extensive wetland systems contiguous and connected to both lakes provide critical spawning habitat and food resources for fish and other wildlife. Wetlands also filter contaminated runoff from the HLW. The report concludes that preserving the healthy function of these watershed features is key to preserving lake ecology and ultimately recreational quality of both lakes.

2002 Great Lakes Environmental Center Aquatic Plant Survey of Upper and Lower Herring Lakes

A survey of the rooted aquatic plants in UHL and LHL was conducted by Great Lakes Environmental Center as part of this current project. The purpose was to map and characterize the vegetation of both lakes as a way to evaluate water quality. Upper Herring Lake hosts the greatest plant diversity. Twenty-three (23) species were identified and mapped. Plant densities are alarmingly high indicating excessive nutrient runoff from the watershed. However, only native plant species are present which supports a diverse fish community and prevents the establishment of exotic/invasive species. While this native plant community structure is preferred, the large densities of plants may be contributing to eutrophication of the lakes by adding nutrients through the annual die back and decay of aquatic plants. LHL, with fourteen (14) plant species, had a less diverse plant community than UHL, although it still denoted a healthy lake ecology. The LHL plant community also included two exotic/invasive species, i.e. Eurasian milfoil (*Myriophyllum spicatum*) and giant reed grass (*Phragmites australis*). Eurasian milfoil was the second most abundant plant identified in the lake signaling a significant concern and need for appropriate management policies. Both exotic/invasive species are problematic because they aggressively out-compete native plants and reduce the overall plant diversity of the lakes. It is not clear why the exotic plants were limited to LHL, although both environmental and human factors are suspected. Differing lake size and depth were to determined to also be a factor. Environmental factors such as changes in water levels and temperatures were also contributing factors. Eurasian milfoil is typically introduced by boats carrying fragments from other affected lakes. LHL has three public boat launches, while UHL has only one - which may further explain the difference in exotic/invasive plant introduction. Other human factors determine to perhaps contribute to the expansion of exotic/invasive plant species included bottom disturbance from boat motors and the removal of competitive native species in shallower shoreline areas. The introduction of Zebra mussels was also determined to likely influence the proliferation of exotic/invasive plant species.

2003 MDEQ Habitat Assessment (Draft)

An update of the 1992 study by MDEQ was completed in August 2003. This survey revisited survey sites from the 1992 study, and added locations at the inlet to UHL and LHL and off Swamp Road in the upper-most portion of the Watershed. Sampling sites near Putney Road revealed a continuation of habitat degradation first detected in 1952. The cause continued to remain from livestock access to tributaries, and a resulting eroding stream bank downstream of the culvert at Putney Road.

MDEQ 1992 and 2003 habitat assessment sampling locations sculpin were observed, however, indicating that this reach of stream continued to support some level of the fishery. The researcher also noted the addition of some cattle fencing along the stream which, while not completely excluding cattle access to the stream, was an improvement over previous conditions. Regardless, this reach of stream received a poor rating for aquatic insects due to an overburden of silt and sand.

The added survey sites along Swamp Road revealed good to excellent habitat conditions. This was attributed to the largely undeveloped stream corridor and surrounding forested wetlands. Erosion caused by road culverts were noted although gravel stream beds continuing to dominate this section. Survey results at M-22 and Elberta Resort Road rated conditions good to excellent for habitat and insect diversity.

Water samples revealed high phosphorous and nitrogen at sample locations between Putney Road and the inlet to UHL. Nutrient levels dipped slightly below UHL. Nutrients in the stream sections along Swamp Road approximated normal ambient water background conditions.

2003 Great Lakes Environmental Center Water Quality Report

A comprehensive monitoring program was conducted including lake and tributary sampling, aquatic weed survey (as cited above), fecal bacteria sampling and a hydrogeologic investigation including soil classification, hydrogeology, land cover analysis and a determination of the chemicals of concern.

2003 Lake Water Quality

Monitoring data for both lakes in 2003 showed phosphorus and nitrogen levels to be overall consistent with other northern Michigan lakes - having good water quality. Another water quality indicator, chlorophyll a was detected at levels high enough to suggest that lake nutrients levels may be increasing in both lakes. Sediment phosphorus was measured at acceptable levels throughout the two lakes except near the inlet of Herring Creek on UHL, and the southern edge of the lake. This was determined to likely be contributing to high weed growth occurring in these areas of the lake.

Tributary Monitoring

Stream sampling was conducted after rainfall events to monitor runoff from agricultural areas. Phosphorus and nitrogen (i.e., nitrate) were measured at levels ranging from 30 parts per billion (ppb) to over 100 ppb. For comparison, the 5-year average for nutrients in surface waters of a watershed with similar characteristics and land use in Leelanau County was 10 to 20 parts per billion - which indicated that significant nutrient loading was occurring to Herring Creek. Dry weather sampling revealed nutrient levels comparable with the 5-year average for dry weather sampling in Benzie County.

Levels of the bacterium, i.e., *E. coli*, measured at the inlet to UHL were generally much higher (i.e., 2-10 times higher) than levels measured upstream in the Herring Creek tributary. However, all samples of *E. coli* were at levels which would likely exceed the State of Michigan standard for *E. coli* in surface water, based on a single sample event. This contamination may have originated from various sources such as septic system failures or wildlife, farm animals, pets or waterfowl waste. The presence of *E. coli* is not necessarily indicative of septic failures, but is an indicator of fecal contamination from warm blooded animals including humans. Unrestricted access of cattle to the Herring Creek tributary was cited as a likely contributor, and future sampling was recommended to confirm or deny this suspicion.

Hydrogeologic Investigation

This portion of the monitoring effort was conducted to collect data to evaluate suspected groundwater contributions to water quality problems in the Herring Lakes. Potential groundwater contamination sites were also assessed. This investigation first determined the best location of permanent and temporary groundwater monitoring wells needed to define subsurface characteristics including depth, flow direction, gradient, etc. Land use and land cover assessments, including a review of local, State and Federal databases were also used to determine the location of potential environmental contamination and areas of concern. High concentrations of phosphorous was detected in near surface groundwater venting to LHL immediately north of the MDNR boat launch on the east side of the lake.

4.3 2016-2017 Herring Lakes Watershed Water Quality Monitoring Results

A considerable amount of water quality data have been collected from surface waters of the Herring Lakes Watershed over the last several decades and was compiled for this plan. As summarized above, historic water quality data was gathered at various locations within the watershed during the period between 1990 and 2014 and is available at the Benzie Conservation District (BCD). For the purposes of this watershed protection plan, the results from 2011 to 2016 are also presented in this chapter together with data collected from this study (i.e., 2016 to 2017). The state water quality monitoring program undertaken by the MDEQ indicates that lakes and streams within the Herring Lakes Watershed were last monitored in 2013, and are scheduled to be monitored by the MDEQ again in 2018.

Water quality sampling and analyses were completed from April 2015 to December 2015 and from April 2016 to August 2016. Thirteen (13) water sampling locations were selected including the two lakes, two locations that evidence groundwater discharge or "inter-discharge" to each lake, and eight (8) surface water sample locations on the inlets, outlets and tributaries to both Upper and Lower Herring Lakes (see Table 16, Figure 23 below). Analyzed water quality parameters include nutrients (i.e., Total Inorganic Nitrogen and Total Phosphorus), turbidity, and chlorine. A hand-held Hydrolab was used at specific depths in the lakes and at all the stream locations to measure and record pH, conductivity, temperature, and dissolved oxygen. Grab samples were also collected and analyzed for *Eschericia coli* (*E. coli*) bacteria, Microbial Source Tracking (i.e., DNA analyses) and caffeine at select locations.

Table 16: Water Quality Sample Locations

Site ID	Location	Latitude	Longitude
WS-1	Outlet of Lower Herring Lake	44 33'37.87" N	86 13'14.50" W
WS-2	Creek between Upper and Lower Herring Lakes	44 34'15.48" N	86 12'18".15 W
WS-3	Outlet of Upper Herring Lake	44 34'29.42" N	86 11'32.95" W
WS-4	Creek Crossing at Gorivan Road (i.e., inlet of Upper Herring Lake)	44 33'34.52" N	86 10'13.34" W
WS-5	Creek Crossing at Putney Road north	44 32'46.6" N	86 09'56.6"W
WS-6	Creek Crossing at Putney Road south	44 32'35.27"N	86 09 39.00" W
WS-7	Creek Crossing at Swamp Road	44 32'33.84" N	86 08'24.76" W
WS-8	Upper Herring Creek (i.e., in wetland)	44 33'15.37" N	86 09'26.27" W
WS-9	Lower Herring Lake	44 33'33.37" N	86 12'43.5" W
WS-10	Upper Herring Lake	44 33'26.86" N	86 10'47.77" W
GW-1	groundwater interflow at MDNR boat launch Lower Herring Lake	44 34'15.54" N	86 12'30.32" W
GW-2	groundwater interflow at Indian Trail Upper Herring Lake	44 33'11.72" N	86 10'44.94" W

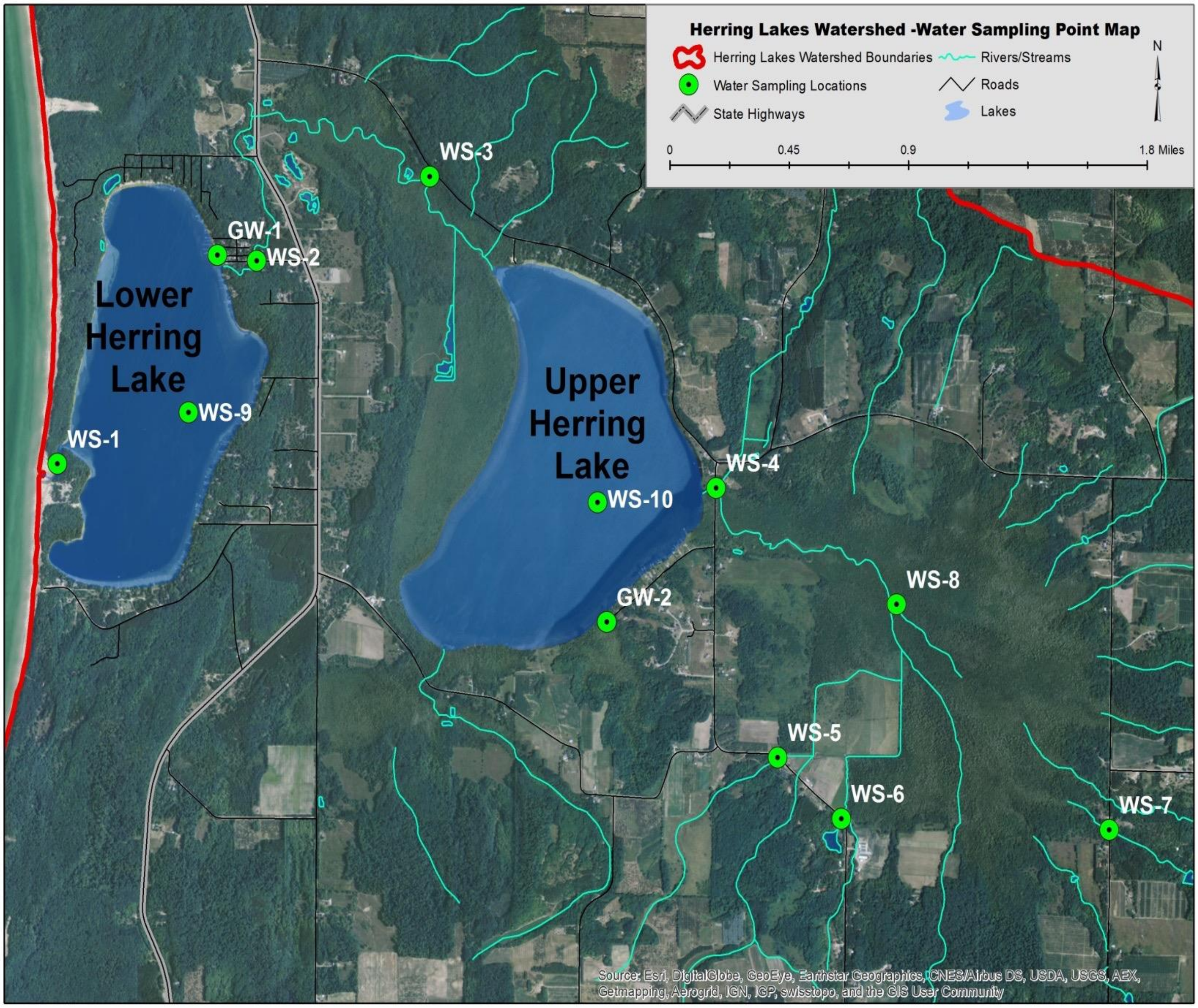


Figure 23: Water Sample Locations, Herring Lakes Watershed

Upper Herring Lake (UHL) and Lower Herring Lake (LHL) were sampled for Total Phosphorus (TP) at the surface and near the bottom from April to December in 2015 and from April to August in 2016. Total Phosphorus (TP) averaged 7.9 ug/L for Upper Herring Lake and 7.6 ug/L for Lower Herring Lake (see Tables 16 and 17). Because the effects of phosphorus vary by region and are dependent on physical factors such as the size, hydrology, and depth of rivers and lakes, there is currently no national surface water quality criterion for TP. Nuisance algal growths are not uncommon in rivers and streams below the US EPA's low reference level (i.e., 0.1 mg/L), however empirical study and statistical analyses of water quality data suggest that more appropriate reference levels for TP range from 0.01 mg/L (i.e., 10 ug/L) to 0.075 mg/L (i.e., 75 ug/L) depending on the ecoregion.[31] Some streams in the lowest category may exceed these recommended water quality criteria. Results show that there were some individual exceedances of the US EPA recommended limit for both lakes, but the yearly averages were below the US EPA recommendation.

Table 17: Average Results of Total Phosphorus (TP), Ammonia (NH3), Total Kjeldahl Nitrogen (TKN), Nitrates (NO3), Total Inorganic Nitrogen (TIN), and Chloride (Cl) for Upper Herring Lake 2015-2016

Parameter	*Surface*	*Bottom*	*Average*
TP (ug/L)	8.3	7.5	7.9
NH3-N (mg/L)	0.02	0.04	0.03
TKN-N ((mg/L)	0.4	0.4	0.4
NO3-N(mg/L)	0.4	0.3	0.4
TIN (mg/L)	0.4	0.4	0.4
Cl (mg/L)	11.3	11.3	11.3

[31] U.S. EPA Report on the Environment, Nitrogen and Phosphorous in Agricultural Streams, https://epa.gov/roe/, data source Mueller and Spahr, 2005.

Table 18: Average Results of Total Phosphorus (TP), Ammonia (NH3) Total Kjeldahl Nitrogen (TKN), Nitrates (NO3) and Chloride (Cl) for Lower Herring Lake 2015-2016

Parameter	Surface	Bottom	Average
TP (ug/L)	8.1	7.2	7.6
NH3-N (mg/L)	0.02	0.03	0.03
TKN-N ((mg/L)	0.4	0.4	0.4
NO3-N(mg/L)	0.2	0.2	0.2
TIN (mg/L)	0.2	0.2	0.2
Cl (mg/L)	12.9	11.4	12.1

The average TP for the Herring Lakes during 2015-2016 were within the US EPA recommended TP concentration of 10.0 ug/L[32] (see Figure 24).

[32] Site-specific TP goals for Michigan rivers range from 0.03 – 0.1 mg/L, and site-specific TP goals for lakes/impoundments range from 0.008 – 0.06 mg/L. https://www.michigan.gov/documents/.../wrd-swas-nutrients-npdeslimits_366813_7.p...

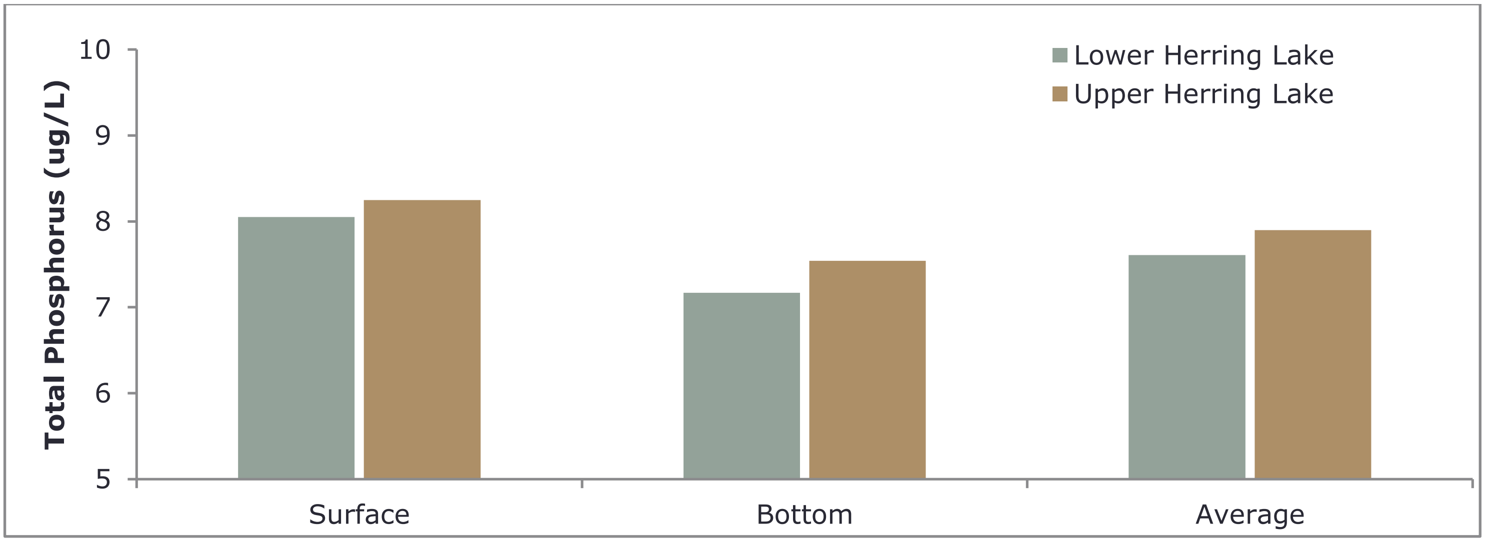


Figure 24: Upper and Lower Herring Lake Total Phosphorus (TP ug/l) levels 2015-2016

Total Phosphorus readings by month from April to November, the readings are lowest in the spring and highest towards the end of the summer on both Lower and Upper Herring Lakes (see Table 19 and Figure 25). The average TP for the Herring Lakes during 2015-2016 were within the US EPA recommended TP concentration of 10.0 ug/L, with the exception of the Upper Herring Lake (UHL) surface water sample location (WS-10), UHL bottom sample (WS-10), and Lower Herring Lake (LHL) surface sample (WS-9) on August 21, 2016. The average TP for the Herring Lakes during 2015-2016 were within the US EPA recommended TP concentration of 10.0 ug/L or less except for Upper Herring Lake during 2015 at 10.3 ug/L.

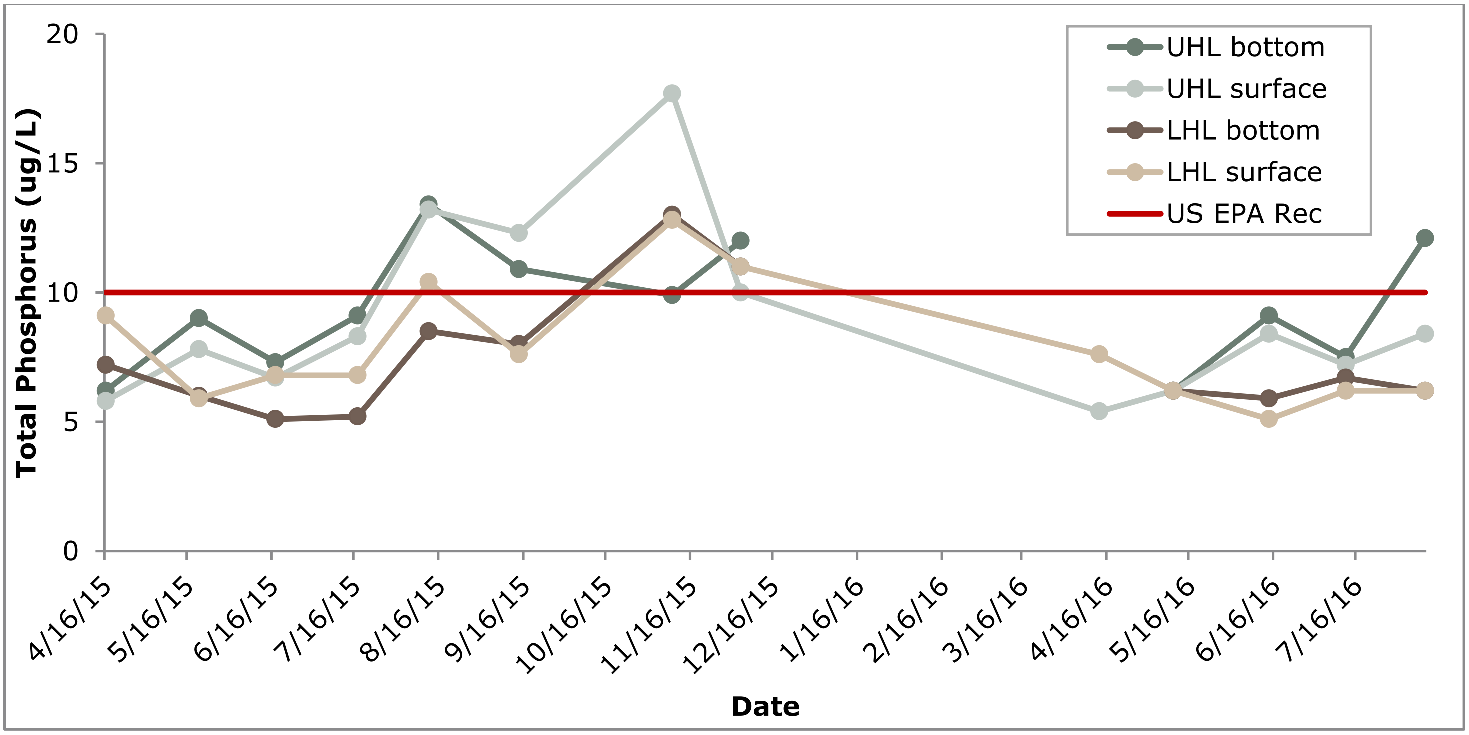


Figure 25: Total Phosphorus (TP) by Month for Herring Lakes 2015-2016

Table 19: Herring Lakes Total Average Phosphorus (ug/L) summary 2010-2016

Year	*Upper Herring Lake*	*Lower Herring Lake*
2010	9.0	7.5
2011	10.0	10.0
2012	BDL*	10.0
2013	BDL	BDL
2014	BDL	BDL
2015	10.3	8.5
2016	8.3	8.1

* BDL = below lab detection limit of 5.0 ug/L

Total Inorganic Nitrogen (TIN) in freshwater can be calculated as the sum of the concentrations of ammonia (NH_3), hydroxylamine (NH_2OH), nitrite (NO_2^-), nitrate (NO_3), and dissolved and particulate organic nitrogen, but NH_2OH is rapidly oxidized and occurs only in very low concentrations.[33] Nitrite too typically occurs in very low concentration, but unusually high nitrite concentrations are an indicator of decreasing water quality and ecological health of the waterbody. Total Inorganic Nitrogen was calculated from the results. Michigan does not possess a water quality criterion for TIN, but an acceptable US EPA range of TIN is 2 mg/L to 6 mg/L. The tables below show that the average TIN for both lakes is below the lowest US EPA recommended concentration of 2 mg/L (see Table 20).

Table 20: Upper Herring Lake (UHL) and Lower Herring Lakes (LHL) Average TIN results (mg/L) 2015-2016

Station	TIN	Min	Max
UHL bottom	0.38	0.08	0.63
ULH surface	0.38	0.01	0.68
All Depths (UHL)	0.38	0.01	0.68
LHL bottom	0.26	0.05	0.36
LHL surface	0.18	0.01	0.35
All Depths (LHL)	0.21	0.01	0.36

Upper Herring Lake (UHL) and Lower Herring Lake (LHL) were also sampled for Chloride (Cl). Upper Herring Lake showed an average of Cl at 11.3 mg/L at the surface and 11.3 mg/L at the bottom (see Table 21). LHL showed an average deep Cl concentration of 11.4 mg/L and 12.9 mg/L at the surface. Michigan does not possess a water quality criterion for Cl, but the US EPA has a recommended chronic

[33] Wetzel, Robert G., Limnology, Lake and River Ecosystems, 1.3 the Phosphorous Cycle, The Importance of Nutrient Loading to Aquatic Ecosystems, Third Edition, Academic Press, 2001, pp. 213.

criterion for Cl for aquatic life of 230 mg/L. The average Cl concentrations for all depths for both lakes are well-below the US EPA recommended chronic criterion (see Table 21).[34]

Table 21: Average Chloride (Cl mg/L) for Upper Herring Lake and Lower Herring Lake 2015-2016

Station	*Average of Cl (mg/L)*
UHL (bottom)	11.3
UHL (surface)	11.3
LHL (bottom)	11.4
LHL (surface)	12.9

E. coli Results

E. coli are diverse group of bacteria that normally live in the intestines of people and other warm-blooded animals. Most *E. coli* are harmless, and actually are an important part of a healthy human intestinal tract. *E. coli* can be monitored in surface waters and used as an indicator of the possible presence of human pathogens. The presence of human *E. coli* in surface waters generally represents a much higher risk of human pathogens being present, rather than *E. coli* from other warm-blooded animals. Increasingly, therefore, DNA analyses of water samples with high *E. coli* counts are being undertaken to determine if humans may be a source. This watershed protection plan therefore undertook DNA analyses of select sample locations indicating the presence of *E. coli*, i.e., WS-2, WS-4, WS-5, WS-9 and WS-10.

Some *E. coli* are pathogenic, meaning they can cause illness, either diarrhea or illness outside of the intestinal tract. The types of *E. coli* that can cause diarrhea can be transmitted through contaminated water (or food), or through contact with animals or persons. Harmful *E. coli* strains are categorized into

[34] As referenced in the USGS National Water-Quality Assessment Program, Chloride in Groundwater and Surface Water in Areas Underlain by the Glacial Aquifer System, Northern United States, Scientific Investigations Report 2009-5086.

"pathotypes." Six pathotypes are associated with diarrhea and collectively are referred to as diarrheagenic *E. coli*, and include:1) Shiga toxin-producing *E. coli* (STEC)—STEC may also be referred to as Verocytotoxin-producing *E. coli* (VTEC) or enterohemorrhagic *E. coli* (EHEC). This pathotype is the one most commonly heard about in the news in association with foodborne outbreaks; 2) *Enterotoxigenic E. coli* (ETC); 3) *Enteropathogenic E. coli* (EPEC); 4) *Enteroaggregative E. coli* (EAEC); 5) Enteroinvasive *E. coli* (EIEC): and 6) Diffusely adherent *E. coli* (DAEC). Water samples collected from within the Herring Lakes Watershed were analyzed for total *E. coli* bacteria, including the above six *E. coli* pathotypes.

Average *E. coli* results within both Upper and Lower Herring lakes were very low, showing numbers well below Michigan water quality criteria (see Table 22).

Table 22: Average *E. coli* readings for Upper Herring Lake and Lower Herring Lake 2015-2016

Station	*E coli (colonies/100 mL)*	*Low*	*High*
Lower Herring Lake (WS-9)	0.23	0.0	2.0
Upper Herring Lake (WS-10)	1.08	0.0	9.0

Elevated *E. coli* within Upper Herring Lake was documented in 2007 from a leaking septic system that was replaced in 2007, with one 2006 reading exceeding the state limit of 300 colonies/100mL.[35] As depicted above, during 2015-2016 average *E. coli* readings for Upper and Lower Herring Lake open waters were well-below the state limit of 300 colonies/100mL (i.e., 0.23 for Lower Herring Lake and 1.08 for Upper Herring Lake.

[35] 300 colonies/100 mL *E. coli* is the Michigan maximum to be protective of total body contact recreation (i.e., swimming and other recreation that involves the immersion of the head), and 1000 colonies/100 m/L *E. coli* is the maximum for waterways to be protective of partial body recreation (i.e., fishing, boating, etc.)

General Water Quality Parameters: (i.e., Temperature, Dissolved Oxygen, Conductivity, pH, and Oxidation/Reduction Potential)

Hydrolab profile data and water samples have were collected from April to November on both Upper and Lower Herring lakes in 2015 and 2016 and their tributaries. There was no hydrolab data for October 2015. Water samples were collected at the surface, bottom and other various depths for the Lakes. Water samples were also collected in two ground water locations and 8 tributary (i.e., stream) locations. Average results by depth are shown below in Tables 22 & 23 for both Herring Lakes.

Table 23: Hydrolab Average Results for (WS-10) Upper Herring Lake 2015-2016

Depth	*Temp (F)*	*pH*	*Specific Conductivity (aeS/cm)*	*Dissolved Oxygen (mg/L)*
1	62.0	8.4	335.0	9.8
5	63.2	8.3	335.9	9.7
10	61.8	8.4	335.6	9.3
15	61.3	8.3	339.0	9.6
20	60.7	8.1	344.6	7.8
25	54.5	7.9	348.6	6.9
All Depths	**60.5**	**8.2**	**340.0**	**8.8**

Table 24: Hydrolab Average Results for (WS-9) Lower Herring Lake 2015-2016

Depth	*Temp (F)*	*pH*	*Specific Conductivity (aeS/cm)*	*Dissolved Oxygen (mg/L)*
1	61.9	8.3	326.1	9.9
10	61.8	8.3	326.1	9.7
20	61.4	8.2	326.4	9.5
30	56.4	7.9	334.7	8.0
35	58.6	7.5	349.6	3.5
40	50.5	7.7	338.0	6.8
50	48.5	7.6	340.3	5.6
55	49.6	7.5	343.3	2.1
60	48.3	7.6	341.0	5.2
Average	**55.3**	**7.9**	**334.1**	**7.4**

pH

The pH was sampled for each of the lakes at various depths from the surface to the bottom. The pH of both Upper and Lower Herring lakes tend to stratify during the summer because of the photosynthetic activity of the plankton. The epilimnion tends to be higher, above a pH of 8.0 and the hypolimnion tends to have pH near 7.5 (see Figures 26 and 27). The average pH for Upper Herring Lake (UHL) during 2015-2016 was 8.2, well within the Michigan water quality range of 6.5 to 9.0 in all waters of the state. The average pH for Lower Herring Lake (LHL) during 2015-2016 was 7.9, well within the Michigan water quality range of 6.5 to 9.0 in all waters of the state.

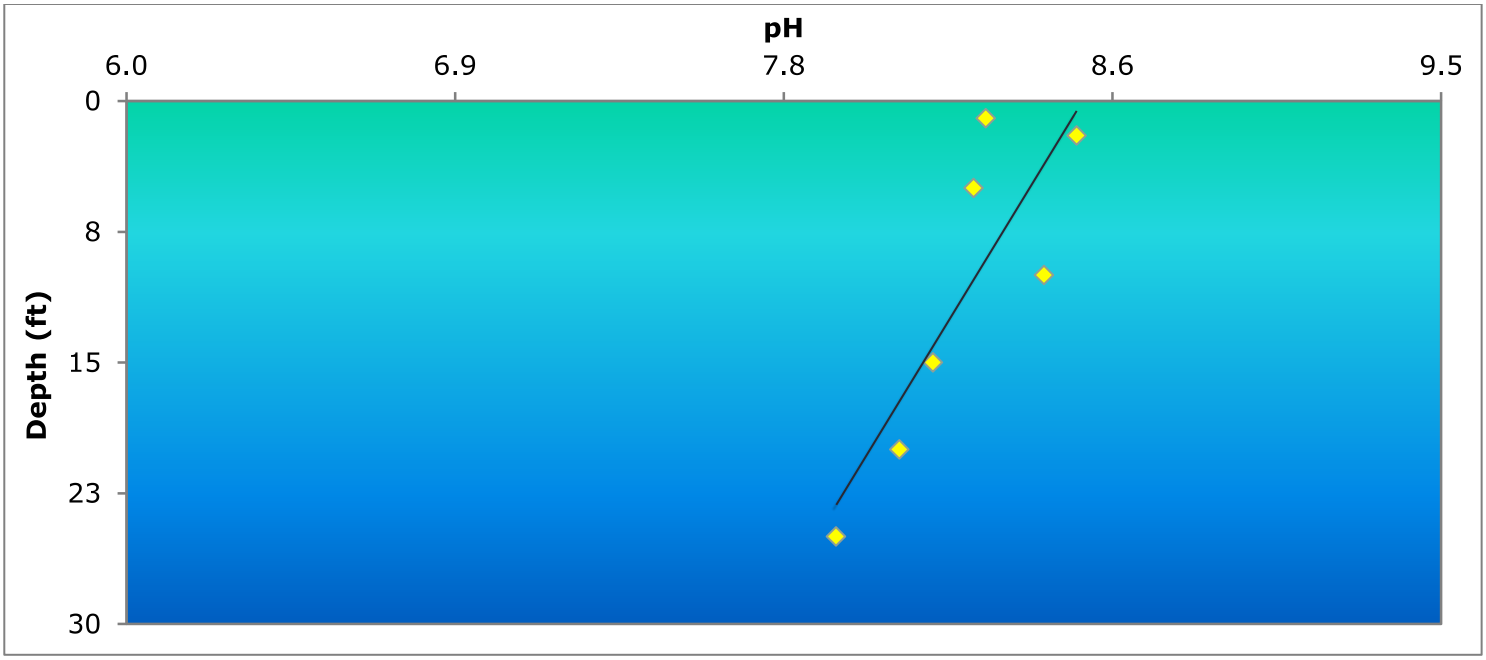


Figure 26: Average pH for Upper Herring Lake (WS-10) by depth - 2015-2016

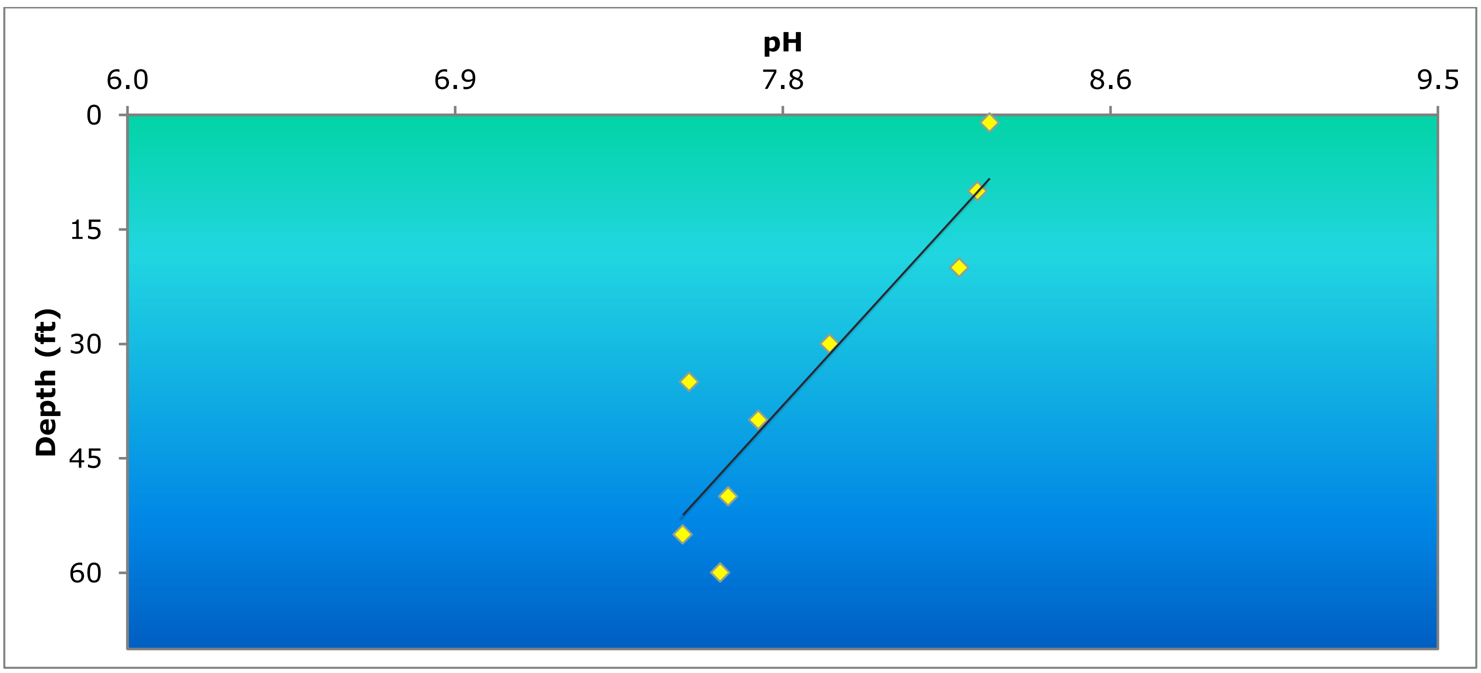


Figure 27: Average pH for Lower Herring Lake (WS-9) by depth - 2015-2016

Dissolved Oxygen

The surface water Dissolved Oxygen for Upper Herring Lake (UHL) for 2015-2016 was well within the Michigan standards that surface waters designated as cold water must meet a minimum of 7 mg/l (see Figure 28 below). The surface water Dissolved Oxygen for Lower Herring Lake (LHL) for 2015-2016 was well within the Michigan standards that that surface waters designated as cold water must meet a minimum of 7 mg/L (see Figure 29 below).

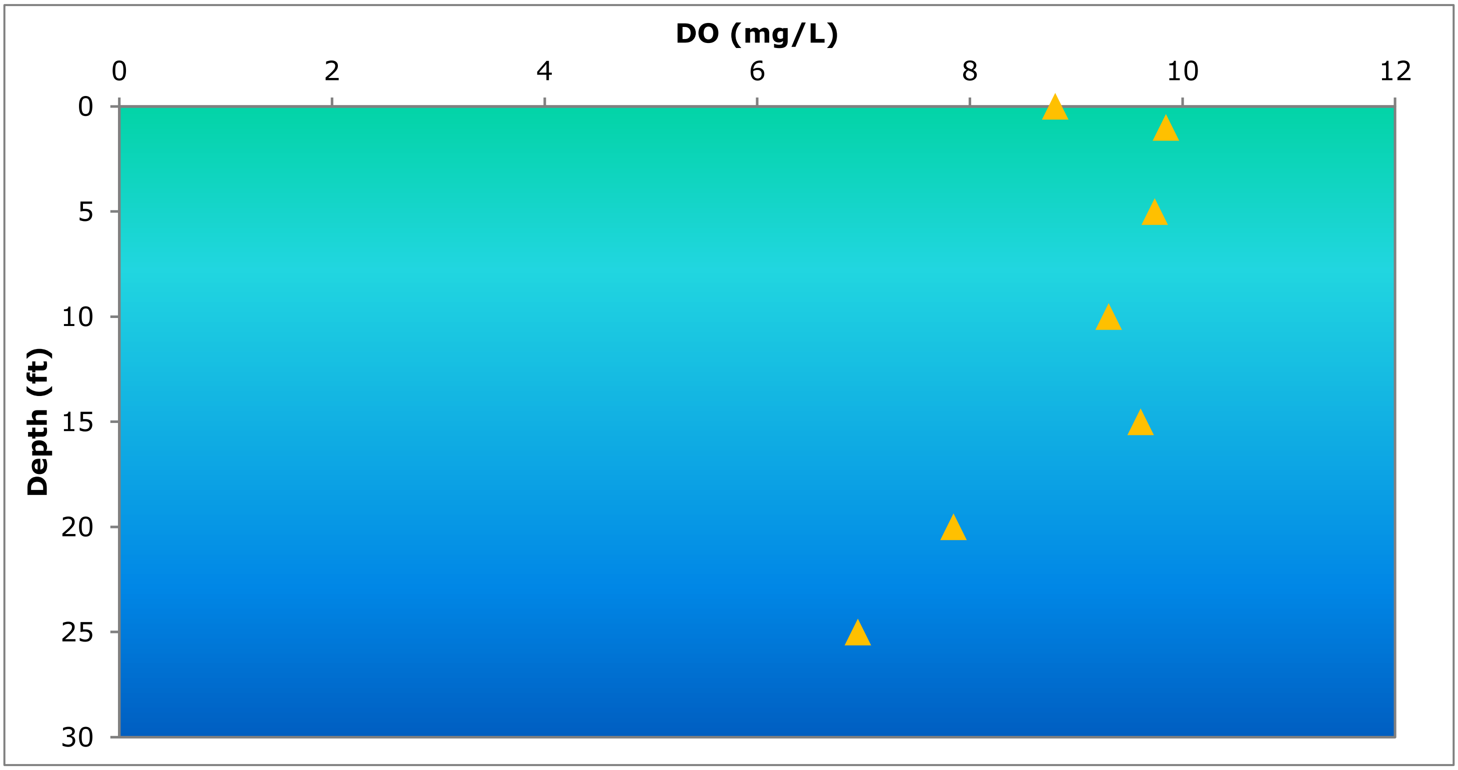


Figure 28: Average Dissolved Oxygen (DO) for Upper Herring Lake (WS-10) by depth 2015-2016

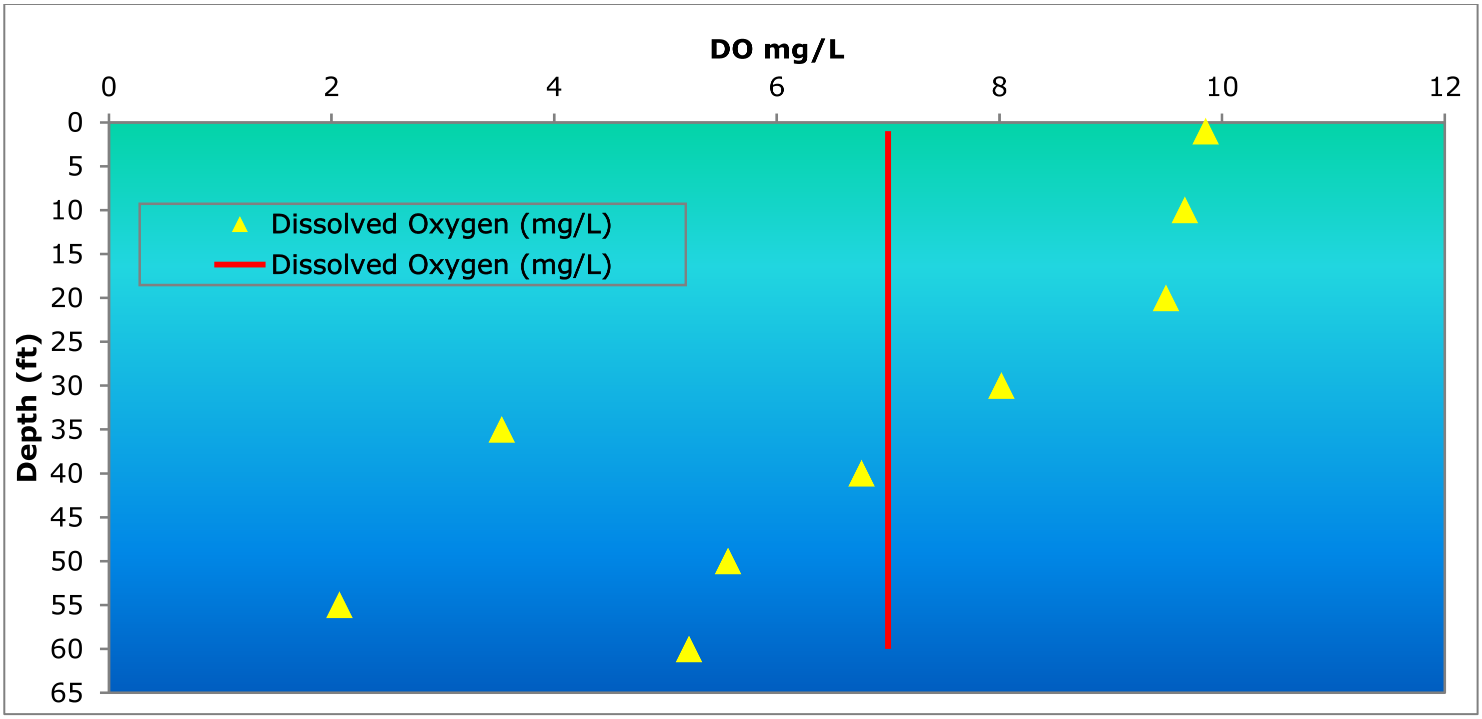


Figure 29: Average Dissolved Oxygen (DO) for Lower Herring Lake (WS-9) by depth 2015-2016

Temperature

The average monthly temperature (°F) for surface water within Upper Herring Lake and Lower Herring Lake for 2015-2016 were well-within recommended Michigan monthly maximum temperature guidelines for ambient waters (see Figures 31 and 32 below).

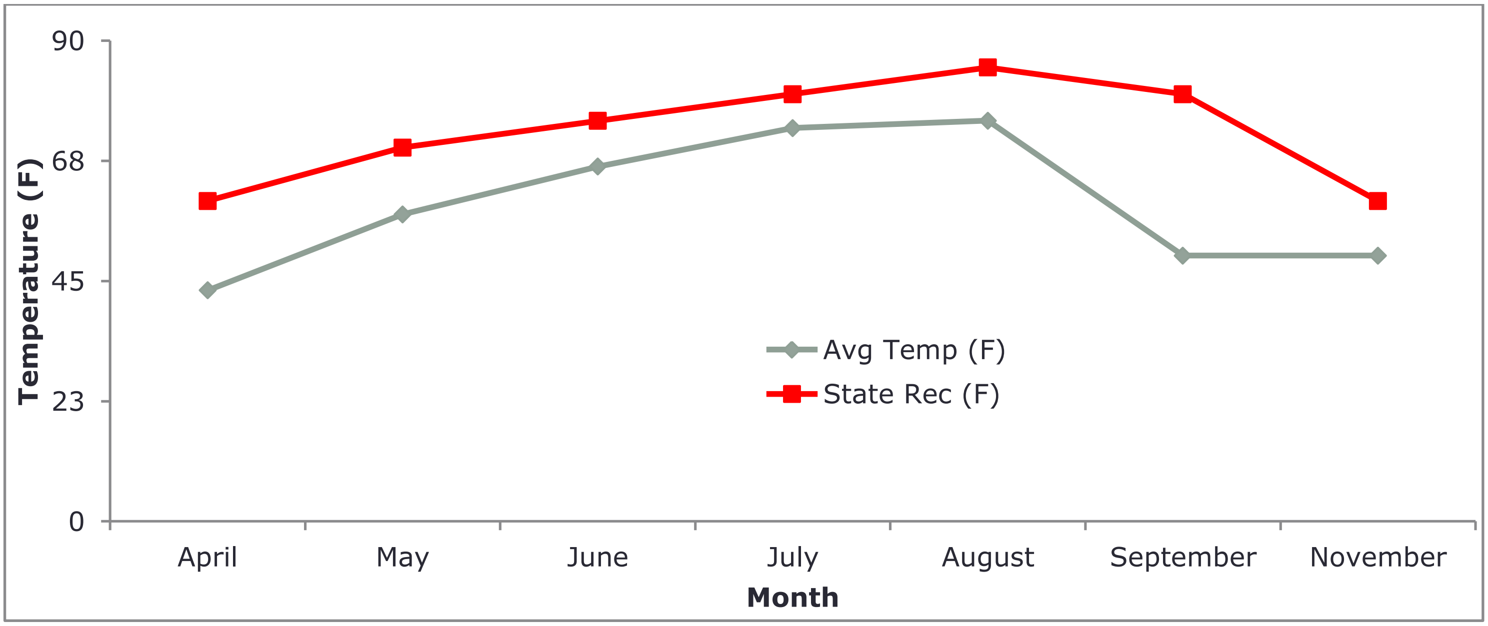


Figure 29: Upper Herring Lake (WS-10) Average Temperature by Month 2015-2016

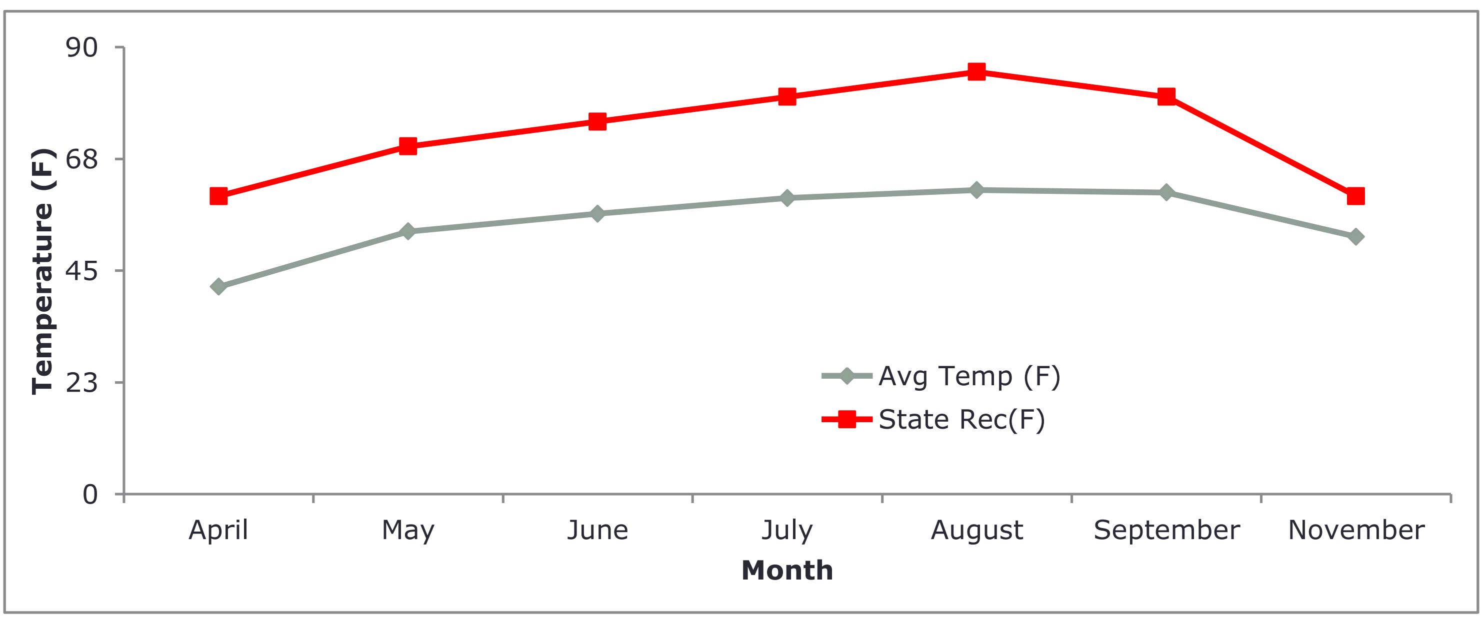


Figure 30: Lower Herring Lake (WS-9) Average Temperature by Month 2015-2016

Conductivity

Conductivity results on both Upper Herring Lake (UHL) and Lower Herring Lake (LHL) show a general increase in the readings the deeper you go. These results fall into the middle or normal range for conductivity. Under 200 µS/cm is considered pristine. Distilled water has a conductivity ranging from 0.5 to 3 µS/cm, while most streams range between 50 to 1500 µS/cm. Freshwater streams ideally should have a conductivity between 150 to 500 µS/cm to support diverse aquatic life.

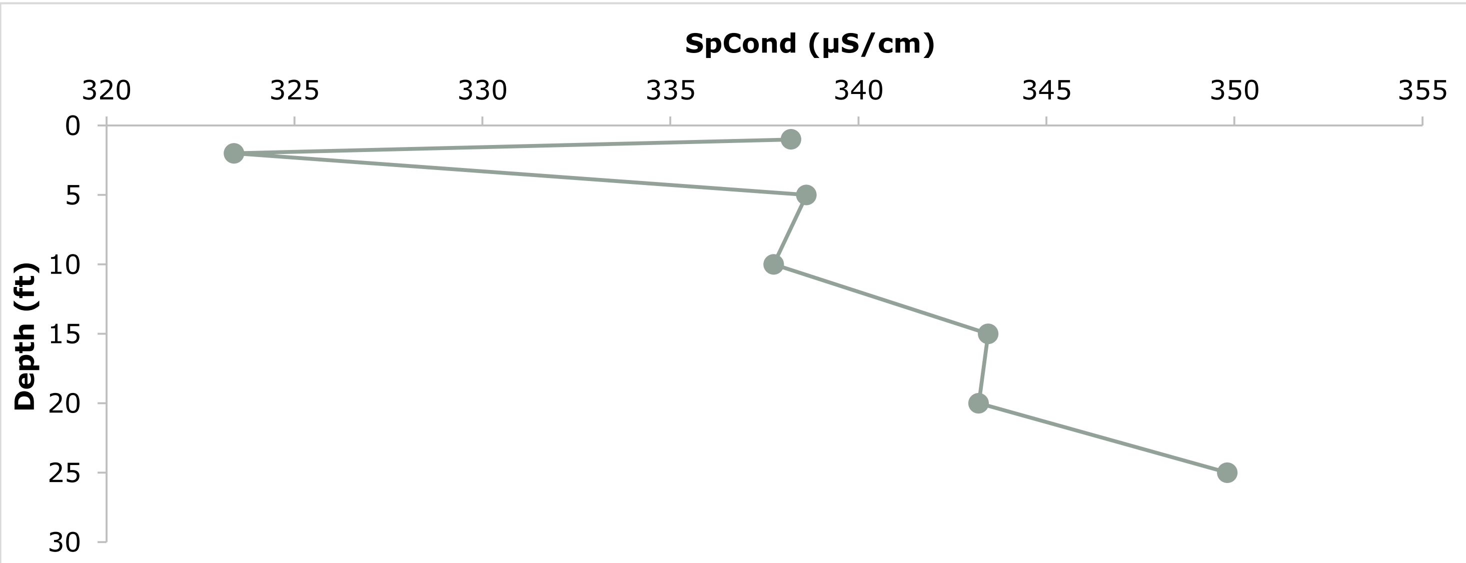


Figure 31: Upper Herring Lake (WS-10) Average conductivity (µs/cm) by depth (ft) 2015-2016

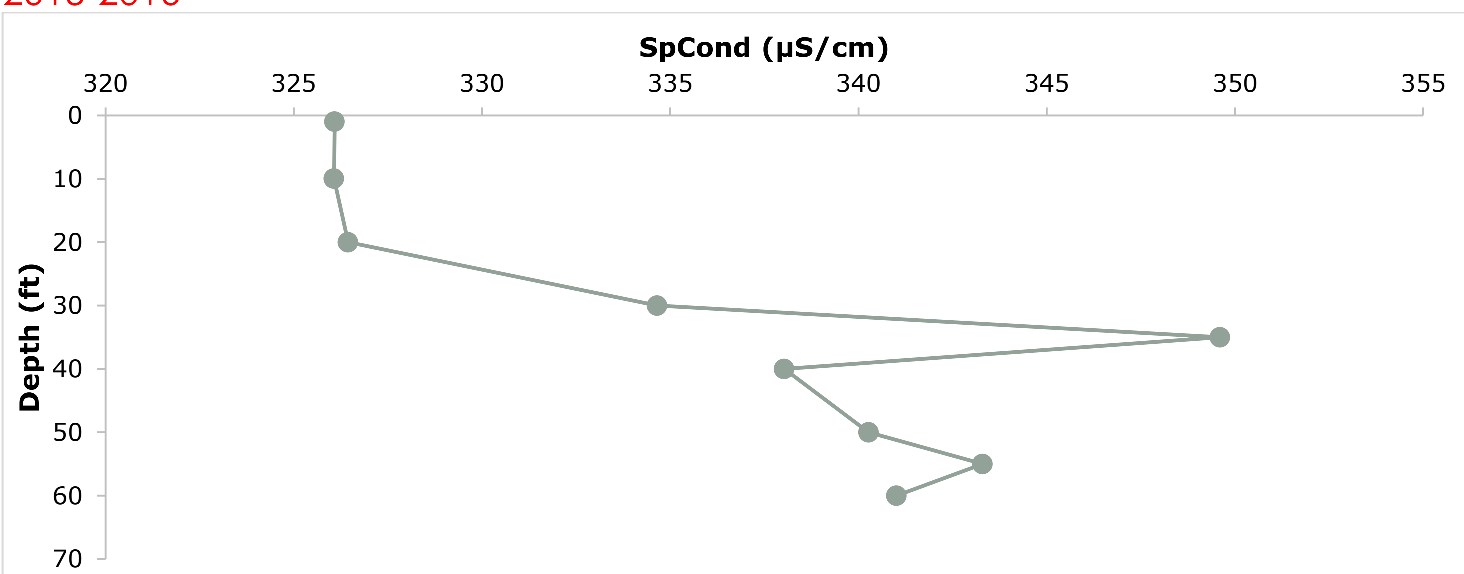


Figure 32: Lower Herring Lake (WS-9) Average conductivity(µs/cm) by depth (ft) 2015-2016

Lower Herring Lake has a lower overall average temperature (55.3 °F) compared to Upper Herring Lake (60.9 °F) (see Figures 29 and 30 above). Upper Herring Lake has an overall higher average DO % (8.9 mg/L) compared to Lower Herring Lake (7.4 mg/L). Upper Herring Lake (8.2) has a slightly higher pH compared to Lower Herring Lake (7.9). Upper Herring Lake has a marl bottom, which buffers pH at about 8. pH will most likely not ever go below 8 due to the marl, calcium carbonate rich mud. The precipitate of leaves on the plant vegetation in Upper Herring Lake is also important to the water chemistry of the lake.

Secchi Disk Readings

The near surface water column of both Upper and Lower Herring lakes has increased in clarity since zebra mussels invaded both lakes and connecting waterways in the early 1990s (see Figures 33 and 34 below). Consequently, light penetration is much greater in both lakes, especially during the spring and early summer months of the year. This phenomenon has in turn altered plant growth and biologic productivity, changing both lakes' aquatic ecosystems. Subsequent and comprehensive research of this mechanism and its impact on future Herring Lakes water quality and biology is recommended in Chapter 8 of this watershed protection plan.

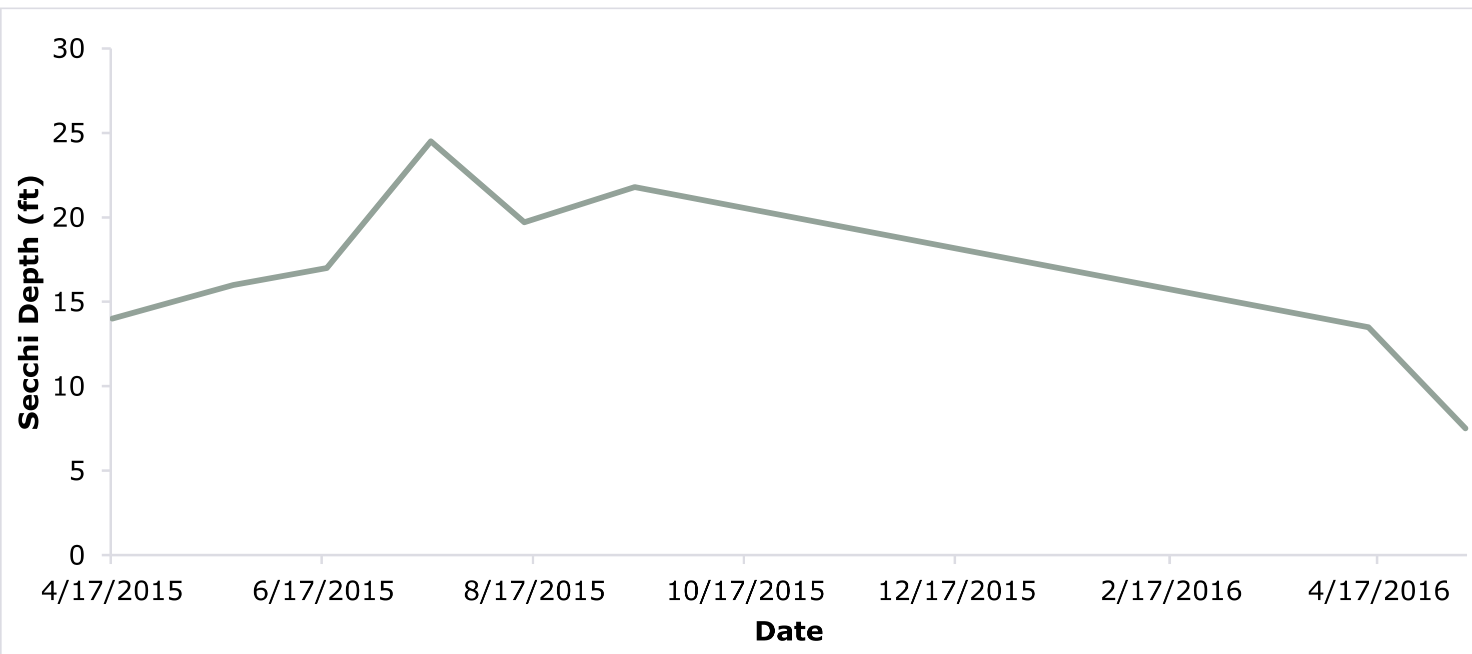


Figure 33: Lower Herring Lake Secchi disk reading at WS-9 2012-2016

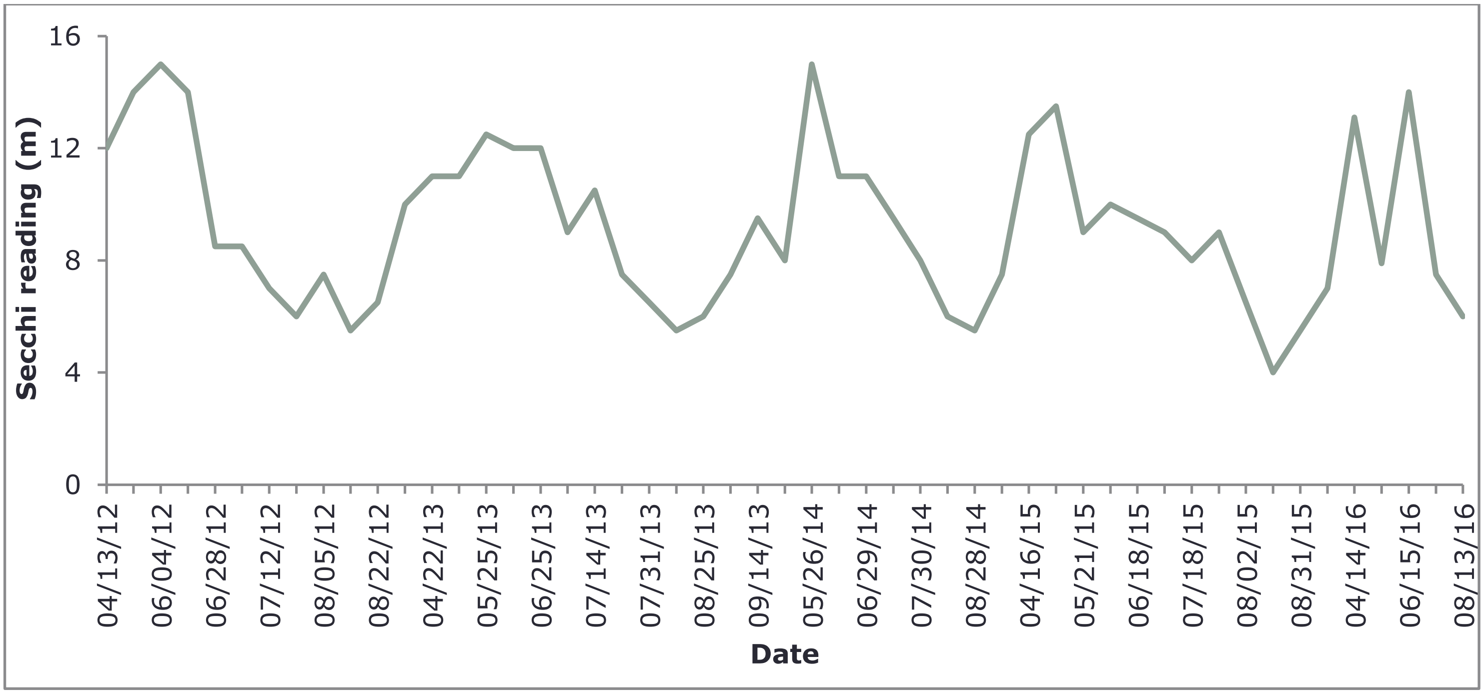


Figure 34: Upper Herring Lake Secchi disk reading at WS-10 - 2012-2016

Groundwater

Samples were also gathered from two groundwater locations (i.e., GW-1 and GW-2). GW-2 is near the southeast end of UHL and GW 1 is near the Northeast end of LHL (see Figure 23 on page 105). The GW-1 locations show a slightly higher TP readings (i.e., 0.19 ug/L) compared to GW-2 (i.e., 0.04 ug/L). Conversely nitrates were higher in GW-2 (0.12 ug/L) compared to 0.01 on GW-1 (see Table 25).

Table 25: Average Total Phosphorus (TP), Total Kjehldahl Nitrogen (TKN), Ammonia (NH_3), Nitrates (NO_3) mg/l readings for ground water locations in the Herring Lakes Watershed

Site #	NO_3	TP	TKN	NH_3	Chloride
GW-1	0.01	0.19	0.73	0.02	18.73
GW-2	0.12	0.04	0.30	0.10	16.20

Plankton of Upper and Lower Herring Lakes[36]

A plankton study was conducted on Upper Herring Lake (UHL) and Lower Herring Lake (LHL) during 2015 and 2016. UHL was sampled on six different dates and LHL was sampled on three dates.

Lower Herring Lake Plankton

Lower Herring Lake has a much more diverse plankton community compared to Upper Herring Lake. The phytoplankton population is much lower in concentration and much more diverse with numerous green algae (*Chlorophyta*), blue green algae (*Cyanobacteria*) and Diatoms in the spring. The phytoplankton population was found to peak in the summer, as expected. Populations as measured by Secchi disk indicate the density of plankton is higher in Upper Herring Lake than in Lower Herring Lake. Secchi disc measures the clarity of water. The Secchi disk can provide a relative plankton population level in lakes since the visibility of the Secchi disk (depth) increases with decreases in the plankton population. Secchi disk readings in Lower Herring Lake range from 22 feet in April to 7.5 feet in August, indicating significant plankton growth as Upper and Lower Herring lake water warms during summers. It was observed the largest increase of phytoplankton as the water warms are blue green algae.

Green Algae	Blue Green Algae	Diatoms
Euglena	*Microcystis*	*Fragilaria*
Microspora	*Chrococcus*	*Tabellaria*
Spirogyra	*Anabaena*	*Stephanodiscus*
Ulothrix	*Nodularia*	*Navicula*
Oedogonium	*Anacystis*	

[36] Written by David Long, Upper Herring Lake Association.

Lower Herring Lake has a diverse zooplankton population. A variety of Copepods, Rotifers, and Cladocera were found in each of the samples.

Copepoda	***Rotifera***	***Cladoceran***
Calaniod Copepod	*Keratella*	*Bosmina*
Cyclopoid Copepod	*Conochilus*	*Polyphemus*
Copepod nanplii		*Harpacticoid*

Upper Herring Lake Phytoplankton

Upper Herring Lake has considerably more plankton, yet plankton species diversity is less than within Lower Herring Lake. Upper Herring phytoplankton is dominated by *Microcystis*, a blue green alga (*Cyanobacteria*), and there were much fewer green algae (*Chlorophyta*) and no diatoms were found in any of the six (6) samples.

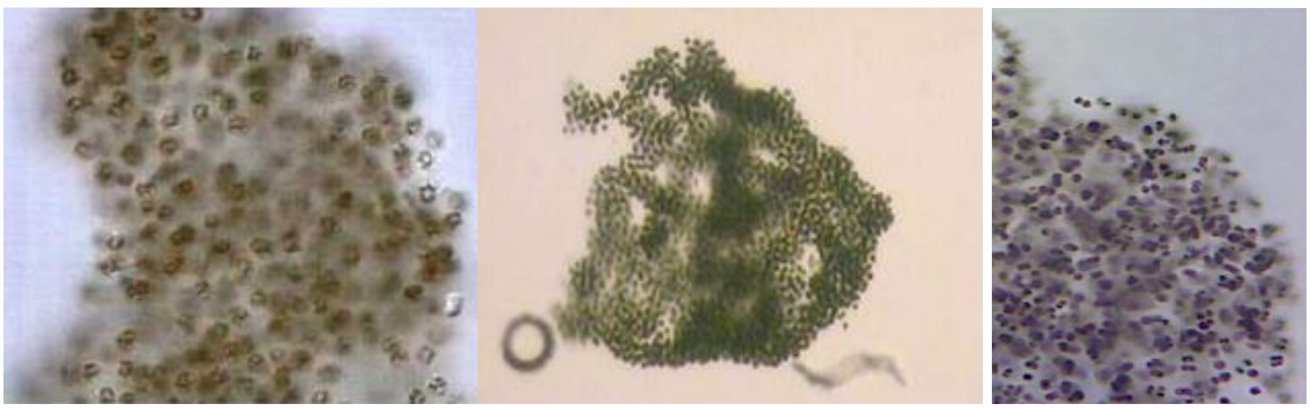
Upper Herring Lake's dominant phytoplankton is *Microcystis* which is found in large colonies that by mid-summer become visible with the naked eye suspended in the water. The small individual cells multiply into many thousands per colony which are imbedded in a mucilage. There are many shapes and sizes of the *Microcystis* colonies. The phytoplankton population peaks in late July or early August as the water temperature warms. Secchi disc readings in Upper Herring Lake range from an average of twelve (12) feet in April to five (5) feet in August, indicating a significant phytoplankton population. Another observation which was made in mid-August 2016 included a large mass of *Hydridictyon*, known as "water net" on the east shore of Upper Herring Lake. Based on discussions with several residents along the eastern shore, this was the first year that it was observed.

Green Algae (*Chlorophyta*)	**Blue Green Algae (*Cyanobacteria*)**
Euglena	*Microcystis*
Microspora	*Chrococcus*
Spirogyra	*Anacyctis*
Hydrodictyon	

The zooplankton population of Upper Herring Lake was quite small, and not as diverse as the zooplankton in Lower Herring Lake. The dominate zooplankton were *Rotifers* with only small populations of *Copepods*. The explanation for the lower populations of zooplankton in both lakes is not readily understood.

Copepoda	***Rotifera***	***Cladocera***
Cyclopoid Copepod	*Keratella*	*Bosmina*
		Polyphemus

Microcystis cells are small, i.e., only a few microns in diameter, and lack individual mucilage sheaths. The cells are usually arranged in colonies that are initially spherical but become irregular or perforated over time. The cells may be grouped tightly or sparsely within the fine, colorless colonial mucilage. The colonies are free-floating and may be composed of clustered sub-colonies.



***Microcystis* colonies**

Phytoplankton Conclusions:

The abundance of *Microcystis* algae in Upper Herring appears to be inhibiting the diversity of both phytoplankton and zooplankton in the lake. Currently, it is not known if the dominance of *Microcystis* is reducing the diversity by competition for nutrients or from a toxic effect. The *Microcystis* in Lower Herring Lake is much less than Upper Herring Lake, but appears more prevalent in 2016 than it was in 2015. It is assumed that the *Microcystis* is entering Lower Herring Lake through Herring Creek. The dominance of *Microcystis* could also be a concern and further study is recommended. Some species of *Microcystis* can produce the toxin, *Microcsytin*, which can be toxic to aquatic life and humans. To date we have not seen any fish kills and no toxic effects for swimmers have been reported. Body contact with

Microcsytin during water recreation may lead to minor skin irritations or allergic reactions of skin, including eye irritation and blistering of the lips.

It is recommended that additional assessment be completed to verify the identification of *Microcystis*. It is also recommended that this *Microcyctis* be identified by species. *Microcystis* growth is stimulated by nutrients and warm water temperatures. 2016 was observed as a warm year, and the water temperature had reached 78 degrees F in the Herring Lakes.

Finally, the appearance of the large bloom of *Hydridictyon* on the east shore on Upper Herring Lake is also an indication of eutrophication of Upper Herring Lake.

Tributaries

Parameters including Total Phosphorus (TP), Nitrates/Nitrites (NO3), Turbidity and Chloride (Cl) were monitored on tributaries in the Herring Lakes Watershed at eight (8) select tributary sites within the Herring Lakes Watershed (i.e., WS-1 through WS-8). Other parameters including pH, Specific Conductivity, Dissolved Oxygen and Temperature were monitored using a hand-held Hydrolab unit. These tributaries were monitored from April to November in 2015, and April to August in 2016.

The average results for each tributary are shown in Table 26 below:

Table 26: Average Concentrations of Chlorides (Cl mg/L), Total Phosphorus (TP ug/L), Turbidity (mg/L) and Nitrates (NO3-N) (mg/L) in Herring Lakes Watershed Tributaries

Station	Average of Cl (mg/l)	Average of TP (ug/l)	Average of Turbidity	Average of NO3-N (mg/l)
WS-1	13.1	6.5	3.1	0.2
WS-2	12.2	11.4	5.3	0.4
WS-3	9.5	17.4	9.2	0.4
WS-4	10.3	17.5	5.4	1.3
WS-5	16.1	36.7	4.5	3.6
WS-6	8.6	10.4	2.7	2.3

WS-7	10.3	6.8	2.5	2.1
WS-8	12.1	14.0	5.6	1.2

Average Total Phosphorous concentrations at WS-2, WS-3, WS-4, WS-5, WS-6 and WS-8 exceeded the US EPA recommended TP concentration of 10.0 ug/L. Such analytical results suggest the potential impairment of water quality within Herring Lakes tributaries (see Table 27). Sources of this phosphorous are likely runoff from surrounding upland and wetland areas (i.e., WS-5), and contribution from impaired groundwater at high density residential areas along the shores of both lakes (i.e., GW-1 and GW-2).

Table 27: Average Total Phosphorus Concentrations (TP, ug/L) in Herring Lakes Watershed Tributaries

Station	*Average of TP (ug/l)*	*Min*	*Max*
WS-1	6.5	5.4	8.3
WS-2	11.4	6.0	15.5
WS-3	17.4	6.7	42.5
WS-4	17.5	11.3	26.4
WS-5	36.7	15.1	60.3
WS-6	10.4	6.1	15.8
WS-7	6.8	5.0	9.2
WS-8	14.0	7.0	31.6

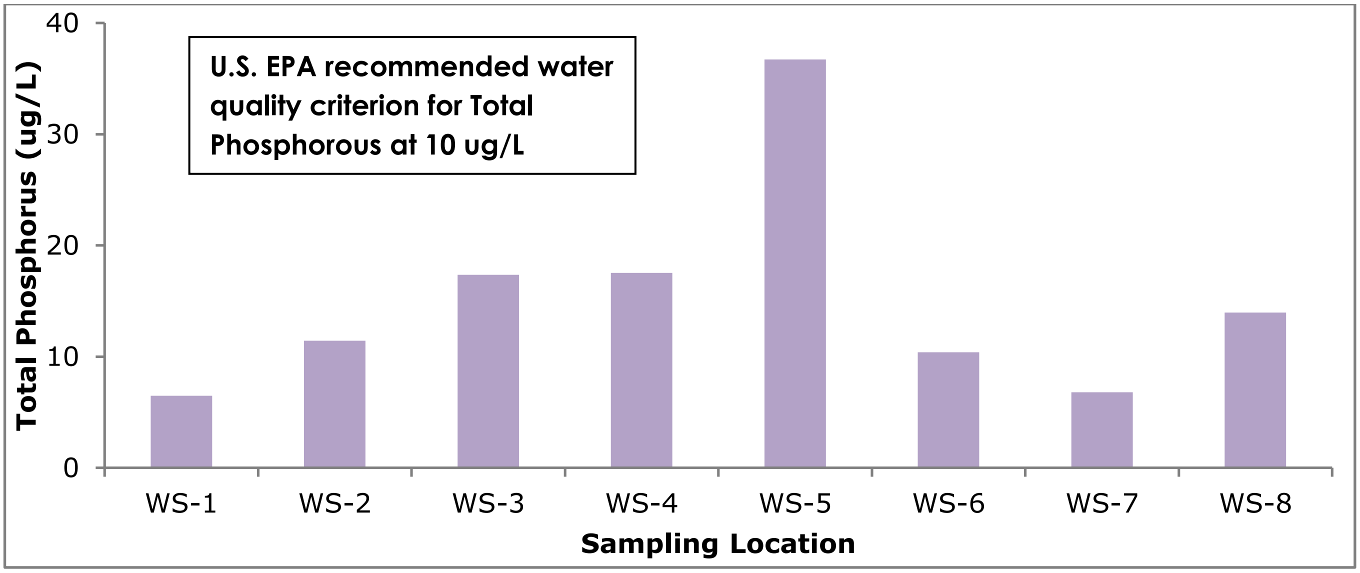


Figure 35: Average Total Phosphorus Concentrations (ug/L) - Herring Lakes Watershed tributaries, 2015-2016

Table 28: Total Phosphorus (ug/L) by Date - Herring Lakes Watershed Tributaries

Date	WS-1	WS-2	WS-3	WS-4	WS-5	WS-6	WS-7	WS-8
5/21/15	5.9	8.6	10.3	14.2	21.4	8.7	5.2	12.0
6/17/15	5.8	10.3	11.1	20.6	29.3	8.9	8.1	13.2
7/17/15	6.8	15.4	26.5	24.0	44.5	10.0	5.0	31.6
8/13/15	7.6	15.2	16.4	19.5	60.3	14.2	8.2	14.1
9/14/15	7.6	13.4	16.2	16.5	50.1	10.7	9.1	12.2
4/13/16	8.3	9.0	7.9	11.7	15.1	15.8	6.0	8.2
5/11/16	5.8	6.0	15.0	11.3	17.4	13.0	6.0	7.0
6/14/16	---	15.5	16.2	26.4	43.6	11.4	9.2	14.6
7/12/16	5.4	13.7	42.5	18.4	48.0	7.1	5.3	14.3
4/16/15	5.7	9.0	6.7	14.5	23.1	6.1	5.6	14.9
8/10/16	5.8	9.5	22.1	15.6	51.2	8.3	7.0	11.5

U.S. EPA recommended water quality criteria for Total Phosphorous at 10 ug/L

Michigan does not possess a water quality criterion for TIN, but an acceptable U.S. EPA range of TIN is 2 mg/L to 6 mg/L. The table above shows that the average TIN for monitored tributaries exceeded the lowest U.S. EPA recommended concentration of 2 mg/L at sample locations WS-5, WS-6 and WS-7 suggesting the likely degradation of water quality within Herring Lakes tributaries (see Table 29 and Figure 36 below). Sources of this Nitrogen are likely runoff from surrounding upland and wetland areas.

Table 29: Calculated Total Inorganic Nitrogen (TIN) (MG/L) – Herring Lakes Tributaries 2015-2016

Date	WS-1	WS-2	WS-3	WS-4	WS-5	WS-6	WS-7	WS-8
4/16/15	0.30	0.60	0.65	1.31	0.05	2.41	1.68	1.33
5/21/15	0.26	0.56	0.56	1.31	3.45	1.84	2.17	1.34
6/17/15	0.25	0.43	0.41	0.89	2.30	2.30	1.84	0.30
7/17/15	0.08	0.24	0.26	1.52	4.55	2.10	2.14	1.27
8/13/15	0.00	0.12	0.10	1.70	4.94	2.30	2.08	1.04
9/14/15	0.02	0.60	0.04	1.07	4.02	2.56	2.24	1.11
4/13/16	0.31	0.60	0.57	1.35	2.15	2.78	2.13	1.13
5/11/16	0.25	0.56	0.59	1.40	2.65	2.41	2.02	1.20
6/14/16	0.30	0.47	0.49	1.45	4.94	2.27	2.36	1.33
7/12/16	0.23	0.21	0.19	1.42	4.58	2.11	1.69	1.28
8/10/16	0.12	0.01	0.01	1.43	5.03	2.37	2.34	1.36

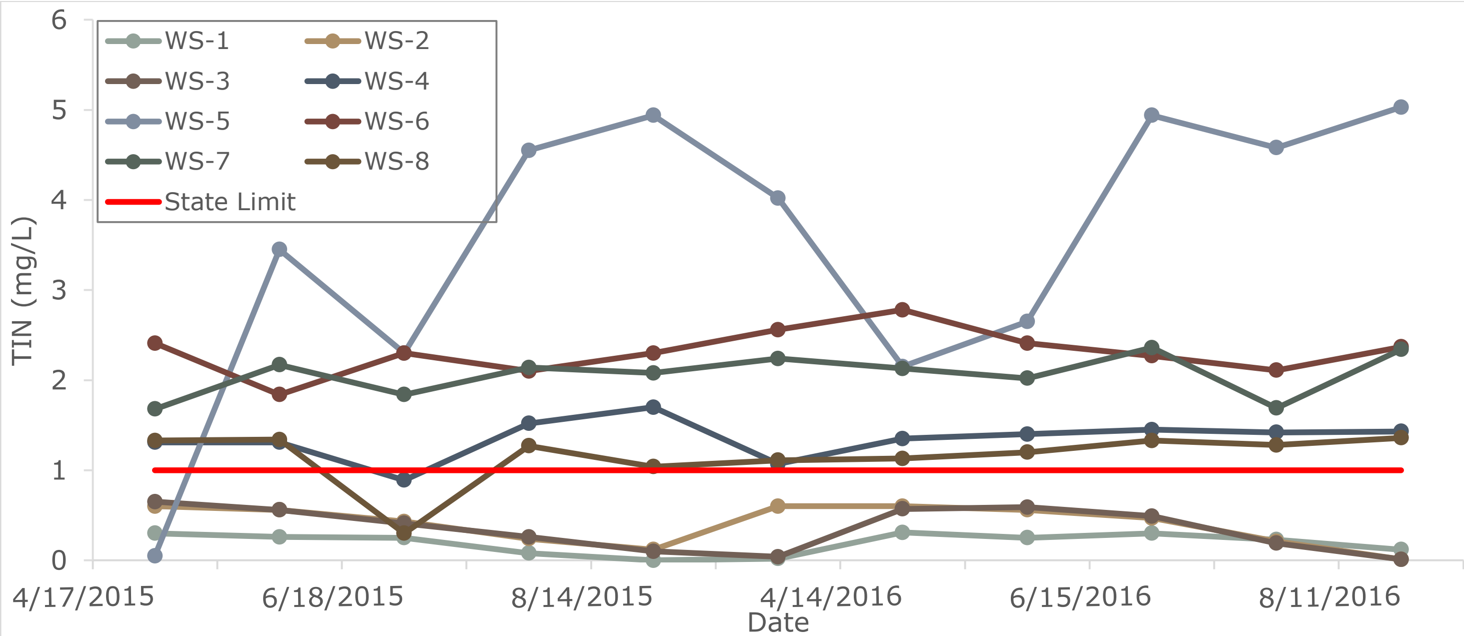


Figure 36: Calculated Total Inorganic Nitrogen (TIN) (mg/L) – Herring Lakes Tributaries 2015-2016

Chloride concentrations within tributaries to the Herring Lakes for 2015-2016 was well below the U.S. EPA has a recommended chronic criterion for Cl for aquatic life of 230 mg/L (Michigan does not possess a water quality criterion for Cl). The average Cl concentrations for all depths for both lakes are also well-below the U.S. EPA recommended chronic criterion (see Table 21, Table 30, and Figure 37).[37]

[37] As referenced in the USGS National Water-Quality Assessment Program, Chloride in Groundwater and Surface Water in Areas Underlain by the Glacial Aquifer System, Northern United States, Scientific Investigations Report 2009-5086.

Table 30: Chloride (mg/l) Concentrations by date - Herring Lakes Watershed Tributaries

Date	WS-1	WS-2	WS-3	WS-4	WS-5	WS-6	WS-7	WS-8
4/16/15	11	9	10	9	13	8	8	11
5/21/15	20	21	12	11	16	9	11	14
6/17/15	12	14	10	9	16	8	8	9
7/17/15	14	11	14	15	20	11	13	22
8/13/15	14	13	12	13	23	17	15	11
9/14/15	12	17	9	11	21	8	10	12
4/13/16	8	7	6	8	12	5	7	10
5/11/16	18	16	7	10	13	8	9	13
6/14/16		10	9	11	16	9	12	11
7/12/16	10	7	6	7	14	5	7	10
8/10/16	12	9	10	9	13	7	13	10

U.S. EPA recommended chronic criterion for Cl for aquatic life of 230 mg/L.

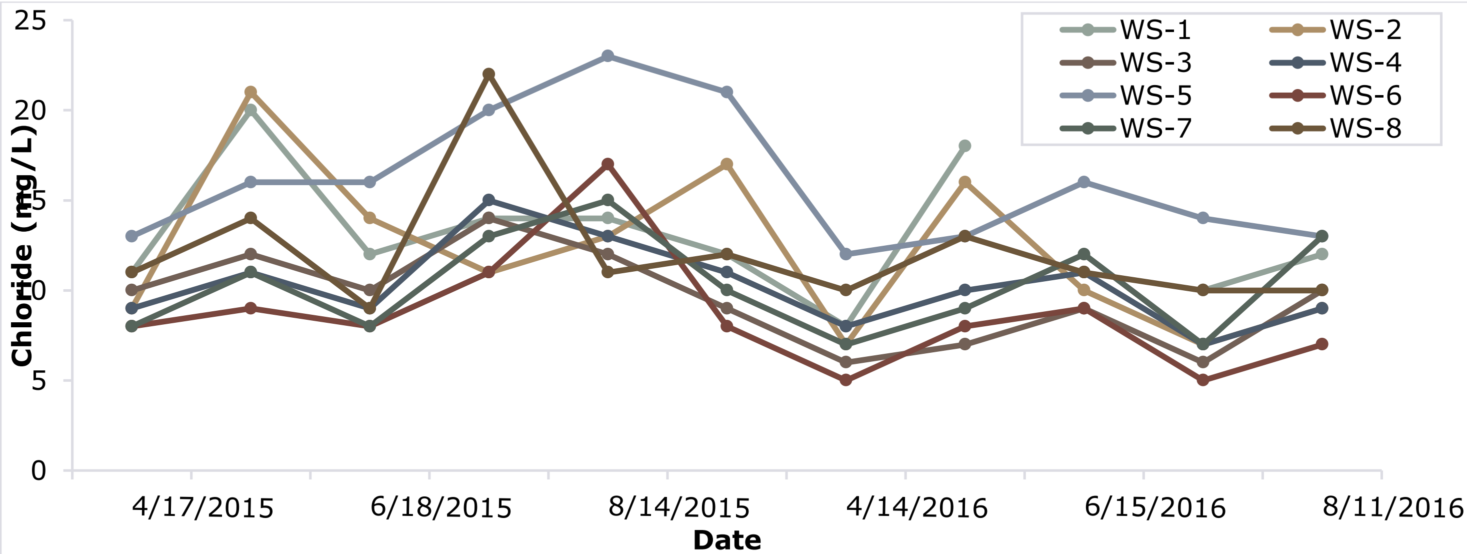


Figure 37: Chloride (mg/L) Concentrations Herring Lakes Watershed Tributaries 2015-2016

U.S. EPA recommended chronic criterion for Cl for aquatic life of 230 mg/L.

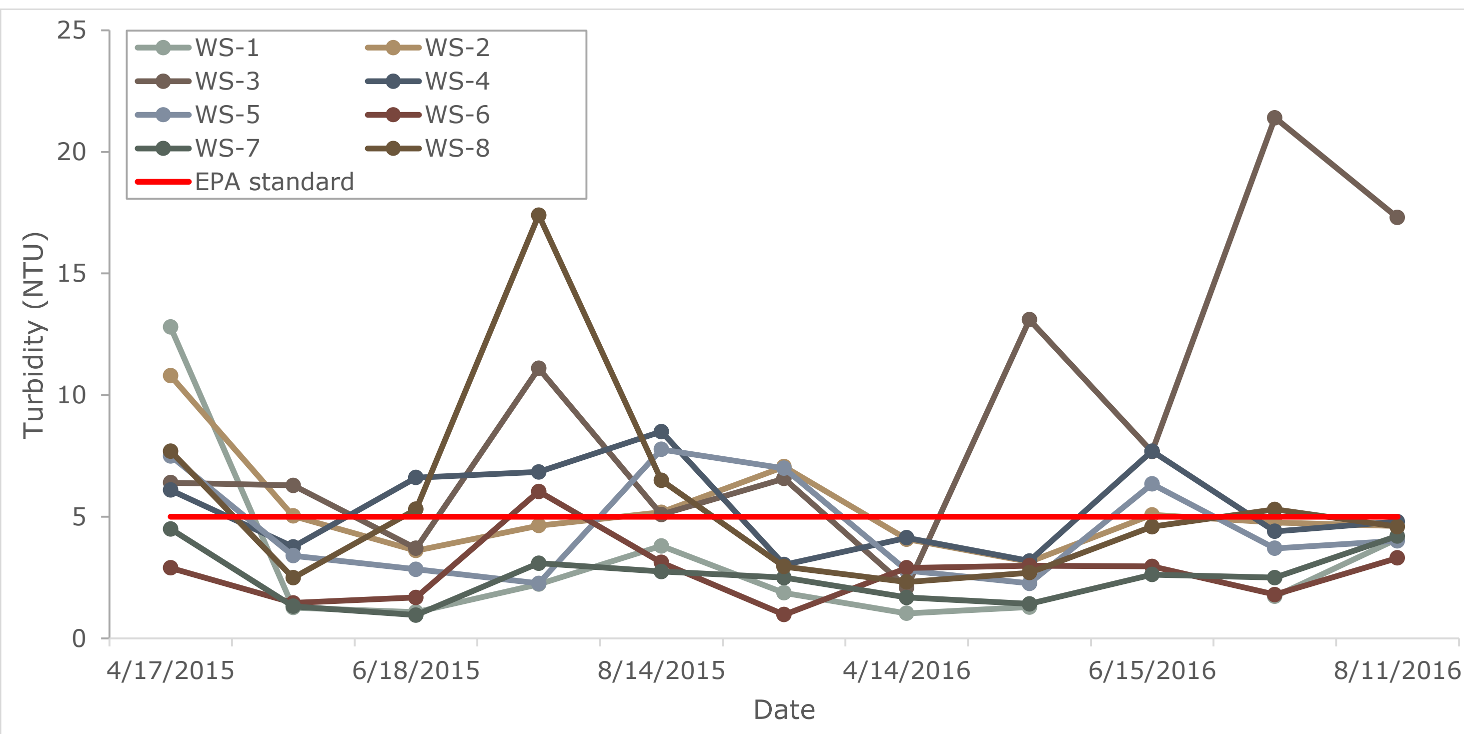


Figure 38: Turbidity (ntu) in the Herring Lakes Watershed Tributaries 2015-2016

Hydrolab results from the Herring Lakes tributaries show that the average pH ranged from 7.97 at WS-4 to 8.15 at WS-1, WS-3 and WS-8 (see Table 31 below). Specific Conductivity ranged from 320.97 æS/cm at WS-1 to 620.45 æS/cm at WS-5 (see Table 31 below). Dissolved Oxygen in Herring Lakes Watershed tributaries ranged from 9.27 mg/L at WS-2 to 10.93 mg/L at WS-4. The highest average temperature was 61.9 degrees (F) on WS-3 and the lowest average temperature was on both WS-4 (50.4 F; see Table 31).

Table 31: Average Hydrolab readings by Sample Station for Herring Lakes Watershed Tributaries

Station	pH	Sp Cond (æS/cm)	DO (mg/L)	Temperatue Deg (F)
WS-1	8.1	320.9	9.5	61.2
WS-2	8.0	338.4	9.3	60.2
WS-3	8.1	335.7	9.4	61.9
WS-4	7.9	400.8	10.9	50.4
WS-5	7.9	620.4	9.7	54.8
WS-6	8.1	365.5	10.6	54.5
WS-7	8.0	423.1	10.5	50.9
WS-8	8.1	409.8	10.8	51.3

Average pH within tributaries to the Herring Lake for 2015-2016 was well within the Michigan standard range for surface waters (i.e., pH 6-9) (see Figure 39).

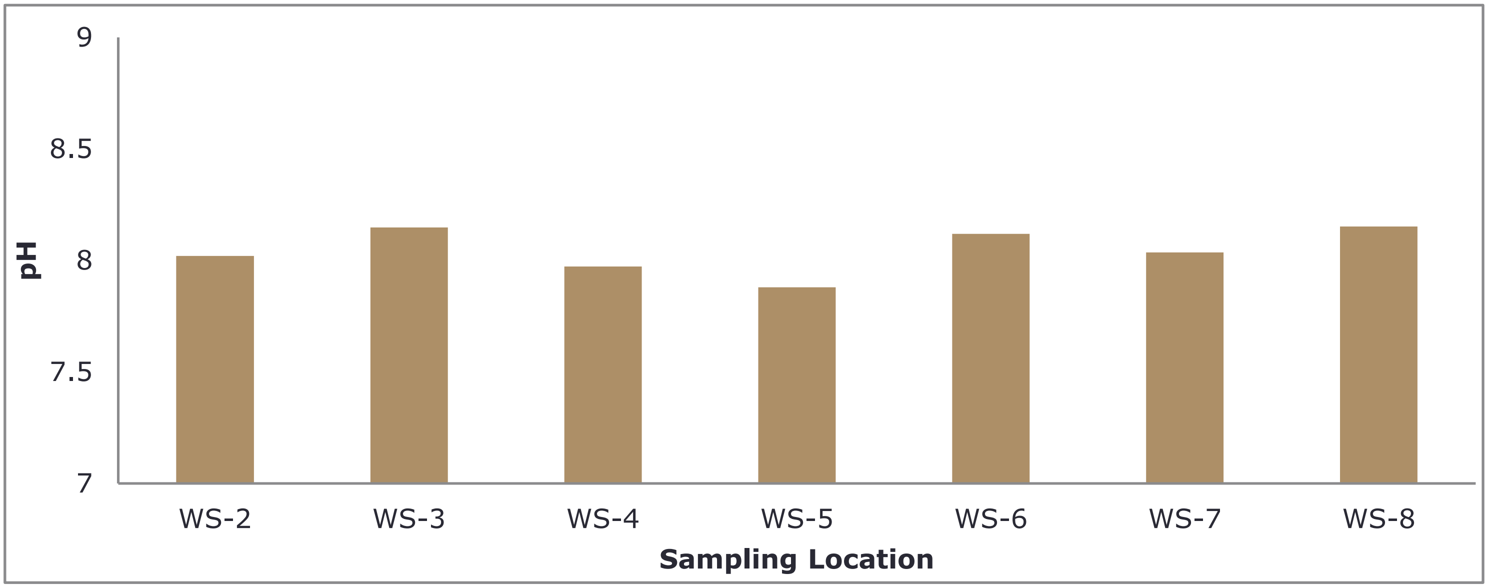


Figure 39: Average pH by sampling station for Herring Lakes Watershed Tributaries

Average Dissolved Oxygen within tributaries to the Herring Lake for 2015-2016 was well-above the Michigan minimum standard for surface waters (see Figure 40).

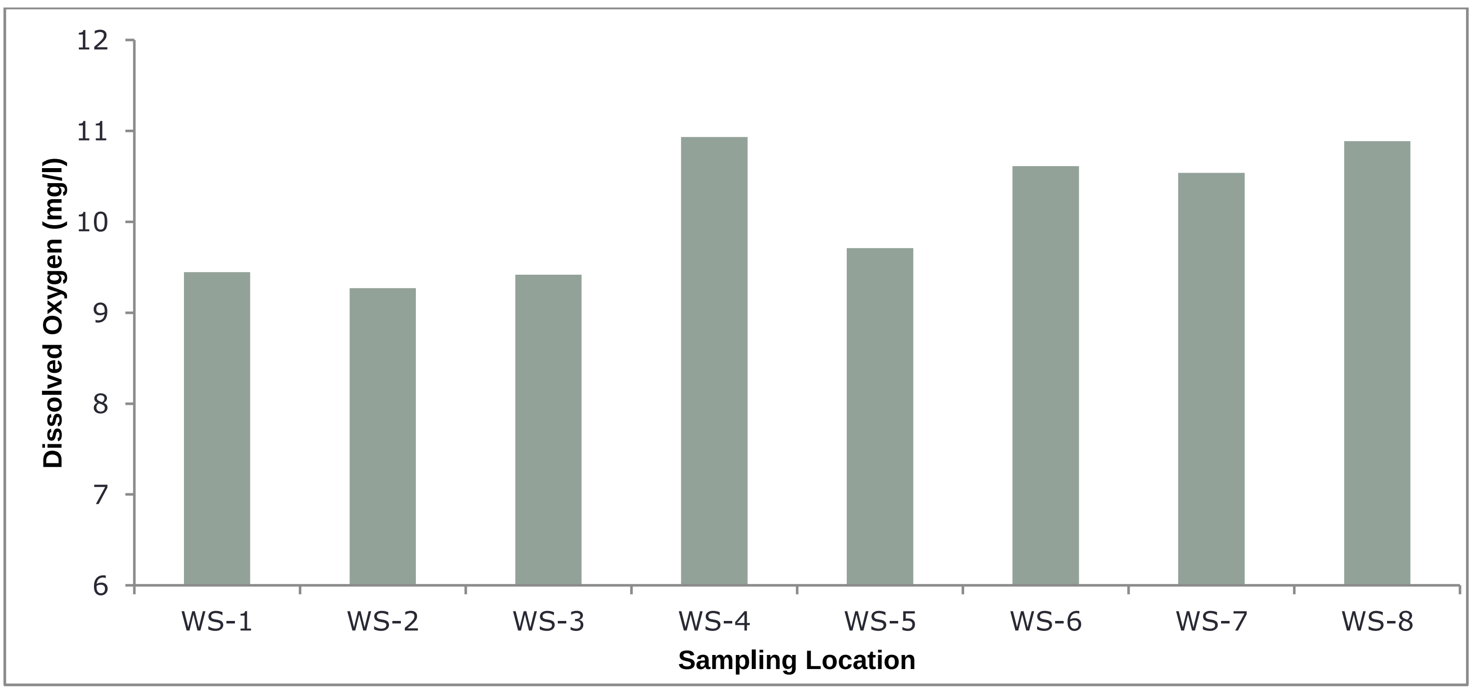


Figure 40: Average Dissolved Oxygen (DO) readings by Sample Station for Herring Lakes Watershed Tributaries

Michigan's monthly maximum temperature water quality standards apply only to permitted discharges, and used here as reference only for ambient water temperature measurements from tributaries within the Herring Lakes Watershed. Average temperature within Herring Lakes tributaries for 2015-2016 by reference are above Michigan monthly maximum criteria at WS-1, WS-2, WS-3 during the summer months, and at WS-5 during the autumn months (see Table 32 and Figure 42).

Table 32: Average Temperature (degrees Fahrenheit) by Month - Herring Lakes Tributaries

Station	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*
WS-1	41.7	41.7	66.1	71.4	75.7	68.3	55.9	51.2
WS-2	44.5	53.3	65.9	70.8	72.8	65.6	50.5	47.1
WS-3	44.7	55.4	67.9	72.2	75.3	68.2	51.2	48.5
WS-4	43.2	47.2	49.0	56.5	57.2	54.3	44.8	43.3
WS-5	45.2	50.3	59.7	59.1	62.2	58.4	49.4	44.3
WS-6	48.7	54.0	59.0	59.6	56.7	56.1	46.4	46.3
WS-7	46.1	50.4	53.1	53.0	53.9	52.2	46.9	45.7
WS-8	43.9	47.9	55.2	53.1	56.6	54.2	45.7	43.9
State reference criteria	**54.0**	**65.0**	**68.0**	**68.0**	**63.0**	**56.0**	**48.0**	**40.0**

Conductivity results show that the majority of the streams, with the exception of WS-5, are within the ideal range for conductivity in streams, which is below 500 uS/cm (see Figure 39). However, conductivity below 1,000 uS/cm is considered an adequate value, but conductivity above 1000 uS/cm would be cause for concern.[38]

[38] http://fosc.org/WQData/WQParameters.htm

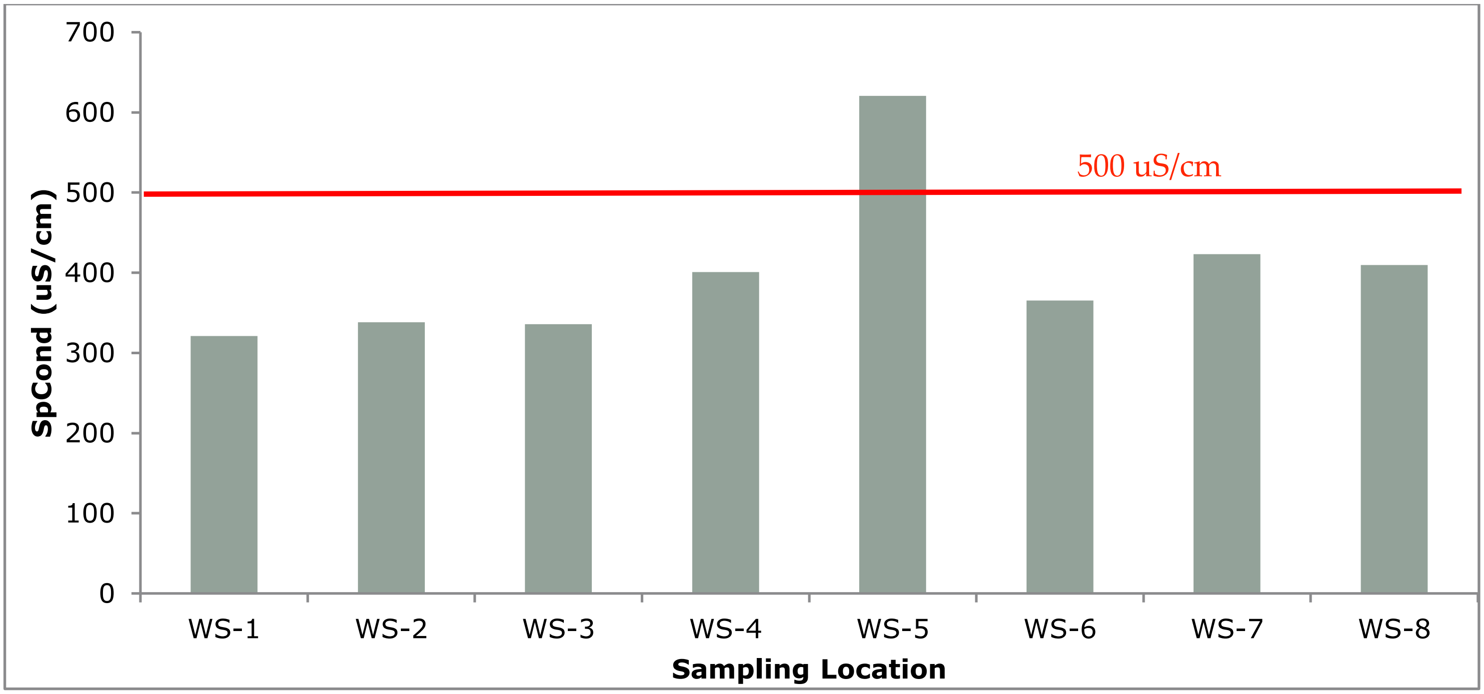


Figure 41: Average Conductivity (uS/cm) for Herring Lakes tributaries from 2015-2016

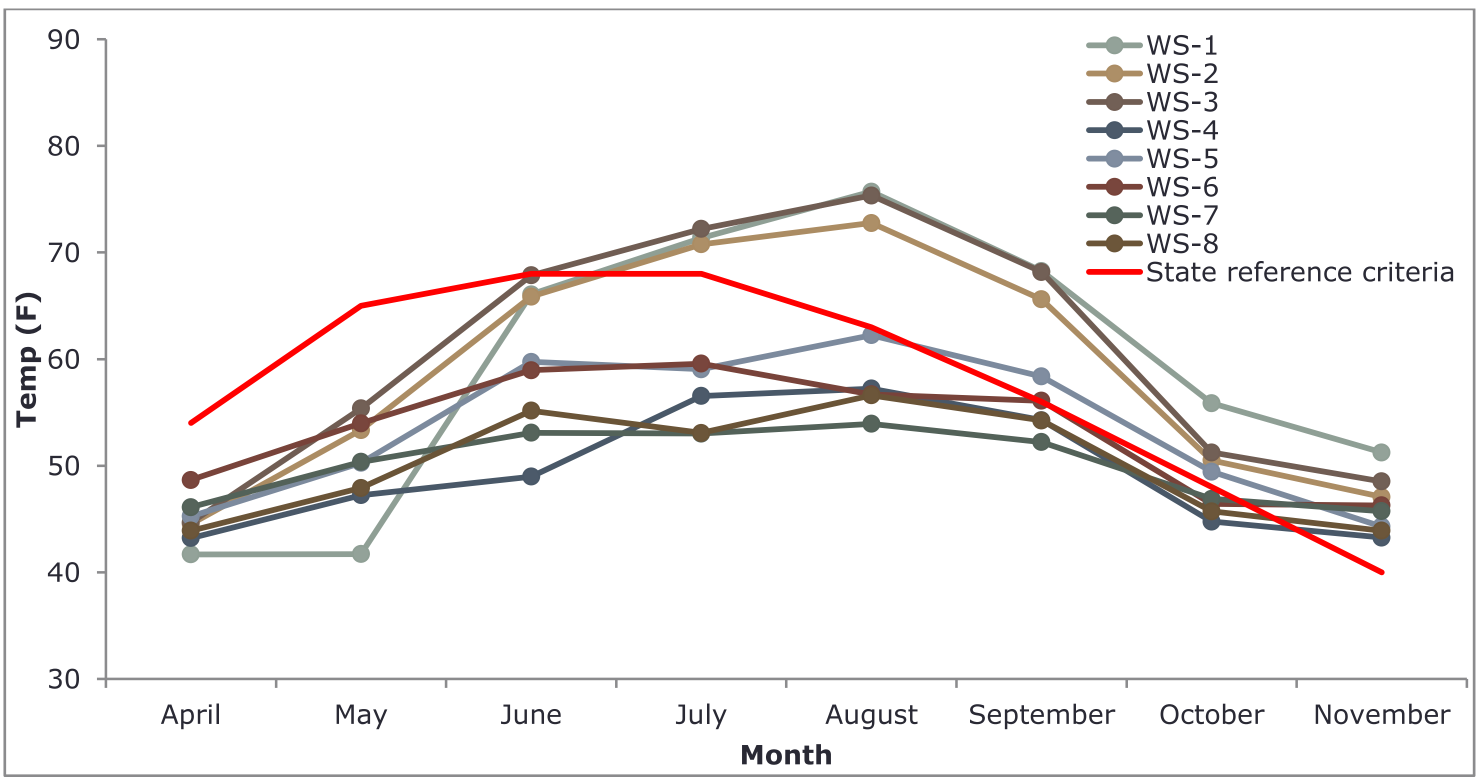


Figure 42: Average Temperature (degrees Fahrenheit) by Month for Tributaries in the Herring Lakes Watershed

E. coli

Tributaries to the Herring Lakes were also sampled monthly for *E. coli* bacteria. *E. coli* sample results at WS-4 (i.e., inlet to Upper Herring at Gorivan Road), WS-5 (i.e., tributary to Upper Herring Lake on Putney Road) and WS-8 (i.e., within the Herring Swamp upstream of Upper Herring Lake), and the average *E. coli* during 2015-2016 at WS-5 exceeded Michigan's surface water quality standard of 300 colonies/100mL. Note that maximum *E. coli* values for WS-4 and WS-5 exceed laboratory quantification methods, hence 2015-2016 average *E. coli* values for both WS-4 and WS-5 are very likely underestimated.

Average *E. coli* concentrations at all other tributary water sample locations within the Herring Lakes Watershed were very low, showing numbers well-below the state limit (see Table 33 and Figure 43).

Table 33: Average *E. coli* - Herring Lakes Watershed Tributaries 2015-2016

Station	*E. coli (colonies/100 mL)*	*State Standard*	*Min*	*Max*
WS-1	18.8	300	0.0	172.0
WS-2	70.1	300	15.0	201.0
WS-3	34.1	300	1.0	248.0
WS-4	462.6	300	7.0	2,419.0*
WS-5	543.9	300	1.0	2,419.0*
WS-6	54.8	300	1.0	291.0
WS-7	45.9	300	1.0	238.0
WS-8	220.6	300	40.0	687.0

*** = *E. coli* values exceed laboratory maximum quantification method**

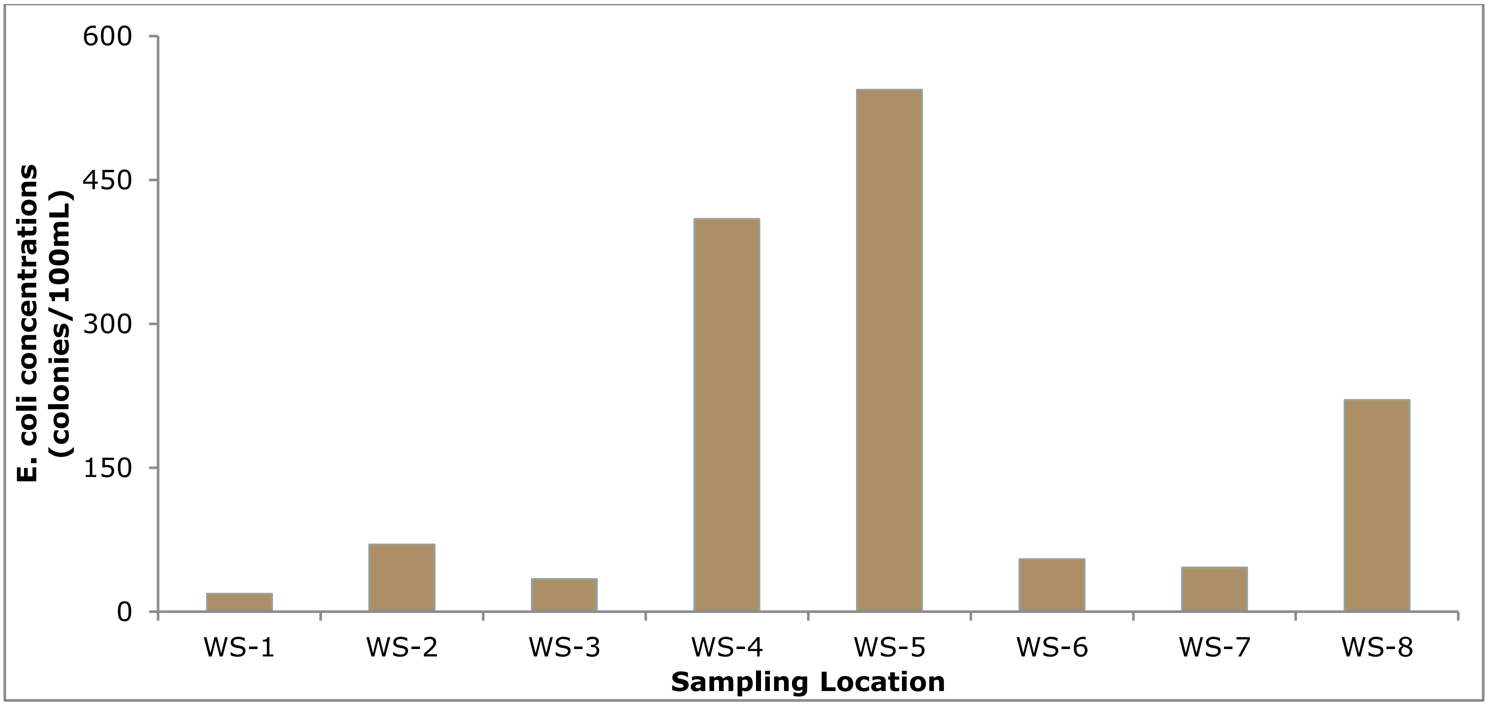


Figure 43: Average *E. coli* readings (colonies/100mL) for Tributaries in the Herring Lakes Watershed for 2105-2016

E. coli numbers based on accompanying DNA analysis were primarily wildlife in source (not specific to any wildlife). There were a few instances of bovine but no human *E coli* was confirmed with DNA analysis. Caffeine was also analyzed during select sample events at WS-2 (i.e., Lower Herring Lake inlet at Elberta Resort) and WS-4 (i.e., Upper Herring Lake inlet at Gorivan Road) (Table 34). Caffeine can be used as a marker of human activity or waste, as humans are the only know users/sources of caffeine in the environment. Caffeine water sample results do not strongly support human sources of *E. coli* or nutrients or potential sources of from human waste at WS-2 or WS-4.

Table 34: *E. coli* and Caffeine results for two tributaries (WS-2 & WS-4)

Station	Date	E coli	Caffeine
WS-2	8/20/15	108	ND
WS-4	8/20/15	199	ND
WS-2	9/29/15	68	0.0002
WS-4	9/29/15	129	0.0006
WS-2	10/28/15	201	ND
WS-4	10/28/15	65	0.0002
WS-2	11/18/15	28	ND
WS-4	11/18/15	7	ND
WS-2	12/17/15	33	ND
WS-4	12/17/15	126	ND

(ND = non-detect)

DNA/Microbial Source Tracking results for three tributaries (i.e., WS-2, WS-4 and WS-5)

Microbial Source Tracking (MST) analyses from water sample locations indicating high *E. coli* results (i.e., WS-2, WS-4 and WS-5) were collected from on 8/12/2015 to 8/10/16 from tributaries within the Herring Lakes. Samples were analyzed for: a) Bacteroides human specific marker (*B. theta*), Bacteroides bovine specific marker (*bobac*) and the Enterococci human specific marker (*esp*). Enterococci human specific marker (*esp*) was not detected in the submitted samples. Bacteroides bovine specific marker (*bobac*) was detected at WS-4 (i.e., tributary culvert at Gorivan Road crossing) in August and September of 2015 and in July of 2016. The Bacteroides human specific (*B. theta*) marker was also detected at WS-4 in July of 2016.

E. coli numbers based on accompanying DNA analysis were primarily wildlife in source (not specific to any wildlife). There were a few instance of bovine but no human *E. coli* was confirmed with DNA analysis. Caffeine is qualitative marker of potential human sources of *E coli* when follow-up sampling was done when/where high *E. coli* numbers were found.

See Appendix C for a summary of the results from 2015-2016 Microbial Source Tracking in Herring Lake, October 3, 2015, Prepared by Matthew Flood, Department of and Wildlife, Michigan State University.

CHAPTER 5: THREATS TO WATER QUALITY IN THE HERRING LAKES WATERSHED

5.1 Water Quality Standards and Designated Uses

Each of Michigan's surface waters is protected by water quality standards for specific designated uses (see Table 35). Designated uses as defined by the State of Michigan are recognized uses of water established by state and federal water quality laws designed to: 1) protect the public's health and welfare; 2) enhance and maintain the quality of water; and 3) protect the state's natural resources.

Table 35: Designated Uses for Surface Waters in the State of Michigan

Surface waters in the state of Michigan are designated for and shall be protected for all of the following uses:
1. Agriculture
2. Industrial water supply
3. Navigation
4. Warm-water fishery
5. Other indigenous aquatic life and wildlife
6. Partial body contact recreation
7. Total body contact recreation between May 1 – October 31
8. Fish Consumption

Citation: R323.1100 of Part 4, Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended

Table 36: State of Michigan Water Quality Standards 3106

Pollutant	*Water quality standards**	*Designated Uses affecting the Herring Lakes Watershed*
pH	6.5 to 9/0	All but navigation
Taste or odor-producing substances	Concentrations which impair or may impair their use	Industrial Water Supply, Agricultural Water Supply, and Fish Consumption
Toxic substances (selected shown here; see rule for complete listing)	DDT and metabolites: 0.00011 mg/m3; Mercury, including methylmercury: 0.0013 mg/m3; PCBs (class): 0.00012 mg/m3; 2,3,7,8-TCDD: 0.0000000031mg/m3 or equivalent units	All but navigation
Radioactive substances	Pursuant to U.S nuclear regulatory commission and EPA standards	All but navigation
Plant nutrients	Phosphorus: 1mg/L monthly average for permitted point-source discharges	All
Microorganisms	130 *Escherichia coli* per 100 mL 30-day mean of 5 or more sampling events 300 *E. coli* per 100 mL 30-day maximum 1,000 *E. coli* per 100 mL 30-day maximum	Total body contact recreation Total body contact recreation Partial body contact recreation

Table 36 (Cont'd): State of Michigan Water Quality Standards 3106

Pollutant	*Water quality standards**	*Affected Designated Uses*
Dissolved oxygen	Minimum 7 mg/L for cold water designated streams, inland lakes, and Great Lakes/connecting waters; minimum 5 mg/L for all other waters Minimum 5 mg/L daily average	Cold water fishery Warm water fishery
Temperature	Natural daily and seasonal temperature fluctuations shall be preserved Monthly maximum for inland lakes: J F M A M J J A S 0 N D 45 45 50 60 70 75 80 85 80 70 60 50 Monthly maximum for inland streams in this watershed: J F M A M J J A S 0 N D 38 38 43 54 65 68 68 68 63 56 48 40	Cold water fishery, other indigenous aquatic life and wildlife, warm water fishery

*Data from Water Quality and Pollution Control in Michigan 2016 Sections 303(d), 305(b) and 314 Integrated Report, Michigan Department of Environmental Quality, Water Resources Division, November 2016, Revised January 2017, MDEQ/WRD-16/001.

5.2 Impaired Designated Uses

If a body of water or stream reach is impacted to the point of not meeting the water quality standards set for a specific designated use, then it is said to be in "nonattainment." A biennially published list of the bodies of water and stream reaches in the State of Michigan that are in nonattainment can be found in the MDEQ's Water Quality and Pollution Control in Michigan 2016 Sections 303(d), 305(b) and 314 Integrated Report.[39] The MDEQ uses a rotating watershed cycle for surface water quality monitoring where each of the 58 major watersheds in the state are scheduled for monitoring at least once every five years. The Herring Lakes watershed was last monitored in 2014 by the Surface Water Assessment Section and results determined that the designated uses were not impaired on a watershed-wide level at that time (see January 2011 SWAS Staff Report).

Due to widespread mercury contamination from industrial emissions occurring in other states lying upwind of Michigan (i.e., in terms of predominate weather patterns), all of Michigan's inland lakes, including lakes in the Herring Lakes Watershed, are not meeting water quality standards for fish consumption. Atmospheric deposition of PCBs or mercury is the primary cause of inland lakes not meeting water quality standards (MDEQ 2008). For further information on mercury sources in the environment and mercury pollution prevention strategies, please refer to publications by Sills (1992) and Mehan (1996), respectively. The problem of mercury contamination and other related toxic contamination problems (i.e., PCB, chlordane, etc.) in the Herring Lakes Watershed will not be discussed in depth in this Protection Plan, since it is caused by atmospheric deposition of industrial emissions from other states and the MDEQ does not consider it to be a treatable 303 (d) impairment through the watershed management planning process as there are state and federal level efforts being directed towards this pollutant.

Degraded water bodies are defined as those that currently meet water quality standards, but may not in the near future. Currently, two designated uses of the Herring Lakes Watershed are degraded from

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[39] Water Quality and Pollution Control in Michigan 2016 Sections 303(d), 305(b) and 314 Integrated Report, Michigan Department of Environmental Quality, Water Resources Division, November 2016, Revised January 2017, MDEQ/WRD-16/001.

inputs of nutrients, increasing human development along with exotic species introduction and proliferation. The HLWPP Steering Committee has identified the total body contact and partial body contact designated uses as degraded (see Table 37). Degraded designated uses were ascertained through water quality monitoring reports, steering committee members, and personal contact with watershed residents and scientific experts on the Herring Lakes Watershed.

Herring Creek (i.e.,16.6 miles long), Herring Creek (i.e., 5.5 miles long), Upper Herring Lake (i.e., 553.9 acres) and Lower Herring Lake (i.e., 434.4 acres) were assessed for all the designated uses including: Total and Partial Body Contact, Agriculture, Navigation, Industrial Water Supply, Warm Water Fishery, Other Indigenous Aquatic Life and Wildlife.

Table 37: Degraded or Impaired Designated Uses in the Herring Lakes Watershed

Designated Uses	
Total Body Contact	Degraded
Partial Body Contact	Degraded
Fish Consumption	Impaired

5.3 Desired Uses

Steering committee and stakeholder input identified the need for establishing Desired Uses to address concerns particular to the watershed that are not addressed by designated uses, which are based on state water quality standards. Desired uses are defined as the ways in which people use the watershed and how they would like to manage and protect the watershed to ensure the sustainability of those uses for future generations. They may range from very general to very specific. Desired uses often help to reflect more qualitative community concerns such as poor sport fishing opportunities or deterioration of scenic viewsheds. Desired uses for the Herring Lakes Watershed include uses for recreational, aesthetic, scenic viewsheds, human health, and ecosystem preservation (see Table 38).

Table 38: Desired Uses for the Herring Lakes Watershed

Desired Use Category	*Location*	*Purpose*
Maintain Existing Recreational Opportunities	Entire watershed	*Sustain high quality inland lake, cold water stream, hunting, paddling, swimming and boating
Aesthetics	Forested ridgelines, natural shorelines, view corridors and surface water bodies	*Protect scenic viewsheds *Maintain water clarity and water quality *Prevent excessive weed and algal growth
Human Health	Entire watershed	*Ensure agricultural activities are not impacting the waterbodies and human health *Protect the potable ground water supply *Protect inland lakes and streams for swimming
Ecosystem Preservation	Priority areas	*Promote sustainable watershed development *Protect fish & wildlife habitat *Preserve natural riparian and wildlife corridors

5.4 Pollutants, Sources, and Causes

There are a number of different pollutants and environmental stressors that adversely affect each of the designated and desired uses (see Table 39). The term environmental stressor is used to describe those factors that may have a negative effect on the ecosystem, but are not necessarily categorized as contaminants that change water chemistry. It is meant to address the wide range of environmental degradation experienced in the watershed. This plan will refer to classic watershed pollutants such as nutrients, sediment, and toxic substances, as well as environmental stressors such as habitat and wetland loss. Environmental stressors representing activities and conditions that negatively impact the designated and/or desired uses of the Herring Lakes Watershed include invasive species, loss of habitat, excess nutrients, and more (see Table 39).

Table 39: Pollutants and Environmental Stressors Affecting Designated Uses in the Herring Lakes Watershed

Pollutant or Environmental	*Designated Uses Affected*	*Desired Uses Affected*
Invasive Species	Warm water/Coldwater Fishery Other Indigenous Aquatic Life	Recreation and Aesthetics
Nutrients	Warm water/Coldwater Fishery Other Indigenous Aquatic Life	Ecosystem Preservation and Aesthetics
Pathogens (*E. coli*)	Total Body Contact	Human Health Recreation
Sediment	Warm water Fishery Other Indigenous Aquatic Life	Aesthetics Recreation Navigation
Altered Hydrology	Warm water/Coldwater Fishery Other Indigenous Aquatic Life	Aesthetics Recreation

Toxins (Pesticides, Herbicides, Oils, Gas, Grease, Salt/Chlorides, Copper Sulfate, Microcystis)	Warm water/Coldwater Fishery Other Indigenous Aquatic Life Fish Consumption	Human Health Aesthetics Ecosystem Preservation
Loss of Habitat	Warm water/Coldwater Fishery Other Indigenous Aquatic Life	Aesthetics Ecosystem Preservation
Thermal Pollution	Coldwater Fishery Other Indigenous Aquatic Life	Ecosystem Preservation

Note: This is a general list that encompasses stressors and/or pollutants for the entire Herring Lakes Watershed. Not all reaches in the watershed are impacted by all of the pollutants and/or stressors listed above.

Sources and Causes of Pollutants

A Comprehensive Watershed Protection Table was developed listing potential (p), suspected (s) and known (k) sources and causes of watershed pollutants and environmental stressors (see Table 40). This table summarizes key information necessary to focus on water quality protection, provides specific targets to act upon for watershed management and forms the basis for future implementation projects to protect the quality of the watershed. Sources and causes were identified using a wide variety of methods including: road stream crossing inventories, scientific research reports, water quality monitoring reports, steering committee member local knowledge and personal contact with watershed residents.

Table 40: Pollutants, Sources, and Causes of Water Quality Degradation in the Herring Lakes Watershed (Comprehensive Watershed Protection Table)

Environmental Stressor or Pollutant	*Affected Designated Use*	*Sources: K = known, S = suspected, P = potential*	*Causes: K = known, S = suspected, P = potential*
Invasive Species	Warm/Coldwater Fishery	Landscaping practices that remove native vegetation or plant invasive species (k)	Invasive perennials at nursery and landscaping stores (k) Lack of awareness and/or concern (s) Removal of native riparian vegetation (k)
	Other Indigenous Aquatic Life	Introduction of Invasive Species from Boat Hulls, Personal Watercraft, Live Wells, Bilges, Trailers, wading shoes, etc. (k)	Lack of restrictions on boat travel (k) Lack of awareness and/or concern (k) Not properly cleaning boats between lakes (k)
Nutrients	Warm/ Coldwater Fishery Other Indigenous Aquatic Life	Improper Residential, Agricultural or Commercial Fertilizer application (amount, timing frequency, location, method, or P content) (k)	Lack of awareness and/or concern (s)
		Septic Systems (s)	Inadequate design, sited, sized, maintained (s) High density/age of systems (s)
		Soils exposed to storm water runoff (k)	Lack of vegetation from natural shorelines (s) Poor forestry practices, improper road construction or land use practices (s) Improper landscaping practices on private waterfront residential properties (s)

Table 40 (cont'd): Pollutants, Sources, and Causes of Water Quality Degradation in the Herring Lakes Watershed (Comprehensive Watershed Protection Table)

Environmental Stressor or Pollutant	*Affected Designated Use*	*Sources: K = known, S = suspected, P = potential*	*Causes: K = known, S = suspected, P = potential*
Pathogens (E. coli and Fecal Coliform indicators)	Total Body Contact	Animal Waste (k)	Poorly managed livestock operations adjacent to water bodies (p), wildlife (k)
		Septic Systems (p)	Poorly designed, sited, sized, maintained (p) High density/age of systems (p) Uninspected systems (p)
Toxins (Pesticides, Herbicides, Oils, Gas, Grease, Microcystis, etc.)	Warm/ Coldwater Fishery	Contaminated groundwater (s)	Inadequate disposal facilities, illegal dumping (p)
	Other Indigenous Aquatic Life Fish Consumption	Runoff from developed areas (p)	Direct runoff of impervious surfaces to surface water (roads, parking lots, driveways, roof tops) (p) Infiltration to groundwater from improper storage and over use (p) Road salt and dust (k)
		Atmospheric Deposition (k)	Industrial emissions (k)
		Contaminated Soils (k)	Inadequate disposal facilities, illegal dumping (s)

Table 40 (cont'd): Pollutants, Sources, and Causes of Water Quality Degradation in the Herring Lakes Watershed (Comprehensive Watershed Protection Table)

Environmental Stressor or Pollutant	*Affected Designated Use*	*Sources: K = known, S = suspected, P = potential*	*Causes: K = known, S = suspected, P = potential*
Toxins (Pesticides, Herbicides, Oils, Gas, Grease, Microcystis, etc.) (cont'd)	Warm/ Coldwater Fishery Other Indigenous Aquatic Life	Oil, Natural Gas, Hydrocarbon, & Underground Injection Wells (p)	Natural Gas Fracking operation (p) Inadequate Fracking Fluid Storage (p) Abandoned Wells (leaking, uncapped) (p)
		Underground Storage Tanks (p)	Leaking tanks (p)
		Automobiles (p)	Oil, gas, and other leaks from cars, farm equipment, etc. (p)
		Motor Boats (s)	Inefficient or poorly maintained watercraft motors (s) Fuel spills (p)
		Abandoned Wells (leaking, uncapped) (p)	Improper disposal of chemicals (p)
		Improper Chemical Use & Disposal (p)	Lack of disposal facilities and/or limited hours of operation (p)
		Road Salt in Winter (k)	Runoff from roads (k)
		Liquid Brine Disposal (s)	Improper dust control management practices on roadways (s)
		Agriculture (p)	Pesticide runoff from crops (p)

Table 40 (cont'd): Pollutants, Sources, and Causes of Water Quality Degradation in the Herring Lakes Watershed (Comprehensive Watershed Protection Table)

Environmental Stressor or Pollutant	*Affected Designated Use*	*Sources: K = known, S = suspected, P = potential*	*Causes: K = known, S = suspected, P = potential*
Sediment	Warm/Cold water fishery Other indigenous Aquatic Life Navigation	Road Stream Crossings (k)	Erosion of embankments (k) Road sanding (k) Inadequate design/construction/maintenance (k) Lack of erosion/surface runoff controls (k) Steep approaches (k) Culverts not aligned to streambed (k) Undersized culverts (k) Failing/eroding culverts/bridges (k)
		Bank/Shoreline Erosion (k)	Improper culvert sizing and placement (s) Removal of riparian vegetation from natural shorelines (s)
		Residential and Road Construction (k)	Inadequate soil erosion and storm water management practices (k)
		Direct runoff entering water bodies from residential and developed areas (k)	Inadequate storm water management practices (k)
		Soil exposed to storm water runoff (k)	Improper landscaping or land use practices, lack of riparian vegetation (k)
		Forestry Practices (k)	Inadequate road design, management (k) Inadequate timber harvest practices (k)

Table 40 (cont'd): Pollutants, Sources, and Causes of Water Quality Degradation in the Herring Lakes Watershed (Comprehensive Watershed Protection Table)

Environmental Stressor or Pollutant	Affected Designated Use	Sources: K = known, S = suspected, P = potential	Causes: K = known, S = suspected, P = potential
Loss of Habitat	Warm/ Coldwater Fishery	Conversion of forested areas to developed land uses (s)	Increasing local population without sufficient land use regulations in local zoning ordinances to protect high priority land protection areas (s) Shoreline development (s)
	Other Indigenous Aquatic Life	Native species out competed by invasive species (s)	Availability and preference for invasive perennials at nursery and landscaping stores (s) Lack of awareness and/or concern (s) Lack of restrictions on boat travel (s)
		Road Stream Crossings (k)	Undersized culverts (k)
Altered Hydrology	Warm/ Coldwater Fishery	Stream channel alteration (p)	Sedimentation of stream channel from eroding banks (p)
	Other Indigenous Aquatic Life	Road and stream crossings (s)	Small impoundments (k) Perched and undersized culverts (k)

Table 40 (cont'd): Pollutants, Sources, and Causes of Water Quality Degradation in the Herring Lakes Watershed (Comprehensive Watershed Protection Table)

Environmental Stressor or Pollutant	*Affected Designated Use*	*Sources: K = known, S = suspected, P = potential*	*Causes: K = known, S = suspected, P = potential*
Thermal Pollution	*Coldwater Fishery *Other Indigenous Aquatic Life	Storm water runoff from developed areas (s)	Storm water runoff being allowed to directly enter surface water bodies (s) Shoreline development (s)
		Lack of Streamside Canopy (p)	Removal of streamside vegetation (p) Logging practices (p)
		Ponds, impoundments, & other water-control devices (p)	Poorly maintained dam ponds & other water control devices (p)

The Herring Lakes Watershed Goals (see 48) may be used as a reference to distinguish what the major sources of pollutants and environmental stressors exist on a watershed-wide scale. However, it does not distinguish between pollutants and their sources and causes at specific locations. And, as stated earlier, not all of the pollutants listed are a problem everywhere in the watershed.

5.5 Priority Pollutant Ranking

It is important to rank and prioritize pollutants and stressors in order to focus funding and implementation efforts. However, this is a complex task due to the synergistic relationships of the pollutants and stressors, which creates greater impacts than any one pollutant or stressor does on its own. Thus it is important to recognize and address medium and low priority pollutants as well as high priority ones in order to help maintain the Herring Lakes Watershed's overall good water quality. Table 40 outlines the steering committee's pollutant priorities for the watershed. Table 41 then ranks the pollutants and stressors in the Herring Lakes Watershed.

Table 41: Environmental Stressor Priorities for the Herring Lakes Watershed

Pollutant	*Priority in Watershed*
Invasive Species	High
Nutrients	High
Pathogens (*E. coli*)	High
Altered Hydrology	Medium
Sediment	Medium
Loss of Habitat	Medium
Thermal Pollution	Low
Toxins (Pesticides/Herbicides, Oils, Gas, Grease, Salt/Chlorides, Copper Sulfate, *Microcystis*)	Low

The project steering committee determined that the specific sources for each pollutant and stressor are the most important items to rank and prioritize because that is where one can actually stop pollution from entering waterways (see Table 42). Additionally, as noted above, because most of the pollutants and stressors are interconnected, dealing with one source and its causes could actually reduce a number of different pollutants and stressors from affecting water quality. This concept is discussed in more depth in Chapter 5.

Table 42: Pollutant Source Priority Ranking

Environmental Stressor or Pollutant	Sources: K = known, S = suspected, P = potential	Priority
Invasive Species	Lack of awareness and/or concern (s)	High
	Removal of riparian vegetation (p)	High
	Invasive perennials at nursery and landscaping (s) stores (k)	Medium
	Not properly cleaning boats between lakes (k)	Medium
	Lack of restrictions on boat travel (k)	Low
Nutrients	Inadequate septic system design, sited, sized, maintained (s)	High
	Improper fertilizer application (s), frequency, location, method, P content) (p)	High
	High density/age of septic systems (s)	High
	Poor forestry practices, improper road construction or land use practices (s)	High
	Lack of vegetation & natural shorelines (s)	Medium
Pathogens (E. coli)	Poorly managed livestock operations adjacent to water bodies (p)	High
	Poorly designed/sited/ sized/maintained septic systems (k)	High
	High septic system density/age of systems (p)	High
	Uninspected septic systems (p)	High
	Improper landscaping practices on private waterfront residential properties (s)	Med

Environmental Stressor or Pollutant	Sources: K = known, S = suspected, P = potential	Priority
Altered Hydrology	Perched and undersized culverts (k)	High
	Sedimentation of stream channel from eroding banks (p)	Medium
	Small impoundments k)	Medium
	Undersized culverts (k)	Medium
Sediment	Erosion of embankments (k)	Medium
	Road sanding (k)	Medium
	Inadequate culvert design/construction/maintenance (k)	Medium
	Improper landscaping or land use practices, lack of riparian vegetation (k)	Medium
	Failing/eroding culverts/bridges (k)	Medium
	Culverts not aligned to streambed (k)	Medium
	Improper culvert sizing and placement (s)	Medium
	Removal of riparian vegetation from natural shorelines (s)	Medium
	Inadequate soil erosion and storm water management practices (k)	Low
	Steep approaches (k)	Low
	Lack of erosion/surface runoff controls (k)	Low
	Inadequate timber harvest practices (s)	Low

Environmental Stressor or Pollutant	*Sources: K = known, S = suspected, P = potential*	*Priority*
Loss of Habitat	Shoreline development (s)	Medium
	Availability and preference for invasive perennials at nursery and landscaping stores (s)	Medium
	Lack of awareness and/or concern (s)	Low
	Increasing local population without sufficient land use regulations in local zoning ordinances to protect high priority land protection areas (s)	Low
	Lack of restrictions on boat travel (s)	Low
	Undersized culverts (k)	Low
Thermal Pollution	Poorly maintained ponds & other water control devices (p)	Medium
	Shoreline development (k)	Medium
	Removal of riparian vegetation from streams (p)	Low
	Improper Logging practices (p)	Low
	Storm water runoff being allowed to directly enter surface water bodies (k)	Low

Environmental Stressor or Pollutant	Sources: K = known, S = suspected, P = potential	Priority
Toxins (Pesticides, Herbicides, Oils, Gas, Grease, etc.)	Direct runoff of impervious surfaces to waterways (p)	High
	Leaking fuel tanks (p)	Medium
	Fuel spills (p)	Medium
	Improper disposal of chemicals (p)	Medium
	Pesticide runoff from orchards and crops (s)	Medium
	Inadequate Fracking fluid Storage (p)	Low
	Oil, gas, and other leaks from cars, boats, farm equipment, etc. (p)	Low
	Inefficient or poorly maintained watercraft motors (s)	Low
	Lack of disposal facilities (s)	Low
	Runoff from roads (k)	Medium
	Improper dust control management practices on roadways (s)	Low
	Improper brine disposal (s)	Low
	Abandoned Oil Wells (leaking, uncapped) (p)	Low
	Road salt and dust (k)	Low
	Industrial emissions (k)	Low
	Natural Gas Fracking operations (p)	Low

5.6 Pollutants and Environmental Stressors of Concern

NUTRIENTS

Nitrogen and phosphorus are critical nutrients for all types of plants, including aquatic species. Phosphorus has shown to contribute to excessive algae growth. Phosphorus is the primary nutrient of concern in the Herring Lakes Watershed. Sources of increased nutrients to the Herring Lakes Watershed resulting from human activities include residential and commercial fertilizer use, storm water runoff and septic system effluent.

Fertilizers

Residential and agricultural fertilizer applications can be a significant source of nutrient input to the watershed. Since phosphorus is most often the limiting nutrient in aquatic systems, phosphorus concentrations in fertilizers could have a dramatic impact on water quality in the Herring Lakes Watershed due to the high groundwater flow and permeable soils.

Septic Systems

Another potential source of nutrient enrichment in the Herring Lakes Watershed is from failing septic systems. Septic systems are the most common method of treating wastewater from toilets, wash basins, bathtubs, washing machines, and other water-consumptive items in the Herring Lakes Watershed.

A septic system consists of two basic parts: a septic tank and a soil absorption field or drain field. Wastes flow from the house into the septic tank where most solids are separated to the bottom and are partially decomposed by bacteria to form sludge. Some solids float and form a scum mat on top of the water. The liquid effluent from the septic tank, carrying disease-causing organisms and liquid waste products, is discharged into the soil absorption field. In the absorption field, the water is further

The Benzie-Leelanau District Health Department has rules for septic systems (see Environmental Health Regulations, Chapter II). These rules require that "all flush toilets, lavatories, bathtubs, showers, laundry drains, sinks and any other similar fixtures or devices to be used to conduct or receive water carried sewage shall be connected to a septic tank of some other device in compliance with the minimum standards and the Michigan Department of Public Health regulations and finally disposed of in a manner in compliance with these minimum standards and the Michigan Department of Public Health regulations and any other applicable law, ordinance or regulation" (see Environmental Health Regulations, Chapter II). The rules require a percolation test and require specific setbacks of septic tanks and subsurface disposal system (or drain field) from wells, property lines and water bodies.

The best way to prevent septic system failure is to ensure that the system is sited and sized properly and employs appropriate treatment technology and maintenance. Design requirements vary according to local site factors such as soil percolation rate, soil composition, grain size, and depth to water table.

The effectiveness of septic systems at removing pollutants from wastewater varies depending on the type of system used and the conditions at the site. Even a properly operating septic system can release more than 10 pounds of N per year to the groundwater for each person using it (see Ohrel 2000). The average pollutant removal effectiveness for a conventional septic system is as follows: total suspended solids – 72%, biological oxygen demand – 45%, total nitrogen – 28%, and total phosphorus – 57% (see USEPA 1993). This shows that even properly operating conventional septic systems have relatively low nutrient removal capability, and can be a cause of an increased nutrient loading into groundwater flows.

According to the Benzie-Leelanau Health Department, over 90% of residents in Benzie and Leelanau counties utilize on-site sewage disposal and on-site residential water supplies (website: bldhd.org). The health department issues, on a per capita basis, more on-site septic and well permits than any other Environmental Health Division in the state of Michigan. In 2002 a new alternative treatment system regulation for sewage disposal was adopted in Benzie County. The Environmental Health Regulation for the Benzie County Health Department describes what is commonly known as the point of sale septic ordinance. This was adopted in 1990. The details are found in Section IX– Notification and Transfer of Premises with Sewage Disposal Systems and are summarized below.

The purpose of the ordinance is to protect public health and to prevent or minimize degradation of groundwater or surface water by improper or malfunctioning sewage disposal systems or water well systems through the regulation of the transfer or sale of the property or premises. The rules state that an owner of property shall not sell, convey, assign nor transfer ownership of, or exclusive rights in, any dwelling and/or habitable building or premises unless and until the owner or his designated agent has the property evaluated for the existing on-site water well system and on-site sewage disposal system by a health officer.

This also includes properties that are being sold or are on the market. The owner, purchaser or transferee must notify the Health Department that the premises and its sewage system either: 1) are in substantial conformance with this Code and its Regulations; and 2) submit to the Health Department proof of the following: (a) written contract to cause the sewage system to be brought into conformance; (b) deposit of a surety or performance bond or cash guaranteeing performance of such contract in an amount equal to one and one-half times the estimated cost provided for in such contract; and (c) covenant that the performance called for by such contract shall be completed within one-hundred and fifty (150) days of sale or transfer of the premises. In the event that the health officer is not notified, or in the event an owner, transferee or purchaser does not comply with the requirements of the Code then a health officer may record an Affidavit Concerning Status of Sewage Disposal System with the Register of Deeds office in the County stating the property is not in conformance.

According to the 2011-2012 report from BLDHD, there were 201 Residential Septic Permits Issued and 27 Commercial Septic Permits Issued. There were also 181 septic permit inspections and 612 parcels evaluated for on-site sewage along with 214 Residential Well Permits Issued and 77 well inspections. Looking at the property transfer and septic well evaluation program, 261 septic systems were evaluated and 269 water wells were evaluated. The program also evaluates pumper truck and disposal sites and completed 20 septic truck inspections and seven (7) septage waste disposal site inspections and four (4) sewage facility inspections. This is compared to 235 sewage permits and 227 well permits in 2009 along with 176 septic/well evaluations.

Typical Impacts from Excessive Nutrients

Impact #1: Increased weed and algae growth impact water recreation and navigation.

Impact #2: Decomposition of algae and weeds removes oxygen from lakes, harming aquatic life and impairing the warm and cold water.

Impact #3: Exotic plant species like Eurasian Watermilfoil and Purple Loosestrife proliferate and outcompete native plants under nutrient rich conditions.

Impact #4: Blue green algae proliferate and outcompete native phytoplankton in phosphorus rich conditions. Certain species of blue green algae are toxic to animals and humans and may cause taste and odor problems in drinking water.

Impact #5: High nitrate levels in drinking water are a known human health risk.

SEDIMENT

Sediment is comprised of fine organic soil or sand particles and sedimentation is the process whereby sediment is deposited into a stream or lake. Sediment, along with nutrients, is the number one threat to water quality in the Herring Lakes Watershed. Excessive sedimentation can severely degrade an entire aquatic ecosystem and has been identified as a major cause of degradation to aquatic life in many Michigan streams and rivers (see DEQ 1998). Excessive sediment deposition in many of Michigan's streams also severely impacts the amount of suitable habitat needed to support healthy and diverse communities of fish and macroinvertebrates. When sediment enters a stream it covers gravel, rocky, and woody habitat areas, thereby leading to decreases in habitat diversity and aquatic plant production.

Sedimentation caused by stream bank erosion may increase channel widening. Increased width and resulting shallower depth can increase the overall water temperature of a cold-water stream such as Herring Creek. Because fish and macroinvertebrates are sensitive to habitat alteration, sedimentation results in degradation of their populations and diversity.

The most significant sediment source in the watershed is road/stream crossings. Storm water runoff from improperly handled storm water or poor land-use practices are other significant sources for the entire watershed. Unrestricted livestock wading in small stream systems has been found to cause significant bank erosion and sedimentation of channel substrate on some of the Herring Lakes smaller unnamed groundwater tributaries.

Impervious surfaces (i.e., roads, rooftops and parking lots) create erosive storm water run-off forces that degrade water quality if allowed to directly enter surface water bodies. Properly infiltrating storm water run-off into groundwater flows through installation of retention basins, improving degraded road stream crossings and managing recreational traffic in the lower watershed will help prevent additional sedimentation of aquatic habitat.

Typical Impacts from Sedimentation

Impact #1: Sedimentation of aquatic habitats reduces fish spawning, macroinvertebrate diversity, reduces habitat diversity, alters hydrology and navigation.

Impact #2: Nutrients attached to sediment particles enter the water when suspended and increase phosphorus and nitrogen loads significant. The vast majority of the storm event phosphorus is transported on sediment particles.

Impact #3: Organically rich suspended sediments (silt) undergo aerobic respiration as they breakdown, which uses up dissolved oxygen. Excessive sedimentation with silt or other organic-laden sediments can increase Biological Oxygen Demand due to the microbial decomposition, which in turn can cause in-stream dissolved oxygen concentrations to plummet below the levels required by fish and macroinvertebrates. This can lead to widespread fish kills and eliminate sensitive macroinvertebrate populations.

Impact #4: Excess sedimentation can impair navigation by making the water too shallow for boats and boat access.

Impact #5: Sediment accumulation decreases stream depth, and increases stream width, thereby causing the water temperature to rise.

INVASIVE & NUISANCE SPECIES

Invasive species (also called exotic or non-native species) have threatened the Great Lakes ever since Europeans settled in the region. Exotic species are organisms that are introduced into areas where they are not native. While many exotic species are introduced accidentally, others are intentionally released, often to enhance recreational opportunities such as sport fishing. The Pacific salmon, which was purposely stocked in the Great Lakes, is an exotic species, but not considered to be a "nuisance" species. Species are considered a nuisance when they disrupt native species populations and threaten the ecology of an ecosystem, as well as, cause damage to local industry and commerce. Without pressure from the competitors, parasites, and pathogens that normally keep their numbers in check, invasive species may undergo large population increases.

Stowing away on boat hulls and in bilges is one of the primary ways many invasive species are introduced into the Herring Lake Watershed. Other ways of introduction include landscaping practices and lack of awareness by homeowners of the threat (i.e., this is how purple loosestrife was introduced to Michigan) and hitching a ride on other biota like frogs, birds or migratory fish from Lake Michigan.

Invasive species are becoming problematic throughout many of Michigan's inland lakes. Many of these species exhibit vast increases in numbers following their introduction, or following changes in the environment. Exotic species can affect the watershed in many ways. Zebra mussels and Eurasian watermilfoil influence the overall water quality and stability along with recreational use. Zebra mussels also alter the amount of available P by concentrating it on lake bottoms.

The most critical documented aquatic invasive species in the Herring Lakes Watershed are Eurasian milfoil, *Phragmites,* quagga mussels, round gobies and zebra mussels.

Invasive Plant Work

Within the Herring Lakes Watershed, invasive plants can be found in aquatic, wetland, and terrestrial habitats. Some species have been present for many years and are well established, while others are recently arrived and less common. If allowed to spread, these species can radically change a native landscape and lower the biodiversity of an area. The terrestrial species of primary concern have been garlic mustard, baby's breath, blue Lyme grass, autumn olive, honey suckle, Japanese knotweed, and oriental bittersweet. The latter two species are early detection/rapid response (ED/RR) priorities because of their recent introduction and destructive potential. Wetland species of primary concern are invasive *Phragmites*, narrow-leaved cattail, and purple loosestrife. The first two species are ED/RR priorities. Eurasian water-milfoil is the most common aquatic species, and is present in both Upper and Lower Herring lakes. Establishing in nutrient-rich lakes, this invasive easily crowds out native vegetation with its thick mass of stems. Additionally, it interferes with water recreation such as fishing, boating, and swimming.

Monitoring and control of invasive plants in the Herring Lakes Watershed is done by several different groups. First, many private landowners have become aware of the more common invasive species such as garlic mustard or *Phragmites*, and have addressed the problem on their own properties. The Northwest Michigan Invasive Species Network (ISN) is a coalition of partner organizations coordinated by the Grand Traverse Conservation District that covers four counties, including the entire Herring Lakes Watershed. The group has 23 partner organizations and focuses on invasive plant education, monitoring, and treatment. The Grand Traverse Regional Land Conservancy also treats invasive species found within their preserves in the watershed. The Benzie Conservation District has begun treating invasive plants in Benzie County, where most of the Herring Lakes Watershed is found. The Benzie Conservation District is an active partner with ISN and has treated mostly *Phragmites* and garlic mustard. In addition, some lake and property associations treat invasive plants within their areas of influence.

The treatment and control of invasive plants is dependent on available funding, expertise, and awareness. It is nearly impossible to eradicate a species once it is established, so priorities must be set in control efforts based on the probability of success and the value of the ecosystem being invaded. Priority is given to those species with the greatest potential for ecological impact, usually ones located within water or very near an aquatic system. ED/RR species such as Japanese knotweed, giant knotweed, kudzu, oriental bittersweet, *Phragmites,* and narrow-leaved cattail should be treated as soon as possible after they are detected in order to minimize the cost of control and maximize the potential for successful treatment. Of the species that are more common, it is best to treat them as soon as possible after they invade a new area. The ISN is funding control for kudzu, oriental bittersweet, and both knotweed species as the infestations become known. There have been efforts in the past three years to locate and treat infestations of *Phragmites* and garlic mustard, which are relatively common, yet have not taken over as they have in other parts of the state. Most of the groups mentioned above have done garlic mustard control.

Typical Impacts from Invasive Species

Impact #1: Invasive species often have no natural predators and can out-compete native species for food and habitat.

Impact #2: Introduction of a single key species can cause a sudden and dramatic shift in the entire ecosystem's structure. New species can significantly change the interactions between existing species, creating ecosystems that are unstable and unpredictable. (Example: Established populations of zebra mussels can promote toxic blue-green algal blooms.)

Impact #3: In some cases, invasive species can interfere with recreation in the watershed. For example, rows of zebra mussel shells washed up on shore can cut beach walkers' feet, and Eurasian watermilfoil can get tangled up in boat propellers.

THERMAL POLLUTION

Thermal pollution increases the temperature of a body of water, and even small increases in temperature can dramatically alter natural processes. Water's ability to hold dissolved oxygen decreases as temperature increases; thereby reducing the available amount of oxygen in the water to fish and other aquatic life. Temperature also influences the rate of physical and physiological reactions such as enzyme activity, mobility of gases, diffusion, and osmosis in aquatic organisms. For most fish, body temperature will be almost precisely the temperature of the water. Fish will seek water that is in their preferred temperature ranges so as to avoid stress from elevated water temperature. If unable to avoid the higher temperatures a fish's body temperature increases, and this then changes its metabolic rate and other physical or chemical processes as well. When thermal stress occurs, fish cannot efficiently meet their energetic demands (see Diana 1995). Optimal water temperatures for trout are in the 60^{o} F range (15-20^{o} C) or below. Lethal maximum temperatures vary with different trout species, but temperatures above 76^{o} F (24.4^{o} C) can be lethal.

Other sources of thermal pollution in the Herring Lakes Watershed are heated storm water runoff from paved surfaces, the removal of shade vegetation along streambanks and shorelines, and undersized culverts at road stream crossings that create warm pools of retained water upstream, coupled with low flows and shallow pool depth below. Excessive inputs of sediment into streams and lakes may also contribute to thermal pollution. Sediment inputs can fill stream pools and lakes, making them shallower and wider and, consequently, more susceptible to warming from solar radiation.

Changes in climate due to global activities also may increase thermal pollution in a watershed. Average global surface temperatures are projected to increase by 1.5^{o} C to 5.8^{o} C by the year 2100 (see Houghton *et al.* 2001). Increases in surface temperatures may increase stream water temperatures as well, although impacts will vary by region. Overall, increases in stream water temperature will negatively affect cold-water aquatic species. For example, cold-water fish, such as trout and salmon, are projected to disappear from large portions of their current geographic range in the continental United States due to an increased warming of surface waters (see Poff *et al*. 2002). Though actions to address climate change itself are beyond the scope of the plan, projects may be implemented that would mitigate some of the impacts (e.g., tree/shrub planting along riparian corridors to increase the leaf canopy over the stream; infrastructure sized to accommodate larger storms; etc.).

Typical Impacts from Thermal Pollution

Impact #1: Increased water temperature decreases the amount of oxygen available to organisms in the water, potentially suffocating them.

Impact #2: Warm water increases the metabolism of toxins in aquatic animals.

Impact #3: Algae and weeds thrive in warmer waters.

Impact #4: Human made impoundments increase stream temperatures creating lethal conditions for cold-water species such as brook trout.

LOSS OF HABITAT

The population of Benzie County increased by 9.5% from 2000 to 2010 (see U.S. Census). As the population grows throughout the currently rural watershed, the increasing residential and road development fragments the large forested parcels and impedes wildlife movement. Areas of higher quality habitat become smaller and in smaller isolated pockets of remnant habitat, many of the important natural process such as seed dispersal and movement of large mammals are lost. The remaining populations become more vulnerable to disease as well and the impact of increasing nearby human development. Specifically, wetlands are found within the Herring Lakes Watershed that provides important habitat and water quality protection. Proper land use practices on the private land across the watershed can help focus future residential growth near existing villages and population centers to prevent hap-hazard development of high-quality forested habitat into large residential lots with no nearby community infrastructure.

Typical Impacts from Habitat Loss

Impact #1: Extinction and extirpation of native species.

Impact # 2: Habitat fragmentation, increase of edge effect.

Impact #3: Loss of overall biological community stability and function.

Impact #4: Reduction of the scenic magnitude of the Herring Lakes Watershed which is the heart of the region's attraction and draw for over a million annual tourists and residents.

PATHOGENS

Pathogens are organisms that cause disease and include a variety of bacteria, viruses, protozoa and small worms. These pathogens can be present in water and may pose a hazard to human health. The US EPA recommends that fresh-water recreational water quality be measured by the presence of *Escherichia coli* (*E. coli*) or by the presence of a group of bacteria called *Enterococci*. Michigan has adopted the US EPA's *E. coli* water quality standards. *E. coli* is a common intestinal organism, so the presence of *E. coli* in water indicates that fecal pollution has occurred. However, the kinds of *E. coli* measured in recreational water do not generally cause disease; rather, they are an indicator for the potential presence of other, disease causing pathogens - especially if E. coli sources are human. US EPA studies indicate that when the numbers of *E. coli* in fresh water exceed water quality standards, swimmers are at increased risk of developing gastroenteritis (stomach upsets) from pathogens carried in fecal material. The presence of *E. coli* in water does not indicate what kinds of pathogens may be present, if any. If more than 130 *E. coli* are present in 100 mL of water in 5 samples over 30 days, or if more than 300 *E. coli* per 100mL of water are present in a single sample, the water is considered unsafe for swimming.

Fecal pollution entering the Herring Lakes Watershed may come from wildlife (i.e., especially discharging from Herring Lake Swamp), storm water runoff, animals on the land or in the water, or defective septic systems. Different sources of fecal pollution may carry different pathogens. Peak *E. coli* concentrations often occur during high flow periods when floodwater is washing away possible contaminants along streambanks and shorelines from waterfowl like ducks and geese.

Three tributary water sampling locations (i.e., WS-4, WS-5 and WS-8) showed exceedances of *E. coli* certain times of the year (see water quality section for details on the *E. coli* sampling results).

Typical Impacts from Pathogens

Impact #1: High levels of pathogens in the water pose a threat to human health and reduce the recreational value of a waterbody, thereby degrading use and enjoyment of the watershed.

TOXINS

Toxic substances such as pesticides, herbicides, oils, gas, grease, salt, and metals often enter waterways unnoticed via storm water runoff. These types of toxins are perhaps the most threatening of all the watershed pollutants because of their potential to affect human and aquatic health. Every time it rains, these toxic pollutants are washed from the roads, parking lots, driveways, and lawns into the nearest storm drain or road ditch, eventually reaching nearby lakes and streams. Additionally, farms, businesses, and homes throughout the watershed are potential sites of groundwater contamination from improperly disposed and stored pesticides, solvents, oils, and chemicals. Storm water runoff from impervious surfaces can also carry oils directly into surface waters or wash them into groundwater recharge basins.

Traditionally, toxic substances such as mercury and other heavy metals have been regarded as the most serious due to their human health impacts. As fossil fuels burn, chemicals are released into the atmosphere. When rain falls through the clouds, it carries these suspended chemicals to the surface water, via runoff that eventually flows into receiving lakes and streams. In addition to transporting airborne pollutants, surface runoff can also leach these toxic compounds that have accumulated in soil or on impervious surfaces, such as roads, into streams and lakes. The toxins bio-accumulate through the food web, and therefore the oldest higher vertebrates, in this case fish, contain the greatest concentrations. In addition to the substances noted above, another potentially toxic substance in the Herring Lakes Watershed is sodium chloride. Sodium chloride enters the watershed primarily as a result of road salt application in the winter and subsequent runoff in the winter and spring. Higher levels of sodium chloride in streams and lakes can impair fish and macroinvertebrate communities.

Typical Impacts from Toxins

Impact #1: Toxic chemicals entering waterbodies harm stream life, potentially causing entire reaches of a stream to be killed off if the concentrations of contaminants are high enough. Additionally, reproductive processes may be harmed.

Impact #2: Persistent toxic pollution in a stream may put human health and recreation at risk. Serious human health risks may include liver failure, kidney disease, and cancer.

Impact #3: Contaminated groundwater may pose a problem for homes and businesses throughout the watershed that rely upon groundwater wells for their drinking water. This poses a risk to human health and often requires difficult and costly cleanup measures.

ALTERED HYDROLOGY

The two major natural hydrologic functions that help drive the Herring Lakes Watershed are groundwater infiltration and discharge. As water flows out of the ground and coalesces into stream channels it carves the path of least resistance. When natural hydrologic flow patterns are altered for transportation infrastructure, large-scale water withdrawals or to create artificial lake levels, the entire hydrologic process becomes compromised. Natural sediment transport regimens become interrupted and aquatic habitat is quickly compromised. The most common altered hydrologic condition throughout the watershed is found in the myriad of un-named groundwater tributary streams that are have been compromised by the installation of undersized culverts that creates a "choke-point" for as well as creating biologically unsuitable current forces that can fragment stream segments. The undersized structures are also prone to creating "perched" conditions, where the downstream end of the tube is actually perched above the receiving stream channel creating an impassable waterfall. Another main issue in the Herring Lakes Watershed potentially impacting stream hydrology is the low-head dam between Lower Herring Lake and Lake Michigan. The low-head system blocks sediment transport along the stream bottom and creates a massive back-up and accumulation of very fine sands and organic silt above the dam structure. This structure also blocks migratory movements of non-jumping native fishes such as walleye, suckers and northern pike.

Typical Impacts from Altered Hydrology

Impact #1: Undersized culverts can promote a "perched" condition and further fragment the stream channel.

Impact #2: Biologically intolerable current forces from undersized culverts.

5.7 Priority and Critical Areas

Although watershed management plans address the entire watershed, there are certain areas within the Herring Lakes Watershed that warrant more extensive management or specific protection consideration. Areas that are most sensitive to impacts from pollutants are considered ***Priority Areas.*** Areas that require focused monitoring, restoration, remediation and/or rehabilitation are considered ***Critical Areas.*** Currently, the some of the designated uses of the Herring Lakes Watershed are degraded from inputs of nutrients, increasing human development along with exotic species introduction (e.g., zebra mussels, round gobies, etc.) and proliferation.

Priority Areas

Priority areas in the Herring Lakes Watershed are defined as the geographic portions of the watershed that are most sensitive to impacts from pollutants and environmental stressors. The prescribed goals, objectives and tasks for these areas typically focus on preservation and protection. The priority areas were identified by analyzing the sources, causes, and prioritization of watershed pollutants (see Table 43). Other resources used to identify the Priority areas include; scientific research reports, the Michigan Natural Features Inventory, water quality monitoring reports, and assessment by scientific consultants to the Herring Lakes Watershed Steering Committee.

The priority areas for the Herring Lakes Watershed divided three different tiers of protection priorities (i.e., High, Medium and Low Priority) that cover six (6) geographic portions of the watershed. The priority areas and tiers are described below and shown in (see Figure 44).

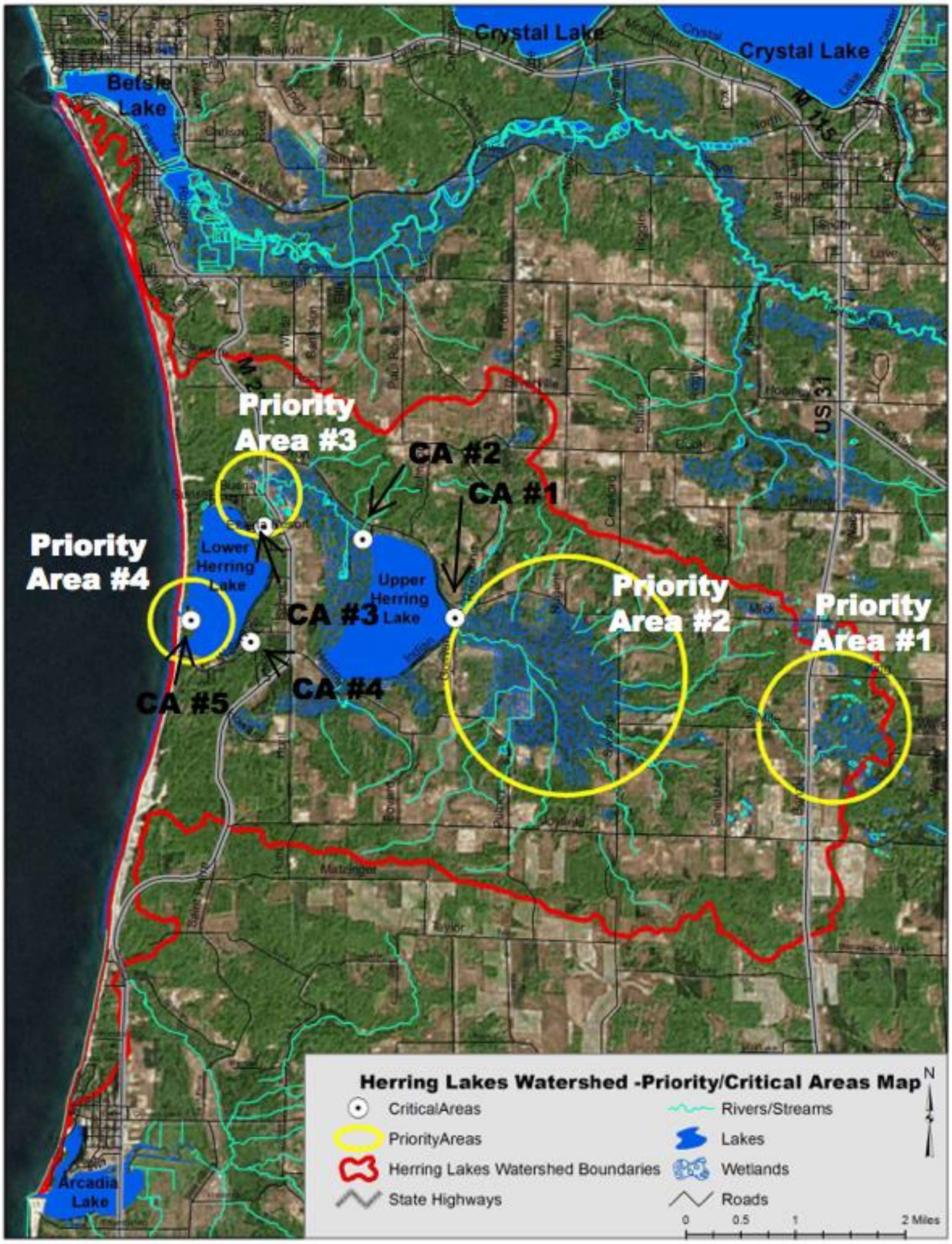


FIGURE 44: PRIORITY AND CRITICAL AREA MAP IN THE HERRING LAKES WATERSHED

Priority Area Descriptions

Area 1 - The Eastern portion of the HL Watershed

Area 2 - Herring Swamp in the center of the watershed

Area 3 - Herring Creek, lower portion down stream of M-22 highway

Area 4 - Lower Herring Lake Outlet

Area 5 - Upper and Lower Herring lakes

Area 6 - Shoreline and small lot development-private septic disposal systems in high density residential development areas

Tier 1 (Highest Priority)

- Habitat for or areas with threatened, endangered or species of special concern
- Existing public or protected land within the state, conservancies and or natural areas and preserves
- Herring Lakes swamp and eastern wetlands
- Exotic/invasive species
- High-risk erosion areas

Tier 2 (Medium Priority)

- Surface water bodies (i.e., lakes and streams), shorelines, wetlands and land within 500' of them
- Land protection areas and preserves
- Groundwater recharge areas

Tier 3 (Lower Priority)

- Steep slopes
- Wildlife corridors

Given there is habitat for rare, endangered and/or threatened species in the Herring Lakes Watershed (see Section 2.7), the first priority area (i.e., Tier 1) focuses efforts where these species may occur as well as within the national lakeshore, state land and other protected land. Since these areas tend to have high quality habitats and include important wetlands and shoreline, continuing to protect these ecological values will contribute to the overall watershed health. Tier 1 also includes the Herring Swamp. This diverse wetland contains superb ecological examples of quaking bog, rich conifer swamp, poor conifer swamp, and emergent and submergent wetland communities.

Tier 2 prioritizes the protection of all undeveloped land within 500 feet of all streams, bodies of water and wetlands in the designated priority areas. In addition, conservation planning by regional land conservancies has identified large, priority parcels tied to water quality by analyzing multiple datasets. The resulting set of mostly privately-owned parcels is prioritized for voluntary permanent land protection options due to their water quality protection and wildlife corridor functions. Groundwater recharge areas are critical to groundwater driven systems such as the Upper Herring Creek. Groundwater recharged and discharge areas as defined by the most acceptable groundwater mapping technology available should be prioritized for protection. Keeping these areas in a natural state facilitates natural groundwater flow and promotes high water quality.

Tier 3 includes wildlife corridors and steep slopes. While there are not a lot of steep slopes in this watershed, it is important to control erosion and protect streams and water bodies with significant buffers for wildlife and water quality. It is a priority in the Herring Lakes Watershed to implement best management practices that will protect the water bodies from increased sediment. It is also a priority to protect wildlife habitat and ecological diversity by connecting natural lands and promoting best management practices for wildlife enhancement. Table 43 describes the areas and what tier is relevant to each area.

Table 43: Priority Areas Chart

Priority Areas 1-6	Tier 1	Tier 2	Tier 3
Area 1	c,g	f,k	d,h,i,j
Area 2	b,f,g,k	a,i,j	D
Area 3	f,g,k	h,j	d,a,h,i
Area 4	j,d,e,h	i,k	a,g
Area 5	j,c,g,k	e,f	a,b,d,h
Area 6	e,g,k	h	j

*If letter is not listed, it is not relevant for that priority area

a-habitat or areas with T & E species or special concern species
b-existing public or privately protected lands
c-Herring Lakes swamp & eastern wetlands
d-High Risk Erosion Areas
e-Surface water bodies, shoreline, wetland areas within 500′ of waterbodies
f-land protection areas/preserves
g-groundwater discharge and recharge areas
h-steep slopes
i-wildlife habitat, corridors and fish
j-exotic/invasive species
k-land use/zoning

Critical Areas

Any areas that are especially sensitive and may require future restoration and rehabilitation (i.e. buffers, streambank restoration, etc.) are considered Critical Areas (depicted as CA-1 through CA-7 on Figure 44 above). The critical areas for the Herring Lakes Watershed include the following areas:

- Herring Lake Swamp (CA-1)

- MDNR Boat Launches (CA-2 and CA-3)
- Boo Hoo View Road End (CA-4)
- Lower Herring Lake Outlet (CA-5)
- Tributaries/Road Crossings and Culverts
- Upper and Lower Herring Lakes
- High Density Residential Shoreline Development Areas

Descriptions of Critical Areas

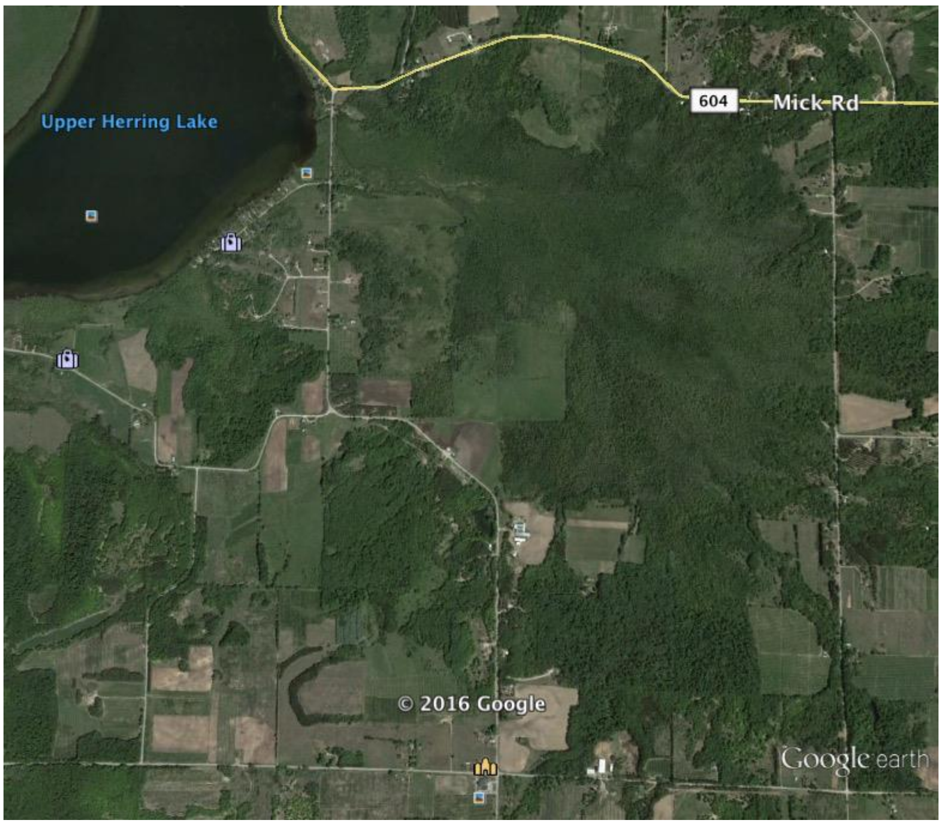
Upper and Lower Herring Lakes - The ecology of both Upper and Lower Herring lakes has changed significantly since the unintended introduction of zebra mussels (*Dreissena polymorpha*) in the Great Lakes in mid-1980s and quagga mussels (*Dreissena rostriformis bugensis)* in the late 1980s. Both species have found their way to the Herring Lakes, and the presence of these invasive/exotic "bivalve" filter feeders has led to increased light penetration within the near surface water columns of the Herring Lakes. As a result, native fresh water clams have been lost, and a significant increase lake biological productivity has occurred - as represented by the accelerated and enhanced growth of undesirable aquatic plants such as Chara (commonly known as "Skunkweed"), milfoils, algae, and *Microcystis*. This plan recommends the completion of a comprehensive and in-depth study of the shifting ecology and changing biological productivity of both Herring Lakes from this phenomenon. Such study is intended to better understand current lake ecology, explore zebra and quagga mussel management options, and to recommend practices, techniques, methods and resources to return both lakes to an aquatic biology approximating pre-zebra and quagga mussel conditions.

High Density Residential Shoreline Development Areas - Areas of high-density cottage/residential shoreline development exist within specific locations in the Herring Lakes Watershed. These areas entirely rely upon private septic systems to treat and dispose of sewage. A fundamental concern in these is the high density and high number of potentially outdated and out-moded septic systems, and the lack of records of what such systems are even comprised of. Such development and reliance upon likely inadequate septic treatment and disposal represents a significant threat to water quality within both Herring Lakes. This plan recommends working within such areas to fully implement the Benzie County point of sale septic inspection program, identify outdated septic systems, provide resources and financial incentives to replace problematic or outdated septic systems, explore options for legal organization of such areas into planned unit or similar develops to lead to the establishment of state of the art centralized common and/or decentralized shared community septic treatment and disposal systems. Additional effort is recommended to provide detailed, yet easily understandable resource information to riparian landowners to identify and promote land care and other ownership practices to reduce and minimize nonpoint runoff sources of pollutants, especially nutrients, to both lakes and their connecting waterways. A related benefit from such efforts may include the clear specification of back lot lake access to both lakes, and the implementation of water conservation and thereby the minimization of septic waste generation in these locations.

MDNR Boat Launches - There is concern that invasive species and/or pathogens and pollutants are entering both lakes through boat launching and/or bait box dumping at MDNR launches on Lower and Upper Herring lakes. This plan recommends increasing outreach and education relative to these issues, including developing a boat wash station, providing written information and installing additional signage at both launches. Following and building upon the models of the Glen Lake Association in Leelanau County and the Michigan Lake & Stream Association's Clean Boats, Clean Waters programs, volunteers can show boaters how to inspect their equipment, demonstrate cleaning techniques for boats and trailers and share educational information about invasive species to prevent the spread of exotic/invasive species, pathogens and pollutants to the Herring Lakes from other waterbodies.

MDNR Boat Launch at Elberta Resort, Lower Herring Lake

Herring Lake Swamp - The Herring Lakes Watershed in supplied and dominated by a very large shrub scrub swamp upslope and upstream of Upper Herring Lake. The "Herring Lake Swamp" is entirely privately-held, and protecting it from degradation and development likely represents a lynch-pin and substantial long-term opportunity to protect the water quality of Upper and Lower Herring lakes and their connecting waterways. This plan recommends identifying and working cooperatively with willing private landowners to permanently protect the Herring Lake Swamp through land purchase and/or conservation easement purchase, lease or donation. This plan also recommends working with both Joyfield and Blaine townships to develop appropriate planning and zoning tools to protect the swamp and other wetlands within the watershed through required development setbacks and native vegetation buffers, etc.



Herring Lake Swamp

Tributaries/Road Crossings and Culverts - This plan recommends the improvement of road crossings and culverts as resources become available and/or when the Michigan Department of Transportation and/or Benzie County Road Commission plans and budgets for road crossing improvements. The Benzie Conservation District also commits to taking the lead to work with the Michigan Department of Transportation and the Benzie County Road Commission to implement best management practices to minimize sediment transport, thermal impact and other pollution from storm water runoff and to improve fish passage at existing culverts on tributaries to the Herring Lakes. Importantly, this plan also recommends working directly with landowners engaged in agriculture to identify financial resources and best management practices, and to provide incentives to implement livestock fencing and other barriers to prevent livestock wading within and increased streambank erosion from grazing, spraying and cultivation practices.

Boo Hoo View Road End - This road end serves as an informal boat launch, and as such gets a good deal of use. There is concern about soil erosion and sedimentation to the east shore of Lower Herring Lake. Plans include the improvement of this boat launch and implementation of best management practices to retain and treat storm water. Specifically, this plan advances the intent of placing tri-lock block or a similar non-skid, erosion resistant material within the bed of the boat launch, the rerouting of storm water away from the boat launch through grading and direction into bioswales or similar innovative storm water treatment and groundwater infiltration. Potential partners and sources of funding for the improvement of the Boo Hoo View Road end include the Benzie County Road Commission, the Benzie Conservation District, the Watershed Center of Grand Traverse Bay, Michigan State University Extension, and Upper and Lower Herring lake associations. Potential sources of funding include the Michigan Coastal Zone Management Program, the Benzie County Road Commission, and the Lower Herring Lake Association.

Boo Hoo View Road end at Lower Herring Lake, looking west.

<u>Lower Herring Lake Outlet</u> - With rising Lake Michigan water levels the Herring Lakes outlet closes off from the sand sedimentation at the beach at Lake Michigan. On occasion the Herring Lakes system's outlet closes off, and water backs up and overtops the flow control structure below Lower Herring Lake. Consequently, there is concern over the introduction of invasive species from Lake Michigan along with sedimentation through heavy recreational use in this area. The Great Lakes ecosystem has been severely damaged by more than 180 invasive and non-native or "exotic" species. More than 25 invasive species of fish have entered the Great Lakes since the 1800s, including but not limited to the round goby; sea lamprey; Eurasian ruffe; alewife; zebra mussels; spiny water flea; and the Asian Carp. The Great Lakes have also been troubled by fast-growing invasive plants that displace the native plants that support wildlife habitat and prevent erosion. These include but are not limited to common reed or *Phragmites,* reed canary grass; purple loosestrife; curly pondweed; Eurasian milfoil; frogbit and narrow-leaved cattail.

Such exotic and/or invasive species reproduce and spread, ultimately degrading habitat, out-competing native species, and short-circuiting food webs. Concern with the introduction of invasive species to the Herring Lakes has led to plans to investigate and implement an exotic species barrier at the outlet structure. Such technologies could include a fish weir/ladder combined with an electronic barrier or similar technology at the existing outlet structure.

Substantial dune erosion from concentrated recreational use at and around the Lower Herring Lake outlet is also a concern. Foot traffic, sometimes heavy, has cut informal pathways through the dune/beach ecosystem and degraded water quality and harmed threatened and endangered plant species such as the Pitcher's thistle at this location.

Lower Herring Lake Outlet at Lake Michigan, looking north from outlet flow control structure.

5.8 Conservation Priorities

One of the main goals of the Herring Lakes Watershed Protection Plan is to prevent increases in nutrient and sediment loading to the Herring Lakes and other waterbodies. The pollutant loading models discussed in Section 5.2 are grounded in the fact that natural land uses such as forest and wetlands produce far less total nutrient and sediment loading than residential or other developed land uses. Permanent land protection, such as conservation easements are an important tool available to private landowners who wish to voluntarily prevent conversion of their natural lands. A conservation easement is a voluntary legal agreement between a landowner and a land trust that permanently limits a property's development potential while protecting its conservation values.

The GTRLC is a non-profit accredited land trust serving five counties including Benzie County**.** The Conservancy works with interested landowners to establish permanent voluntary conservation easements on ecologically important land. They also work to establish natural areas and preserves that are open to the public.

The GTRLC developed an approach to identify priority lands for conservation in the northwest Lower Peninsula, and some of this land is within the Herring Lakes Watershed (see Figure 45). The factors used to prioritize these lands are opportunities for water quality and aquatic resource protection, parcel size, proximity/adjacency to protected land, habitat fragmentation, presence and contiguity of wetlands, endangered species occurrence, and shoreline length. This process identified a few areas adjacent to Upper Herring Lake, Herring Creek, and within the Herring Swamp as the highest priorities for conservation (Tier 2 and 3 Priorities).

The information from the GTRLC was reviewed by members of the Herring Lakes Watershed steering committee; the members agreed that the method is well developed and is the best approach to identify areas for conservation through acquisition of fee simple or lesser interests in land within the watershed. The GTRLC updates its priority list from time to time as new parcels are acquired or as conditions change. More information is available on its website: www.gtrlc.org. In addition to lands identified by the GTRLC, wetlands areas adjacent to the Herring Lakes were also identified as priorities for conservation. The BCD has also accepted title to a five (5) acre wetland parcel for conservation/preservation within the Herring Lakes Watershed.

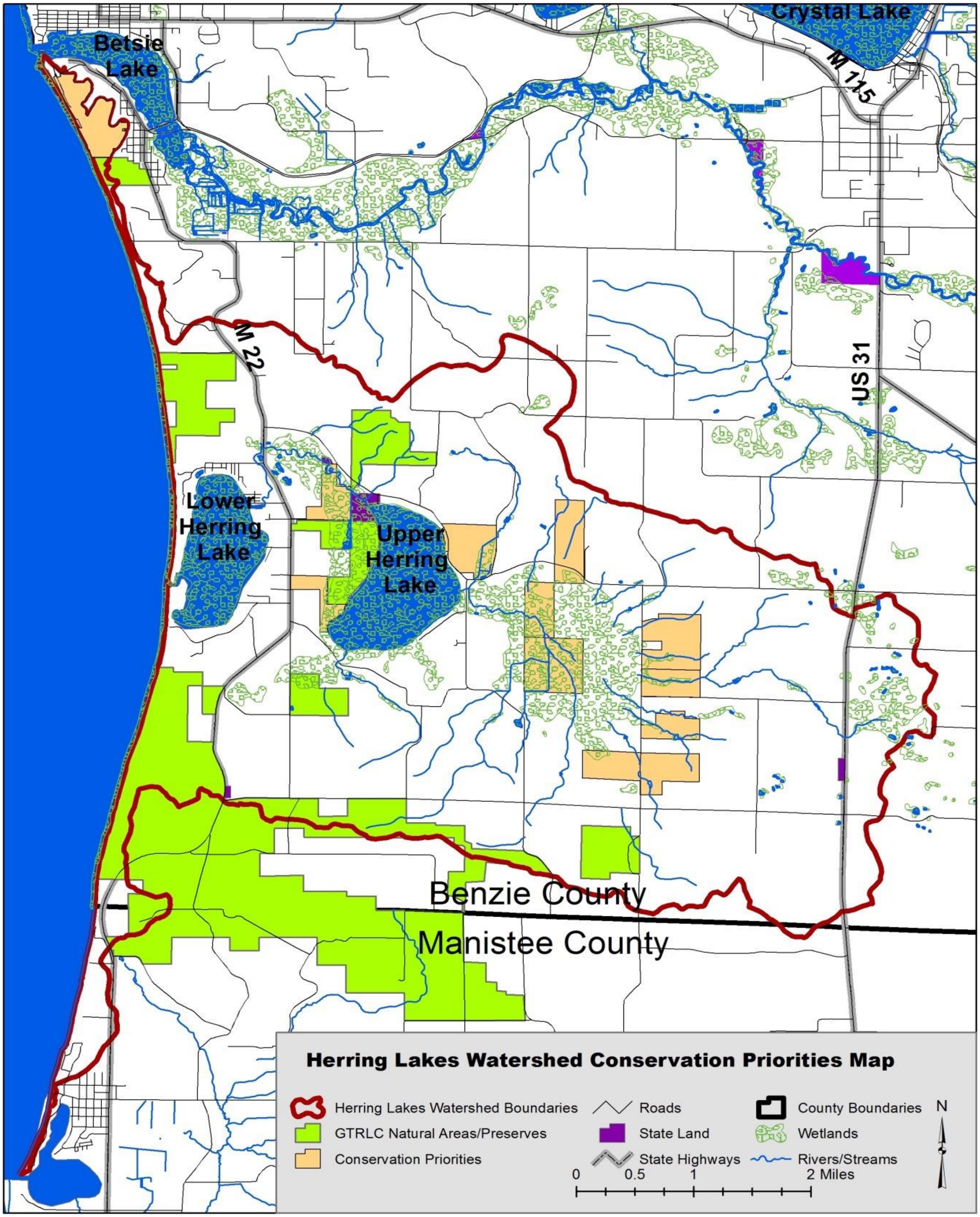


Figure 45: Conservation Priorities for the Herring Lakes Watershed

CHAPTER 6: BEST MANAGEMENT PRACTICES

6.1 Types of Best Management Practices (BMP's) and Sources

Best Management Practices (BMPs) are any structural, vegetative, or managerial practices used to protect and improve surface water and groundwater (see MDEQ 2001). Each treatment site must be evaluated independently, and specific BMPs can be selected to best protect site conditions.

Structural BMPs are physical systems that are constructed for pollutant removal and/or reduction. This can include rip-rap along a stream bank, rock check dams along a steep roadway or bio-retention basins, oil/grit separators, and porous asphalt for storm water control.

Non-structural BMPs include managerial, educational, and vegetative practices designed to prevent or reduce pollutants from entering a watershed. These BMPs include riparian buffers and filter strips, but also include education, land use planning, natural resource protection, regulations, operation and maintenance, or any other initiative that does not involve designing and building a physical structure. Non-structural BMPs focus on source control treatments which usually are more cost effective than restoration efforts after degradation has occurred (i.e., like the saying, "an ounce of prevention is worth a pound of cure"). Individual non-structural BMPs often address multiple pollutants or stressors simultaneously. Establishing a perpetual conservation easement over a priority area will prevent a number of different pollutants (sediment, nutrients, toxins, etc.) from entering the watershed.

Table 44 identifies possible BMPs to address common sources and causes of pollutants or stressors in the Herring Lakes watershed as well as where to find more information about each type of BMP. The table also notes if a potential load reduction estimate is available for a specific BMP.

Table 44: BMP Examples by Pollutant Source

Major Source or Cause	*Affected Pollutant*	*Potential Actions to Address Pollution Source/Cause*	*Potential Load Reduction*	*Information Source*
Bank/Shoreline Erosion	Sediment Habitat Loss	Stream bank stabilization: bank slope reduction, riprap, tree revetments, vegetative plantings, bank terracing, etc.	Varies *(see milestones in Chapter 8)*	-Conservation Resource Alliance (CRA) -Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual -Michigan Ag BMP Manual
Storm water and Impervious Surfaces	Sediment Nutrients Toxins Pathogens	Develop storm water management plans	*See milestones in Chapter 8*	-The Watershed Center's Storm water Management Guidebook -Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual -Center for Watershed Protection – Storm center website
Road Crossings - eroding, failing, outdated	Sediment Nutrients	-Road Crossing BMPs (vary widely – See Road Stream Crossings)	Varies *(see milestones in Chapter 8)*	-Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual

Table 44 (cont'd): BMP Examples by Pollutant Source

Major Source or Cause	*Affected Pollutant*	*Potential Actions to Address Pollution Source/Cause*	*Potential Load Reduction*	*Information Source*
Road Crossings - eroding, failing, outdated	Sediment Nutrients	-Road Crossing BMPs (vary widely – See Road Stream Crossings)	Varies *(see milestones in Chapter 8)*	-Guidebook of BMPs for Michigan Watersheds -MI Low Impact Development Manual -Green Infrastructure Manual
Septic Systems (Leaking)	Nutrients Pathogens	-Conduct education on proper septic system maintenance including workshops, brochures, flyers, videos, etc. Septic system inspections -Ensure proper septic system design -Demo projects for alternative wastewater treatment systems -Chemical treatment of septic systems to reduce nutrient loading	Varies/ Not available	-Leelanau/Benzie Health Department -Public Information and Education Strategy (see Chapter 9)
Development and Construction	Sediment Habitat Loss	-Implement soil erosion control measures -Utilize proper construction BMPs like barriers, staging and scheduling, access roads, and grading--Establishing perpetual conservation easements with voluntary landowners in priority areas	Varies/ Not available	-MI Low Impact Development Manual -Green Infrastructure Manual -Public Information and Education Strategy (see Chapter 9)

Table 44 (cont'd): BMP Examples by Source

Major Source or Cause	*Affected Pollutant*	*Potential Actions to Address Pollution Source/Cause*	*Potential Load Reduction*	*BMP Manual or Agency Contact**
Purposeful or Accidental Introduction of Invasive Species	Invasive Species	-Boat washing stations -Workshops, Brochures, Flyers, Videos, Etc. -Educational Programs	Not available	-Benzie Conservation District -Public Information and Education Strategy (see Chapter 9)

***** Green Infrastructure Manual: www.newdesignsforgrowth.com --> NDFG Programs; MI Low Impact Development Manual --> www.semcog.org/lowimpactdevelopmentreference.aspx; Natural Resources Protection Strategy for Michigan Golf Courses --> www.michigan.gov/documents/deq/ess-nps-golf-course-manual_209682_7.pdf***

6.2 Pollutant Load Reductions

This plan relies on the pollutant load model developed by the Illinois Environmental Protection Agency for estimating the various nutrient loads for differing land uses in areas not serviced by municipal sewers that rely on drain fields for wastewater disposal. Information on pollutant removal efficiency, costs, and designs of structural storm water BMPs is constantly evolving and improving. As a result, information contained in Tables 45 and 46 may be updated to reflect new information and data if new techniques are found to improve results.

Using these tables project partners will be able to quantify storm water pollutant reductions for each of their implemented best management practices to produce quantitative progress results, specific to the Herring Lakes Watershed. It is a task in this plan to develop a program to evaluate local pollutant removal efficiency and costs for storm water best management practices.

Table 45: Average Pollutant Loads by Land Use

Land Use	*Total Suspended Solids (tons/acre/yr)*	*Total Nitrogen (lbs/acre/yr)*	*Total Phosphorus (lbs/acre/yr)*
Commercial	0.52	18	1
Industrial	0.54	12	1
Institutional	0.39	7	1
Transportation	0.67	8	1
Multi-Family	0.52	9	1
Residential	0.08	3	0.4
Agriculture	0.08	2	0.2
Vacant	0.02	0.5	0.088
Open Space	0.01	0.2	0.13

Table 46: Total Estimated Annual Pollutant Loads for the Herring Lakes Watershed

Land Use	*Total Suspended Solids*	*Total Nitrogen*	*Total Phosphorus*
Open Space (forest, wetlands, beach; 11,737.6 acres)	117.4 tons	2,347.5 lbs	1,525.8 lbs
Agriculture (4082.9 acres)	326.6 tons	8,165.8 lbs	816.6 lbs
Residential (279.6 acres)	22.4 tons	838.8 lbs	111.8 lbs
Commercial (100.9 acres)	52.5 tons	1,816.2 lbs	100.9 lbs
TOTAL	518.9 tons	13,168.3 lbs	2,555.1 lbs

Note: Acreages were taken from Table 8 (page 39) in order to group land use categories appropriately. Water is not included in this table.

Permanent Conservation Easement Pollutant Load Reduction (lbs/yr)

The total pollutant load reduction from a permanent conservation easement is determined by subtracting the total pollutant loading coefficient for the more developed land use, such as residential, from the total pollutant loading coefficient for a more natural land use, such as forest. This plan utilizes pollutant load modeling methodology developed by the Illinois Environmental Protection Agency to determine estimations of annual pollutant load reductions from voluntary permanent conservation easements implemented in Priority Areas. Annual pollutant loads for various land uses are delineated in Table 46 above.

The watershed plan goal is to permanently protect 500 acres of land within identified Priority Areas throughout the watershed by 2024. (See Land Protection and Management Goals in Chapter 8.) Successful implementation of permanent voluntary conservation easements over 500 acres will prevent 33.5 tons of sediment, 1,450 lbs. N, and 135 lbs. P from entering the Herring Lakes Watershed each year.

Pollutant Reduction Estimates for Stormwater BMPs

The primary storm water source in the Herring Lakes Watershed is direct runoff from roadways. Table 47 lists the total percent removal of phosphorus, nitrogen, sediment (i.e., total suspended solids), and metals and bacteria for selected storm water BMPs that could be used for storm water pollution particular to the Herring Lakes Watershed.

Listing BMP effectiveness by percentage is often a more useful way of conveying the data to the general public rather than using specific concentration values, which can be difficult to comprehend.

It should be noted that the percent removal values in Table 47 are comparative numbers that approximate how much pollutant is removed as compared to no BMP implementation. For example, it is assumed that porous pavement values approximate the percentage of pollutants removed compared to regular pavement storm water runoff; or that Riparian Buffer values approximate the percentage of pollutants removed as compared to runoff from a landscaped, fertilized lawn. For more specific information on these storm water BMPs, see the Center for Watershed Protection's Storm Water Center website at www.stormwatercenter.net. Not every BMP may be the best selection for every site. Some areas are better suited for specific BMPs than others. There are other factors to consider besides pollutant removal efficiency when deciding which BMP to use at a site. Other factors include the size of site, money available for implementation, and the purpose of the land (i.e., what the site will be used for).

Table 47: Pollutant Removal Effectiveness of Selected Potential Storm Water BMPs

Management Practice	Total % Phosphorus Removal	Total % Nitrogen Removal	Total % Suspended Solids Removal	% Metal and Bacteria Removal	Other Considerations
Riparian Buffer*	Grass: 39 - 88 Forest: 23 - 42	Grass: 17 - 87 Forest: 85	Grass: 63 - 89 Forest: N/A	n/a	Increase in property value; public education necessary
Porous Pavement	65	82	95	Metals: 98	\$2 - 3/ft^2 (traditional, non-porous asphalt is \$0.50-1.00/ft^2)
Infiltration Basin	60 - 70	55-60	75	Metals: 85 - 90 Bacteria: 90	\$2/ft^3 of storage for a ¼-acre basin - Maintenance is essential for proper function
Infiltration Trench	100	42.3	n/a	n/a	\$5/ft^3
Bioretention (e.g. rain gardens, bioswales, etc.)	29	49	81	Metals: 51 - 71 Bacteria: 58	\$6.80/ft^3 of water treated Landscaped area anyway; Low maintenance cost; Note possible export of bacteria
Grassed Filter Strip (150ft)	40	20	84	n/a	Cost of seed or sod

Pollutant removal efficiencies will increase as buffer width increases. Grasses in this case mean native grasses -not regular lawn or turf grass.

Table 47 (cont'd): Pollutant Removal Effectiveness of Selected Potential Storm Water BMPs

Management Practice	*Total % Phosphorus Removal*	*Total % Nitrogen Removal*	*Total % Suspended Solids Removal*	*% Metal and Bacteria Removal*	*Other Considerations*
Sand and Organic Filter Strip	Sand: 59 +/-38 Organic: 61 +/-61	Sand: 38 +/-16 Organic: 41	Sand: 86 +/-23 Organic: 88 +/-18	Sand: Metals: 49-88; Bacteria: 37 +/-61; Organic: Metals: 53-85	Not much information, but typical costs ranged from $2.50 - $7.50/ft of treated storm water
Grassed Channel/Swale	34 +/-33	31 +/-49	81 +/-14	Metals: 42-71 Bacteria: 25	$0.25/ft^2 + design costs; Poorer removal rates than wet and dry swales; - Note the export of bacteria
Constructed Wetlands** 1) Shallow Marsh 2) Extended Detention Wetland 3) Pond/Wetland 4) Submerged Gravel Wetland	1) 43 +/-40 2) 39 3) 56 +/-35 4) 64	1) 26 +/-49 2) 56 3) 19 +/-29 4) 19	1) 83 +/-51 2) 69 3) 71 +/-35 4) 83	1) Metals: 36-85; Bacteria: 76; 2) Metals:(-80)-63; 3) Metals: 0-57 4) Metals: 21-83; Bacteria: 78	Relatively inexpensive; $57,100 for a 1 acre-foot facility; Data for 1 and 2 based on fewer than five data points

***** Wetlands are among the most effective storm water treatment practices in terms of pollutant removal, and also offer aesthetic value. Storm water wetlands are designed specifically for the purpose of treating storm water runoff and typically have lower biodiversity than naturally occurring wetlands. There are several design variations of the storm water wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.***

Values obtained from Center for Watershed Protection's Storm Water Center website (www.stormwatercenter.net) and Practice of Watershed Protection Manual (see Schueler and Holland 2000).

CHAPTER 7: WATERSHED PLANNING EFFORTS

7.1 Steering Committee, Stakeholder and Partner Outreach

The original Herring Lakes Watershed plan was completed in 2003 (see HLWP 2003). This 2018 Herring Lakes Watershed Protection Plan is an update to the 2003 plan. Activities and accomplishments within the Herring Lakes Watershed since 2003 include:

1. The first action taken by the committee was to begin collecting data on nutrient and *E. coli* from waters in the watershed.
2. The Upper Herring Lake Association (UHLA) was formed in 2010. The purpose of this group is to support the efforts of the HLWSC, with a workforce and finances, in order to maintain and enhance water quality within the Herring Lakes Watershed.
3. Since 2012, the UHLA has participated in the Michigan Lakes and Streams Cooperative Lakes Monitoring Program. As part of this program the UHLA has collected phosphorous and secchi disk readings, and performed lake surveys to identify aquatic plant species in the lake (i.e., the "exotic/invasive species watch").
4. The UHLA, through the Benzie Conservation District (BCD), has treated a small area of UHL to eradicate a small stand of *Phragmites australis*.
5. The Lower Herring Lake Association (LHLA) has been treating and controlling for *Phragmites* since 2003, and continues to do so annually.
6. The LHLA has completed dam/outfall control structure maintenance since 2003, including improving the dam's structural integrity through the addition of rip and steel sheet piling.
7. The LHLA has undertaken annual water quality monitoring of LHL since 2001.
8. Both the LHLA and UHLA worked with Benzie County Road Commission and Blaine Township to replace three (3) culverts along Herring Lake Road to reduce the potential for sedimentation and to improve fish passage within three (3) tributaries to the LHL. This

accomplishment was a direct result of this Herring Lake Water Protection Plan study, then ongoing.

9. In 2017 the LHLA undertook Eurasian milfoil removal and proper disposal with a contractor - the first attempt within LHL to control Eurasian milfoil.
10. The LHLA monitors and maintains flow through the dam at the outfall of LHL. High Lake Michigan water levels since 2017 have cause the outlet channel to clog with sand and have resulted several times in the overtopping of the dam. The LHLA monitoring these conditions and maintains the discharge on an ongoing basis for the public good and to protect riparian landowners' property.
11. The LHLA participates on an ongoing basis with MDNR fish studies and funding assistance for the annual stocking of fish in LHL.
12. Racquel Huddleston, a science teacher at the Benzie Central High School along with her students completed water quality testing within the Herring Lakes Watershed, and shared the data with the UHL Association, LHL Association, and the Benzie Conservation District.
13. Since 2005, the Lower Herring Lake Association (LHLA) has treated areas of LHL for Eurasian watermilfoil and *Phragmities australis*.
14. The BCD oversees volunteer stream monitoring at three (3) sites, twice a year within the watershed and the data is managed by the BCD.
15. The BCD completes two or more water tours per year for the public on LHL, including the 2017 tour with *Plant It Wild* disseminating information and education rito parians and the public regarding natural shorelines.
16. The Grand Traverse Regional Land Conservancy (GTRLC) undertakes invasive/exotic plant species treatments within properties they own within the Herring Lakes Watershed for baby's breath, spotted knapweed, garlic mustard, Blue lyme grass, *Phragmities australis,* and others invasive/exotic plant species.

From January 2015 to February 2017 the Herring Lakes Protection Plan steering committee met at least monthly, and convened four (4) public outreach and stakeholder meetings. The public outreach and stakeholder meetings were facilitated by Dr. Christopher Grobbel, Grobbel Environmental & Planning Associates to inform attendees of project activities, preliminary water quality monitoring results, and importantly, to facilitate public and stakeholder identification and prioritization of environmental stressors, critical and priority areas, and opportunities for water quality improvement and long term protection within the Herring Lakes Watershed. A total of 56 public members and stakeholders participated in facilitated sessions for the Upper Herring Lake Association, Lower Herring Lake Association, watershed landowners, and visitors and the general public. A questionnaire also was developed and made available to the public through survey monkey via the Benzie Conservation District website (*www.benziecd.org*). A copy of the questionnaire is in Appendix A.

Questionnaire Results

Below is a summary of those results and the details can be found in Appendix B.

The majority of respondents are part-time residents (i.e., 44%) or full-time residents (i.e., 32.4%). Of the respondents, we captured a lake association officer and a business owner. When asked what part of the watershed survey respondents were most familiar with, most stated Upper or Lower Herring Lakes and Lake Michigan. Survey respondents were asked about the types of activities they enjoy in the watershed and where they enjoy these activities. Swimming, motor boating and fishing was most popular on the Lower Herring Lake, and jet skiing was most popular on Upper Herring Lake. Most of the quality of the activities enjoyed in the watershed were rated good to excellent. There were very few "poor" responses for uses in the watershed. The majority of the activities were considered "good" with hiking, sail boating and fishing in Lake Michigan rated as excellent. Many people enjoy the water activities and hiking. Hunting showed the highest percentages for regular/weekly activity while water activities were enjoyed fairly often to sometimes. This makes sense given the four seasons, and that tourism is concentrated in the warmer months.

Nutrients and invasive species were both rated very high concerns. Respondents also seemed concerned with bacteria pollution and swimmer's itch, which were also rated very high by 38.7% and 26.4% correspondingly, and could be considered a high concern. Results show a high concern for aesthetics and a medium concern with lake levels for Herring Lakes and Lake Michigan. When asked what the lowest threats were in the watershed, fluctuations in lake levels and thermal pollution where all ranked low. When asked: "What do you feel is the greatest threat to the Herring Lakes Watershed?", the majority of the responses were: invasive species, septic systems and development.

When asked "What changes specifically, if any, have you noticed since you've lived in the watershed in and WHERE you have noticed these changes?", the majority of respondents noticed changes on Lower

Herring Lake (66.7%) or Lake Michigan (49.4%, and see Figure 46). Invasive species were a theme throughout - for both Upper and Lower Herring lakes as well as Lake Michigan and the upper watershed. Comments about the changes also often contradicted themselves in Upper Herring Lake and Lower Herring Lake and Lake Michigan, and ranged from clean and clearer water to muckier water and more algae. Cattle grazing in the streams was a concern for the upper watershed and tributaries.

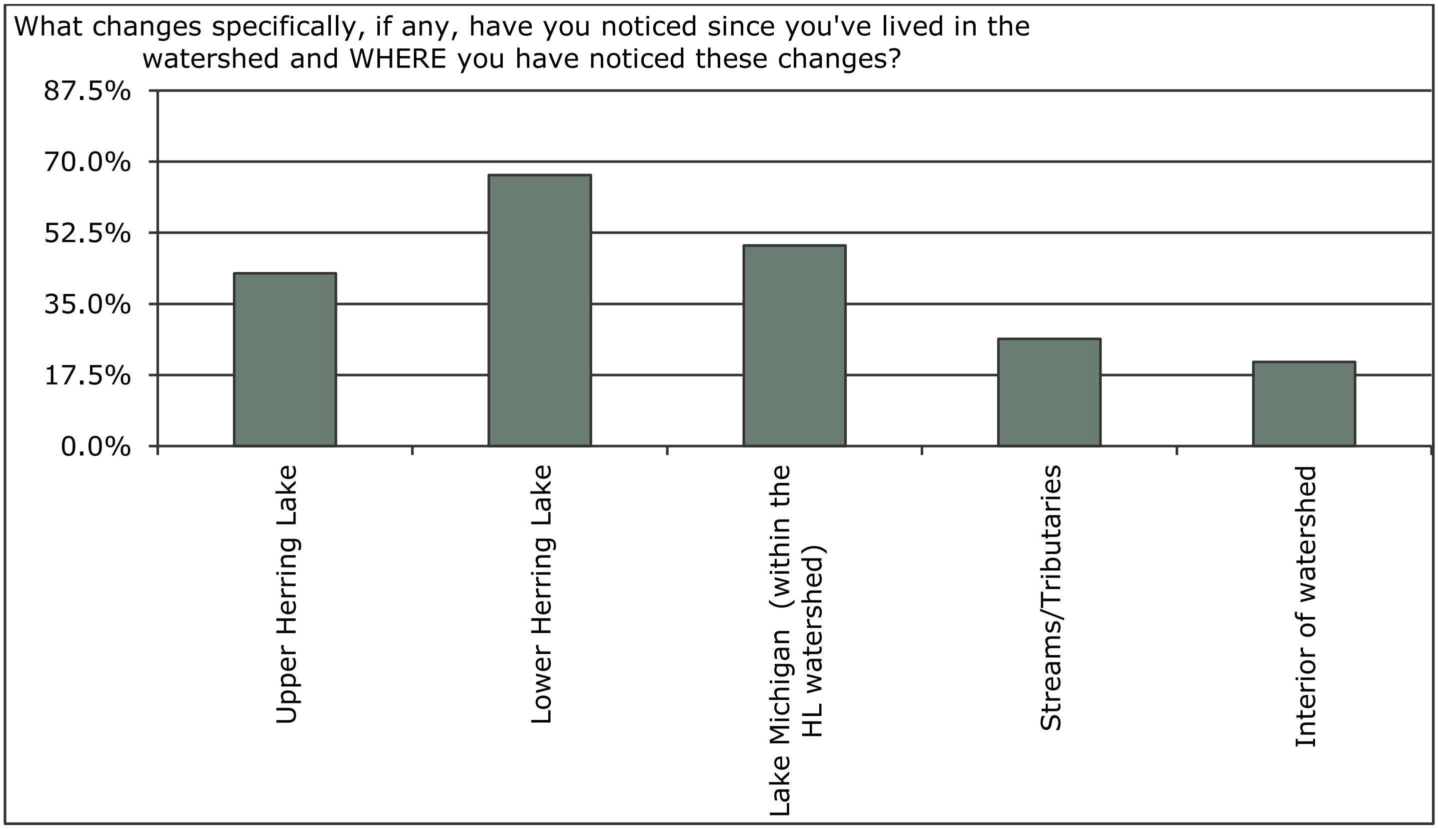


Figure 46: Results from the Herring Lakes Watershed Questionnaire on Changes in the Watershed

When asked if there are any specific sites in the watershed that deserve special attention or management 59 people responded. Below is a list of areas that deserve attention:

Response Text
Education the public
Invasive species
Cattle operation(s) where Keillor Rd merges with Herring/Gorivan roads, north of Putney Corners
Channel closing up by storms and weeds
Land protection of remaining undeveloped parcels, especially wetlands that act as buffers from nutrient runoff on agricultural or residential lands
Upper and Lower Herring lakes (inlets/outlets)
Access site
Algae
Better manage both lakes for fishing opportunities
Chica Love's Lot
Clear Herring Creek of brush to be able to kayak between lakes
Determine E. coli sources in swamp & tributaries & in LHL; reduce E. coli levels
Direct access of cattle to streams
Farms upstream of Upper Herring Lake
Gilroy farm
Homes built only a few feet above lake levels.
Increasing access to Lake Michigan at Watervale Road
Lower Herring Lake and outlet
Septic systems on Lower Herring Lake
Septics in Elberta Resort
Smeltzer Orchard company
Streams that cross cow pastures and lake shores
Swamp perimeter
Swimmers itch
The walking trails need to be kept clear and safe to walk
Tributaries
Watervale

When asked "What do you feel is the greatest threat to the Herring Lakes Watershed?" the top three responses were invasive species, development and septic systems.

7.2. Herring Lakes Watershed Plan Accomplishments to Date

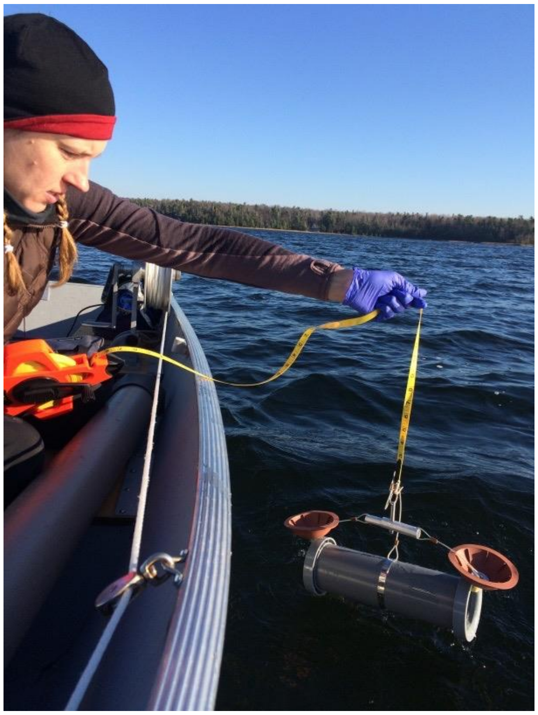
Water Sampling Photos

Sarah Delevan, PhD, measuring stream flow at the Lower Herring Lake outlet (Nov. 9, 2015).

Sarah Delevan, PhD, groundwater sampling at the Lower Herring Lake MDNR boat launch (Nov. 9, 2015).

John Ransom, BCD, secchi disk turbidity sampling on Lower Herring Lake, November 9, 2015.

John Ransom, BCD, hydrolab sampling on Herring Creek, November 9, 2015.



Sarah Delevan, PhD, multi-level water sampling on Lower Herring Lake (Nov. 9, 2015).

Sarah Delevan, PhD, tributary water sampling and John Ransom, BCD, hydrolab sampling at WS-5 Putney Road (November 9, 2015).

Significant accomplishments within the Herring Lakes Watershed for project partners in the last 2 years, i.e., 2015-2016, include the following.

Benzie Conservation District – completed voluntary stream monitoring program with residents in the watershed and completed macroinvertebrate studies; offered water tours for public outreach and education; acquired 5 wetland acres on Herring Road and managed this parcel to maintain water quality of receiving waters – i.e., Herring Creek; ongoing education; outreach and grant application/acquisition for Herring Lakes Watershed projects; secured MDEQ SAW funds for and oversaw the Herring Lakes Watershed Protection Planning project.

Lower Herring Lake Association – ongoing water quality monitoring program; outreach and education; bi-annual newsletter and meetings to raise awareness of issues with its membership; the education of riparians on shoreline vegetated buffers; completed invasive aquatic plant surveys; undertook a yearly *Phragmites* control program since 2011; Lower Herring Lake flow control structure inspections and maintenance; and assisted with the replacement of three (3) inadequate road culverts on Herring Road for tributaries.

Upper Herring Lake Association – ongoing water quality monitoring program; outreach and education; annual newsletter and meetings to raise awareness of issues with its membership; the education of riparians on shoreline vegetated buffers; and completed macrophyte and invasive species surveys.

CHAPTER 8: WATERSHED GOALS AND OBJECTIVES

The overall mission for the Herring Lakes Watershed Protection Plan is to provide guidance for the implementation of actions that will reduce the potential negative impact that pollutants and environmental stressors have on designated watershed uses. The overall goal is to have the Herring Lakes Watershed support all identified designated and desired uses while maintaining its distinctive environmental characteristics and high water quality.

Based on the original goals identified in the first edition of the Herring Lakes Watershed Management Plan, the project steering committee developed six broad goals for the Herring Lakes Watershed (see Table 48). Working to attain these goals will ensure that the designated and desired uses described in Chapter 4 are maintained or improved.

WATERSHED GOALS

Goal 1: Protect aquatic and terrestrial ecosystems.

Goal 2: Protect the quality and quantity of water resources.

Goal 3: Preserve high quality recreational opportunities in the watershed.

Goal 4: Implement and promote educational programs that support stewardship and watershed planning goals, activities, and programs.

Goal 5: Protect the health and safety of watershed users, residents and stakeholders.

Goal 6: Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected.

Goal 1: Protect aquatic and terrestrial ecosystems.

Designated uses: warm/cold water fishery, other aquatic life

Desired uses: ecosystem preservation

Pollutants or stressors addressed: Loss of habitat, invasive species, nutrients, thermal pollution

- Objective 1.1 Establish land and water management practices that conserve and protect the natural resources of the watershed and consider the influences driven by climate change.
- Objective 1.2 Preserve the biodiversity of the watershed.
- Objective 1.3 Protect and restore critical habitat areas for aquatic life and fish.
- Objective 1.4 Protect shoreline habitats and promote the wise use of shorelines.
- Objective 1.5 Preserve the distinctive character and aesthetic qualities of the watershed including viewsheds and scenic hillsides.
- Objective 1.6 Manage and control existing invasive species and minimize the spread of new invasive species.
- Objective 1.7 Maintain and enhance ecosystem functions of the wetland and riparian areas in the watershed.

Goal 2: Protect the quality and quantity of water resources.

Designated Uses: Warm/cold water fishery, other aquatic life, total body contact

Desired Use: Human health

Pollutants or stressors addressed: Nutrients, hydrology, sediment, pathogens, toxins, thermal pollution

- Objective 2.1 Identify threats to high quality water and surrounding ecosystems that are likely influences within watershed.
- Objective 2.2 Control and reduce the amount of pollutants in storm water, storm water runoff entering surface waterbodies.
- Objective 2.3 Identify verifying tests, best practices and action strategies to deal with threats.
- Objective 2.4 Maintain and enhance existing long-term water quality testing program and procedures including monitoring of potential sources and causes of elevated fecal coliform bacteria in the watershed.
- Objective 2.5 Prioritize, stabilize and/or improve road-stream crossing embankments and approaches.
- Objective 2.6 Control and/or minimize the input of pollutants, pathogens and toxic compounds into surface water and groundwater.
- Objective 2.7 Prioritize, stabilize and/or improve shoreline, stream and banks to prevent erosion.
- Objective 2.8 Assure plans and actions reflect the expected influences tied to climate change.
- Objective 2.9 Understand existing hydrology and strive for hydrologic practices that will enhance, expand and support water quality.

Goal 3: Preserve high quality recreational opportunities in the watershed.

Designated Uses: Warm/cold water fishery, total body contact, navigation

Desired Use: Recreation

Pollutants or Stressors Addressed: Loss of habitat, pathogens, toxins, thermal pollution, nutrients

- Objective 3.1 Support desired recreational uses while maintaining distinctive environmental characteristics and aquatic biological communities throughout the watershed.
- Objective 3.2 Maintain and promote high quality and diverse fishing opportunities throughout the Herring Lakes Watershed.
- Objective 3.3 Maintain and promote high water quality to ensure safe and clean areas for public swimming and other types of water recreation.
- Objective 3.4 Maintain and protect un-fragmented large tracts of wetlands, wildlife corridors and forested habitat on public and private lands across the watershed.

Goal 4: Implement and promote educational programs that support stewardship and watershed planning goals, activities and programs.

Designated Uses: All

Desired Uses: All

Pollutants or stressors addressed: Loss of habitat, nutrients, pathogens, invasive species, toxins

- Objective 4.1 Implement Information and Education Strategy outlined in Chapter 9.
- Objective 4.2 Raise awareness, understanding, commitment and action within the Herring Lakes Watershed so that private practices and public policy enhance attainment of the watershed goals.
- Objective 4.3 Involve the citizens, public agencies, user groups and landowners in implementation of the watershed protection plan through meetings, events and workshops with individuals or groups.
- Objective 4.4 Measure effectiveness of outreach activities in increasing awareness and reduction of Non-Point Source (NPS) pollution, including shoreline erosion.
- Objective 4.6 Increase awareness of proper septic system maintenance, fertilizer use and storage of organic wastes and fertilizers.
- Objective 4.7 Encourage appropriate provisions for site plan development and review for water quality and natural resources protection.

Goal 5: Protect the health and safety of watershed users, residents and stakeholders.

Designated Uses: Warm/cold water fishery, partial/total body contact, navigation, fish consumption

Desired Uses: Human health

Pollutants or Stressors Addressed: Nutrients, sediment, pathogens, toxins, thermal pollution, loss of habitat, nutrients, pathogens, invasive species, toxins

- Objective 5.1 Identify and address threats to groundwater and surface water to ensure public drinking water is protected.
- Objective 5.2 Monitor swimmer's itch and develop a program to address swimmer's itch concerns in the watershed.
- Objective 5.3 Monitor waterbodies, including the Lake Michigan shoreline and interface areas, for *E. coli* (fecal coliform), botulism, and fish die-offs and address areas of concern.
- Objective 5.4 Partner with the health department, county and townships to promote proper septic system maintenance and replacement.

Goal 6: Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected.

Designated Uses: Warm/cold water fishery, habitat, partial and total body contact, agriculture

Desired Uses: Recreation, ecosystem preservation

Pollutants or Stressors Addressed: Hydrology, loss of habitat, sediment, pathogens, toxins

- Objective 6.1 Promote developments and land use activities that work in harmony with watershed protection
- Objective 6.2 Adopt the most economically sound approaches to ecologically sound watershed practices
- Objective 6.3 When developing watershed protection policies give consideration to the property values, local business and tourism.

Table 48: Herring Lakes Watershed Goals

Goal	*Designated or Desired Use Addressed*	*Pollutant/Environmental Stressor Addressed*
#1- Goal 1: Protect aquatic and terrestrial ecosystems.	Warm/Coldwater Fishery, Other Aquatic Life, Navigation Desired Use: Aesthetics, *Ecosystem Preservation*	ALL
Goal 2: Protect the quality and quantity of water resources.	ALL	ALL
Goal 3: Preserve high quality recreational opportunities in the watershed.	Warm/Coldwater Fishery, Navigation Desired Use: *Recreation*	ALL
Goal 4: Implement and promote educational programs that support stewardship and watershed planning goals, activities, and programs.	ALL	ALL
Goal 5: Protect the health and safety of watershed users, residents and stakeholders.	Warm/Coldwater Fishery, Other Aquatic Life, Navigation, Aesthetics, *Ecosystem Preservation* Desired Use: *Recreation*	ALL
Goal 6: Protect the economic viability within the watershed while ensuring water quality and quantity resources are protected.	Warm/Coldwater Fishery, Habitat, Partial and Total Body Contact, Agriculture Desired Uses: *Recreation*, *Ecosystem Preservation*	ALL

CHAPTER 9: IMPLEMENTATION TASKS AND ACTIONS

Objectives and Tasks

The goals detailed in Chapter 7 for the Herring Lakes Watershed were developed by the Herring Lakes Protection Project Steering Committee to protect the designated and desired uses of the watershed. The goals are recommendations for implementation efforts within the watershed. Each goal has multiple objectives that outline how the goal can be reached. Tasks were then assigned to address the individual goals and multiple objectives. The detailed task implementation chart (see Table 49) has broken the task down by seven (7) major categories:

1. Water Quality (WQ)
2. Fish & Wildlife Habitat (FWH)
3. Invasive Species (IS)
4. Shoreline/Streambank Protection (SSP)
5. Best Management Practices (BMP)
6. Outreach, Information and education (OIE)
7. Land Protection (LP)
8. Economy, Recreation and Tourism (ERT)

This table (see Table 49) describes the task by category, provides interim milestones, approximates projected costs and assigns a plausible timeline for completion. The chart also identifies possible project partners; however, this does not imply a commitment on behalf of these organizations to accomplish these task criteria. These were developed based on the prioritization of watershed pollutants, sources, and causes while also looking at the priority and critical areas in the watershed (see Tables 43 and Figure 48). The implementation tasks in Table 49 are designed to address individual watershed objectives under each main goal. Some of the tasks are designed to address multiple objectives under one treatment.

Priority Level

Each task has been given a priority level based on the following criteria:

High, Medium, and Low.

Unit Cost/Cost Estimate

An estimated cost is provided when available and applicable. An estimated total cost is provided when it is able to be calculated and/or reasonably estimated. Table 51 summarizes the Goals by Designated and Desired Uses.

Milestones

Milestones are identified, when possible, to establish a measurable benchmark for determining the progress on a specific task or action.

Timeframe

A timeframe of 10 years was used to determine the scope of activities and the estimated costs for implementing the tasks. The year in which the task or action is to begin or end is also noted. When a task or action is ongoing, it is noted as spanning the ten years.

Funding Sources

Likely funding sources for task implementation include state, tribal and federal grant sources (i.e., MDEQ: CMI, CWA Sec. 319, GLRI, NAWCA, GLFT, MDNR, USFWS, GTB, etc.), federally recognized tribes, private foundations, private fundraising from the lake associations, regional land conservancy and volunteer time.

Potential Partners

Potential partners and target audiences are outlined on the next page with acronyms. These include anyone who has the interest or capacity to implement a task or action. Specific tasks or projects call for different groups or project partners. The project partners are also noted in the task tables. It is anticipated identified entities will consider pursuing funds to implement the task or action, work with other identified potential partners and communicate any progress to the Herring Lakes Watershed Protection Plan Steering Committee or project partners. This plan also recommends working with both Joyfield and Blaine townships to develop appropriate planning and zoning tools to protect both lakes through waterfront overlay regulations, development setbacks, secondary containment of hazardous and potentially polluting materials, the adherence to best management practices, and/or native vegetation buffers, etc.

Potential Project Partner Acronyms:

BCD – Benzie Conservation District

BCRC – Benzie County Road Commission

BCPRC – Benzie County Parks & Recreation Commission

BLDHD – Benzie-Leelanau District Health Department

CRA – Conservation Resource Alliance

EPA – United States Environmental Protection Agency

GLA – Glen Lake Association

GTB – Grand Traverse Band of Ottawa and Chippewa Indians

GTRLC – Grand Traverse Regional Land Conservancy

LGOV – Local Governments (BT – Blaine Township, JT – Joyfield Township)

LA – Upper and Lower Herring Lake Associations

MDNR – Michigan Department of Natural Resources

MDEQ – Michigan Department of Environmental Quality

MDOT – Michigan Department of Transportation

MNSP – Michigan Natural Shoreline Partnership

MSUE – Michigan State University Extension

MLSA – Michigan Lake & Stream Association

MUs – Michigan Universities

NRCS – USDA Natural Resources Conservation

NN – Networks Northwest

NMOWTTF – Northwest Michigan Onsite Wastewater Treatment Task Force

NWMSBF – Northwest Michigan Sustainable Business Forum

USFWS – United States Fish & Wildlife Service

Others:

Watervale Resort, Camp Lookout Summer Camp, Area Libraries, Boat/Marine Retailers, Garden Centers and Nurseries, Solid Waste Management entities, Schools, Benzie County Chamber of Commerce, Environmental and Ecological Consultants, Architects and Engineers, Local Realtors, Businesses, Landscaping Companies

Target Audiences Include:

Builders/Developers/Realtors

Schools

Households

Local Governments

Riparian Landowners

Tourists

Local, regional and statewide media (MEDIA)

General Public

Funding Sources:

DEQ: CMI – Department of Environmental Quality, Clean Michigan Initiative

CWA Sec. 319 – Clean Water Act

GLRI – Great Lakes Restoration Initiative

NAWCA – North American Wetlands Conservation Act

GLFT – Great Lakes Trust

MDNR – Michigan Department of Natural Resources

MNRTF – Michigan Natural Resources Trust Fund

The tables on the following pages (see Table 49) include the tasks for implementing the watershed plan, including within direct coastal drainage areas where task appropriate. The evaluation strategy and the information and education strategy are presented in the next two chapters (see Chapters 9 and 10).

Category Costs

The total cost for implementation efforts for all categories was determined using some of the information in Table 44 above, but also information from individual stakeholders and organizations who will be doing the work. The total cost for implementation of the Herring Lakes Watershed Protection Plan (i.e., including outreach activities) is $1,840,000 in one-time expenditures, and $165,000 annually for 10 years.

Table 49: Tasks for Implementing the Herring Lakes Watershed Plan

Category 1: Water quality assessment (WQA)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objectives Addressed*
WQA 1- Ongoing monitoring of nutrients and identification of potential sources of nutrients and elevated bacteria in Herring Creek and tributaries, especially on Putney and E. Smelter Roads	HIGH	$20,000/year	Annual reports, work plans, funding proposals	X	X	X	X	X	X	X	X	X	***BCD & *LAs,** MDEQ, EPA	2.3, 2.4, 2.6, 5.3
WQA 2- Complete a detailed biological study of UHL and LHL ecology to determine causes of increased in Chara growth, and likely outcomes of increased light penetration from proliferation of exotic/invasive filter feeding mussels	HIGH	$25,000	Report of Findings			X		X					***BCD & *LAs,** MDEQ, MDNR, EPA, GTB, MSUE, MUs	1.1, 1.3, 2.1, 2.4, 2.9, 3.1, 6.2
WQA 3- Program to maintain current water quality programs, including groundwater monitoring at high density residential development areas	HIGH	$15,000/year	Annual Report	X	X	X	X	X	X	X	X	X	***BCD & *LAs,** MDEQ, EPA	1.4, 2.1, 2.3, 2.6, 4.6, 5.1, 5.4, 6.3
WQA 4- Calculate sediment and nutrient loading estimates	LOW	$10,000	Report of Findings by 2020						X				***BCD & *LAs,** MDEQ, EPA	1.1, 2.1, 2.2, 2.4, 6.1

*****Bold*** *indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan

Category 2: Fish and Wildlife Habitat (FWH)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objectives Addressed*
FWH1 - Maintain high water quality in both LHL and UHL	MEDIUM	$2,500/year	Annual water quality report by BCD from LAs annual data	X	X	X	X	X	X	X	X	X	***BCD,** GTB, MDNR, LAs	1.2, 1.3, 3.1, 3.2, 6.2
FWH2 - Develop plan and identify resources to improve the LHL outlet structure to prevent invasive species but allow for fish passage, especially walleye	HIGH	$15,000	Report of findings, feasibility study and cost assessment by 2018. Implement plan by 2023		X				X				***BCD, *LAs,** USFWS, MDNR, GTB	1.2, 1.3, 1.6, 3.1, 3.2
FWH3 - Monitor agency surveys relative to population on inland lakes and streams	MEDIUM	$1,000/year Lake surveys are conducted every 10 years. Stream surveys Every 5-10 years	Ongoing review of public agency surveys within 1 year of publication. LHL & UHL last surveyed in 2015	X	X	X	X	X	X	X	X	X	***GTB, *BCD,** MDNR, LAs	1.2, 1.3, 3.1, 3.2, 3.3
FWH4 - Complete study of fish movement between UHL and LHL	LOW	$15,000	Report of findings and recommendations by 2024 relative to maintaining high quality fishery on both LHL & UHL									X	***GTB,** MDNR, USFWS, BCD, LAs	1.2, 1.3, 3.1, 3.2, 3.3

Bold *indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan

Category 2: Fish and Wildlife Habitat (FWH) (Cont'd)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objective(s) Addressed*
FWH5 – MDNR to conduct feasibility study by 2025 regarding re-introduction of brown trout in LHL	LOW	$4,000/yr for BCD support	MDNR re-initiation of brown trout stocking program (i.e., abandoned in 1967)	X	X	X	X	X	X	X	X		***MDNR** GTB, USFWSB CD, LAs	1.2, 1.3, 3.1, 3.2, 6.2, 6.3
FWH6 - Implement BMP's and habitat restoration as needed and as funding is available.	MEDIUM	Estimate $80/foot for 1,000 feet = $8,000 year	Initiate projects as funding available, ongoing	X	X	X	X	X	X	X	X	X	***BCD**, USFWS CRA, MSUE, LGOV (BT &	1.2, 1.3, 2.3
FWH7 - Compile list of priority areas	MEDIUM	$2,000/yr year	Monitor and update project list as projects completed and new priorities are identified, ongong	X	X	X	X	X	X	X	X	X	***BCD**, LGOV (BT & JT), LAs	1.2, 1.3, 2.3

Bold *indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan

Category 3: Invasive Species (IS)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objectives Addressed*
IS-1- Implement an education program to inform watershed landowners and users about invasive species and create a yearly status report on the current conditions of invasive species	HIGH	$5,000/year	Hire a watershed coordinator at BCD by 2019. Seek funding and program implementation.	X	X	X	X	X	X	X	X	X	***BCD,** MDNR, MLSA, MDEQ, EPA, USFWS, GTB, MSUE, LAs	1.6, 2.3, 2.8, 3.4, 4.1, 4.2, 4.3, 6.1, 6.3
IS 2- Establish boat/bait box washing stations on LHL and LHL at respective MDNR boat launches to help control the introduction of invasive species	MEDIUM	$6,000/start up per lake and $2,500/year maintenance	Apply for funding to install a boat/bait box washing stations by 2019 on UHL and LHL		X	X	X	X	X	X	X	X	***BCD,** MDNR, MLSA, MDEQ, EPA, USFWS, GTB, MSUE, LAs, GLA	1.2, 1.6, 2.1, 2.3, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3
IS 3 - Investigate methods to prevent invasive species from Lake Michigan entering LHL, including effective barrier alternatives and costs	HIGH	$15,000	Report of alternatives, feasibility and costs by 2019			X	X						***BCD,** MUs, MDNR, USFWS, BCD, LAs	1.2, 1.6, 2.3, 6.2
IS 4 – Implement a watershed wide Invasive Species (IS) Management Program, including E. milfoil	HIGH	$35,000/year	Annual report of management activities and invasive species inventory	X	X	X	X	X	X	X	X	X	***BCD,** ***LAs,** MDNR, USFWS, MUs	1.1, 1.2, 1.6, 1.7

*****Bold** *indicates lead project partner per task category.*

Table 49: Tasks for Implementing the Herring Lakes Watershed Plan (cont'd)

Category 4: Shoreline and Stream Bank Protection (SSP)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objectives Addressed*
SSBP 1- Collaborate with the Benzie County Road Commission and MDOT to improve culverts and road/stream crossings to enhance passage, control erosion and sedimentation	MEDIUM	$6,000/year	Hire a watershed program coordinator to by 2019 within the BCD to provide information and assistance to road agencies	X	X	X	X	X	X	X	X	X	***BCRD,** MDOT, MDEQ, CRA, GTB, USFWS, BCD, LGOV (BT & JT)	1.7, 2.1, 2.2, 2.3, 2.5, 2.6, 2.7, 6.2
SSBP 2- Continue to inventory the shoreline, streams and lakes in the watershed for erosion, invasive species, etc. and develop a restoration plan for high priority sites.	MEDIUM	$2,000/year with volunteers from LAs	Volunteers from LAs to conduct survey yearly starting in 2019. Update LAs yearly on findings and results.	X	X	X	X	X	X	X	X	X	***LAs**, MNSP, BCDs	1.3, 1.6, 1.7, 2.7
SSBP 3 - Identify priority sites and willing landowners to protect/improve tributary riparian corridors, remove invasive species and/or restore degraded habitat along the shorelines of UHL, LHL and tributaries	HIGH	$2,000/year	Identify priority sites and obtain cost-share funds by 2019.	X	X	X	X	X	X	X	X	X	***BCD, *LAs,** MDEQ, MDARD, NRCS, CRA, MSUE	1.2, 1.3, 1.6, 1.7, 2.8

****Bold** indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan

Category 4: Shoreline and Stream Bank Protection (SSP) (cont'd)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objectives Addressed*
SSBP 4- Identify and provide assistance in the repair/replacement of obsolete septic systems, assist and ensure full implementation of the county-wide point of sale septic inspection program in the watershed, explore and implement community septic systems and legal organization of high density residential development areas in the watershed	HIGH	$15,000/year	Hire watershed program coordinator within the BCD by 2018. Ongoing work with landowners agencies to identify funding sources and assist in septic system repairs/replacements.		X	X	X	X	X	X	X	X	***LBDHD,** NMOWTTF, MDEQ, BCD, MSUE, LAs	2.1, 2.6, 4.5, 5.1, 5.4, 6.1, 6.2, 6.3
SSBP 5- Assist local units of government in the adoption of planning practices and specific zoning tools to protect water quality long-term in the watershed	MEDIUM	$12,000/year	Hire watershed program coordinator within the BCD by 2018. Ongoing work with local units of government	X	X	X	X	X	X	X	X	X	***NN,** LGOV (BT & JT), BCD, MSUE	1.5, 4.2, 4.3, 4.4, 4.6, 6.1, 6.2, 6.3
SSBP 6 – Implement improvement at the Boo Hoo View Road end/boat launch on LHL	MEDIUM	$30,000	Develop a plan for soil erosion/sedimentation control and boat launch improvement in 2019. Implement the plan by 2021 as funds are acquired				X						***BCRD,** MDEQ, LGOV (BT), BCD, LAs	2.2, 2.3, 2.5, 2.6, 2.7, 3.1, 6.2, 6.3

**Bold* *indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan

Category 5: Best Management Practices (BMP)

Categories/Tasks	*<u>Priority:</u> HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objective(s) Addressed*
BMP 1- Investigate methods to help reduce sedimentation through heavy recreational use at the LHL outlet	LOW	$10,000	Complete assessment of erosion/sedimentation problem areas and propose BMPs to repair/restore and guide recreational foot traffic through sensitive areas.			X							***BCD,** MSUE, LAs*	1.4, 1.6, 1.7, 2.7, 3.1, 3.4, 6.3
BMP 2 - Implement a cost share and assistance program to replace outdated or failing septic systems around lakeshores, tributaries and wetlands.	MEDIUM	$50,000/year for five years	Implement cost share program as funding is available for 5 years				X	X	X	X	X		***BLDHD,**MDEQ, BCD, MSUE, LGOV (BT & JT), MUs, LAs	1.3, 1.7, 2.2, 2.6, 5.1, 5.4, 6.1, 6.2, 6.3

**Bold* indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan
Category 5: Best Management Practices (BMP) (Cont'd)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objectives Addressed*
BMP 3 - Work with willing landowners and provide financial incentives to install and maintain BMPs to protect/improve riparian corridors, especially areas in agriculture along degraded tributaries in the watershed	HIGH	$20,000/site for 3 sites	Obtain cost-share funds by 2019. Complete treatment on 3 priority sites by 2020.	X	X	X	X	X	X	X	X	X	***CRA,** MDARDNRCS, MDEQ, BCD, MSUE	1.3, 1.7, 2.1, 2.3, 2.6, 6.2, 6.3
BMP 4 – Provide information and incentives to promote the secondary containment and proper handling, application and disposal of hazardous and potentially polluting substances, including	MEDIUM	$8,000/year	Hire watershed program coordinator within the BCD by 2018. Ongoing work with			X	X	X	X	X	X	X	***MDARD** NRCS, MDEQ, BCD, MSUE	2.1, 2.3, 2.6, 2.9, 5.1, 6.2, 6.3

**Bold indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan

Category 5: Information, Outreach and Education (IOE)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objective(s) Addressed*
IOE 1 - Develop and implement an education an outreach program for landowners in the watershed regarding water quality protection, invasive species, shoreline/stream bank protection, household hazardous substances use and storage, and other watershed BMPs	HIGH	$8,000/year	Develop signage, brochures and presentations	X	X	X	X	X	X	X	X	X	*BCD, MDEQ, EPA, MSUE, LAs	1.2, 2.1, 4.1, 4.2, 4.4
IOE 2 - Develop and implement communication strategy for watershed users in the watershed regarding water quality protection, invasive species, shoreline/stream bank protection, household hazardous substances use and storage, and other watershed BMPs	HIGH	$1,000/year	Develop strategy and implement strategy by 2018	X	X	X	X	X	X	X	X	X	***BCD,** MDEQ, EPA, MSUE, LAs	4.1, 4.2, 4.3
IOE 4 - Assist local land use decision makers to include water quality and natural resources protection as regular practice in site plan and/or special land use	MEDIUM	$1,000/year	Regularly attend planning commission and board meetings	X	X	X	X	X	X	X	X	X	***BCD,** MSUE, LAs	2.6, 4.1, 4.2, 4.3, 4.4, 4.6, 6.1, 6.2, 6.3

**Bold* indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan

Category 5: Information, Outreach and Education (IOE) (Cont'd)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objective Addressed*
IOE 5 - Provide water quality information and news about implementation tasks progress to local and regional media.	MEDIUM	$1,500/yr	Publicize watershed protection progress, updates to the watershed plan in lake association annual reports, in newspaper and on websites.	X	X	X	X	X	X	X	X	X	***BCD,** MSUE, LAs, MEDIA	4.1, 4.2, 4.4, 4.5, 4.6
IOE 6 - Advocate for zoning, master plans and ordinances that protect water quality, human health and natural resources	MEDIUM	$1000/yr	Attend at least 2 meeting annually	X	X	X	X	X	X	X	X	X	***BCD,** MSUE, LAs	1.1, 1.2, 1.4, 1.5, 1.7, 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.3

Bold indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan

Category 7: Land Protection (LP)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objectives Addressed*
LP 1- Establish natural area preserve and/or voluntary conservation easements to protect the Herring Swamp and other identified Priority Areas	HIGH	$150,000/year as funding for 8 years	Permanent protection of 500 acres by 2026	X	X	X	X	X	X	X	X	X	***GTRLC** BCPRCMN RTFMSUE, BCD, LAs, LGOV (BT & JT)	1.2, 1.7, 3.1, 3.4, 6.1, 6.2, 6.3
LP 2-Acquire and develop additional public access sites on public land, lakes and rivers in the watershed.	LOW	$200,000	Secure at least one parcel within 10 years	X	X	X	X	X	X	X	X	X	***LGOV,** MDNR	2.3, 2.1

****Bold** indicates lead project partner per task category.*

Table 49 (cont'd): Tasks for Implementing the Herring Lakes Watershed Plan

Category 8: Economy, Recreation and Tourism (ERT)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objectives Addressed*
ERT 1 - Ensure that zoning ordinances in watershed communities include provisions to protect recreational resources, scenic vistas, agricultural and forest lands, and historic or cultural sites.	LOW	$8,000/year	Assemble a group to attend township meetings by 2021. Work with Township officials throughout the year			X	X	X	X	X	X	X	***LGOV** (BT & JT), MSUE, BCD, LAs	1.2, 1.5, 3.1, 5.1, 6.1, 6.2, 6.3
ERT 2 - Provide ongoing economic and community development incentives to entrepreneurial business efforts that help protect and/or increase access to the region's high-quality natural resources	LOW	$5,000/year	Pending grant funding	X	X	X	X	X	X	X	X	X	***NN**, LGOV, NWMSBF, BCD, MSUE, LAs	1.2, 1.4, 3.1, 3.2, 6.2, 6.3

Bold *indicates lead project partner per task category.*

Table 50: Summary Task Table/Tasks **20**

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026
Ongoing water quality monitoring in	X	X	X	X	X	X	X	X	X
Complete a detailed biological			X		X				
Collaborate with agencies to maintain	X	X	X	X	X	X	X	X	X
Develop and implement plan to improve LHL outlet to prevent invasive species entry from Lake Michigan but allow fish passage	X					X			
Monitor agency surveys	X	X	X	X	X	X	X	X	X
Study fish movement between UHL								X	
MDNR study of establishing brown trout fishery in LHL	X	X	X	X	X	X	X	X	X
Implement BMPs to improve habitat	X	X	X	X	X	X	X	X	X
Implement invasive species education program	X	X	X	X	X	X	X	X	X
Establish/maintain boat wash stations		X	X	X	X	X	X	X	X
LHL outlet improvement feasibility and cost alternatives analysis	X					X			
Watershed wide invasive species	X	X	X	X	X	X	X	X	X
Culvert and road crossing	X	X	X	X	X	X	X	X	X
Invasive species & erosion area	X	X	X	X	X	X	X	X	X
Identify and prioritize restoration of	X	X	X	X	X	X	X	X	X
Identify& assist in repair/replacement	X	X	X	X	X	X	X	X	X
Assist with local governmental	X	X	X	X	X	X	X	X	X
Implement improvement at Boo Hoo View Road end			X						

Table 50: Summary Task Table (cont'd)

Task	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*
Implement a cost-share program for		X	X	X	X	X	X	X	X
Identify methods to restore/protect				X					
Implement a cost-share program for	X	X	X	X	X	X	X	X	X
Implement a cost-share program for willing landowners for secondary					X	X	X	X	X
Develop and implement comprehensive education and outreach program	X	X	X	X	X	X	X	X	X
Develop and implement comprehensive	X	X	X	X	X	X	X	X	X
Assist local government to consider water quality in site plan and special	X	X	X	X	X	X	X	X	X
Assist local government in adopting planning processes and zoning measures to protect water quality	X	X	X	X	X	X	X	X	X
Outreach to local and regional media	X	X	X	X	X	X	X	X	X
Purchase of development rights, conservation easement purchases within the Herring Swamp	X	X	X	X	X	X	X	X	X
Assist local government in adopting planning processes and zoning measures to protect recreational and	X	X	X	X	X	X	X	X	X
Support incentives for high-quality natural resource protection through economic and community development	X	X	X	X	X	X	X	X	X

Table 51: Summary of Implementation Task Costs by Category

Category	*Cost One-time*	*Annual for 10 yrs*
Water quality (WQ)	$35,000	$35,000/yr
Fish & Wildlife habitat (FWH)	$34,000	$17,500/yr
Invasive Species (IS)	$21,000	$42,500/yr
Shoreline/Streambank protection (SSP)	$30,000	$37,000/yr
Best Management Practices (BMP)	$320,000	$8,000/yr
Outreach, Information and education (OIE)	$0.0	$12,500/yr
Land Protection (LP)	$1,400,000	$0.0/yr
Economy, Recreation and Tourism (ERT)	$0.0	$13,000/yr
Total	**$1,840,000**	**$165,500/yr**

Plan Implementation Strategy

The Herring Lakes Watershed Steering Committee recognizes that the Herring Lakes Watershed Protection Plan 2018 is comprehensive, expansive, and rather aggressive in task schedule projections. The plan authors have sought to identify activities and tasks that by their very nature are “ongoing,” as well as those tasks that are one-time on time. It is also recognized that certainly not all tasks will be funded and/or implemented. It is the intent of this effort, strategy for plan implementation, and our shared commitment that the Herring Lakes Watershed Steering Committee and the Board of Directors of the Benzie Conservation District will prioritize tasks covered within this plan, and regularly, i.e., quarterly establish and re-establish task priorities, review and evaluate plan accomplishments, and review potential task funding sources.

CHAPTER 10: INFORMATION AND EDUCATION STRATEGY

The Information and Education Strategy highlights the actions needed to successfully maintain and improve watershed education, awareness, and stewardship for the Herring Lakes Watershed. It lays the foundation for the collaborative development of natural resource programs and educational activities for target audiences, community members, and residents. Environmental awareness, education, and action from the public will grow as the IE Strategy is implemented and resident awareness of the watershed is increased. Implementing the IE Strategy is a critical and important long-term task to accomplish. Initial IE efforts began by the Lake Associations, but more work is needed. Both organizations publish newsletters and host educational events. These outreach activities should be continued and paired with additional ones outlined in this management plan. Considerable time and effort should also continue to be put into introducing stakeholders to the watershed protection plan and its various findings and conclusions, as well as providing general information about the Herring Lakes Watershed and its beautiful and unique qualities. During the implementation phase of the IE Strategy, the critical first steps are to build awareness of basic watershed issues and sources of pollution, as well as how individual behaviors impact the health of the watershed. It will also be necessary to continue to introduce stakeholders to results and information provided in the revised management plan and shows them how they can use the plan to protect water quality in the region.

Information and Education is one of the overall goals of the plan described on pages 225-226. One of the most important tools to use when implementing watershed protection is an effective outreach and education campaign. Watershed residents, businesses, local leaders, seasonal residents, and tourists alike are often unfamiliar with watershed issues. This Information and Education (IE) Strategy addresses the communication needs associated with implementing the Herring Lakes Watershed Protection Plan.

Goals and Objectives

The goal of the IE strategy is to *Establish and promote educational programs that support effective watershed preservation and increase stewardship.* Fixing an erosion problem at a road-stream crossing does not involve a high degree of public involvement. But, developing and carrying out a regional vision for stewardship of water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes.

The objectives of this Implementation and Education Strategy focuses on building awareness, educating target audiences, and inspiring action. In order to accomplish many of these I & E tasks, a part-time position is needed such as a watershed coordinator. This position will be dependent on funding availability and the group does have a strategy in place to work on this project.

Five major objectives have been identified within Goal 4, which is to "Ensure that all watershed property owners, visitors, users and other stakeholders understand stewardship and are able to support and promote watershed protection activities." These include:

1. Raise awareness, understanding, commitment and action within the Herring Lakes Watershed so that private practices and public policy enhance attainment of the watershed goals.
2. Involve the citizens, public agencies, user groups and landowners in implementation of the watershed protection plan through meetings, events and workshops with individuals or groups.
3. Measure effectiveness of outreach activities in increasing awareness and reduction of Non-Point Source (NPS) pollution, including shoreline erosion.
4. Increase awareness of proper septic system maintenance, fertilizer use and storage of organic wastes and fertilizers.
5. Encourage appropriate provisions for site plan development and review for water quality and natural resources protection.

Target Audiences

A number of diverse regional audiences have been identified as key targets for IE strategy implementation. The targets are divided into user groups and decision-making groups.

User Groups

Households – The general public throughout the watershed.

Riparian Landowners – Due to their proximity to a specific water body, the education needs of riparian landowners are different.

Tourists – This area is known for its scenic beauty and recreational opportunities. The seasonal influx of people puts a noticeable strain on area infrastructure and often the environment. There is a growing concern that this important economic segment could eventually destroy the very reason why it exists, and that the region's tourism "carrying capacity" may soon be reached. There is clearly a growing need to educate tourists about their role in protecting the Herring Lakes environment.

Builders/Developers/Real Estate – This region is one of the fasting growing areas in Michigan in terms of population and land use. Increasingly, homes around and near Herring Lakes are being converted from small seasonal cottages to larger, year-round homes. Additionally, new developments are popping up all over the watershed. Members of the development industry segment play a crucial role in this growth and providing ongoing education opportunities about their role in protecting water quality and environmental health is critical.

Agriculture – Agricultural practices in certain streams and wetlands in the Herring Lakes Watershed could be improved, especially as they relate runoff into streams or waterbodies. Educating farmers using this practice would benefit the watershed by reducing erosion, protecting wetlands, and reducing nutrients and pathogens entering streams. Working closely with willing landowners and growers to find resources and other incentives to repair and improve practices is vital.

Education – Area educators and students, primarily K-12.

Special Target Audiences – In addition to the above, certain user groups such as recreational boaters, other sports enthusiasts, garden clubs, churches, or smaller audience segments may be targeted for specific issues.

Local Government Decision Makers

Elected/Appointed Officials – Township, village, city, and county commissioners; planning commissions; zoning board of appeals; road and drain commissioners; etc.

Staff – Planners, managers, township supervisors, zoning administrators, etc.

Message Development

General message outlines have been established for each target audience (see Table 52). These messages will be refined as implementation moves forward. They may also be modified or customized depending on the message vehicle.

Table 52: Target Audience Messages

Target Audience	*Messages*
Households	- Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed - Water quality-friendly lawn and garden practices - Housekeeping practices and the disposal of toxic substances - Septic maintenance - Managing storm water on your property
Riparian Landowners	- Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed - Riparian land management including the importance of riparian buffers - Water quality-friendly lawn and garden practices - Septic system maintenance - Housekeeping practices and the disposal of toxic substances - Clean boating practices
Tourists	- Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed - Help us protect the beauty that you enjoy when you are a guest - Clean boating practices - Role in controlling the spread of aquatic invasive species
Local Government Decision Makers	- Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed - The leadership role that local governments must play in protecting the watershed - The importance of establishing sound, enforceable natural resource protection ordinances - Economic impact and advantages of environmental protection

Table 52 (cont'd): Target Audience Messages

Target Audience	*Messages*
Agriculture	Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed Riparian land management including the importance of riparian buffers and BMPs Water quality friendly types of agricultural practices Disposal of toxic substances and pesticides should be done responsibly NRCS recommended Conservation Practices
Builders, Developers, Real Estate	Monetary advantages of and opportunities for Low Impact Development Identification and protection of key habitats and natural features: aquatic buffers, woodlands, wetlands, steep slopes, etc. Advantages of and opportunities for open space protection and financial incentives for conservation Minimize the cutting of trees and vegetation Impact of earthmoving activities, importance of soil erosion and sedimentation control practices, construction BMPs Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed Educate about and encourage wetland mitigation where landowners will cooperate
Education	Adoption and promotion of a state-approved watershed curriculum in K-12 schools. Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed Connection between watershed organizations' programs and school activities Active participation in watershed protection activities and stewardship

**Table adapted from Grand Traverse Bay Watershed Protection Plan (TWC 2005)*

Action Plan to Implement Strategies

A complete list of tasks by category follows this narrative (see Table 53); the categories are the same as those used to outline the implementation tasks in Chapter 8. Several priority areas for the Herring Lakes Watershed have been identified and the plan for rolling out the IE Strategy will correspond to these priority areas (see Section 5.7, Table 43, and Figure 38). Additionally, the IE Strategy will support other implementation efforts to control nutrient loading, loss of habitat, input of harmful toxins, and the impacts of invasive species in the watershed, and the impacts of other pollutants outlined in Section 4.6.

The IE Strategy tasks use a diverse set of methods and delivery mechanisms. Workshops, presentations, demonstration projects, brochures, public and media relations, web sites, e-mail and other communications tools will be used for the different tasks and target audiences. Broadcast media, most importantly television, is beyond the reach of most area partner organizations – at least at a level of reach, frequency and timing that can be expected to have any impact on awareness and behavior. This is a barrier to use of this effective medium, but effort should be placed on building coalitions that can pool resources to address larger picture issues through broader-based, more long-term communications efforts. Additionally, the use of social networking websites such as Facebook and Twitter have increased exponentially over the past few years. These sites offer advantages to reaching out to a broader segment of individuals that might not be reached via other means.

Partnerships

Due to the large amount of public land under state and federal control combined with the long history of active management within the Herring Lakes Watershed, several important and significant partnerships have developed to address issues that impact multiple management agencies. The Benzie Conservation District works closely with the Lake Associations and MDNR to implement ongoing information and education activities and invasive species control throughout the watershed. The Benzie Watershed Coalition was formed in 2011 and includes several additional organizations in partnership with the Benzie Conservation District to address water quality issues within and adjacent to the Herring Lakes Watershed. There are many partnerships and coordinated efforts between the Lake Associations and various organizations such as the Benzie Conservation District, Grand Traverse Regional Land Conservancy and the Conservation Resource Alliance. These are examples of the many partnerships that have formed and will continue forming as the project partners focus on implementing their respective tasks.

The total cost for implementation efforts for all categories is detailed in Chapter 8. The total costs for I & E efforts, which includes Goals 1, 2, 4 and 5 from Table 53 below is $396,000.

Table 53: Information and Education Tasks for the Herring Lakes Watershed

Information, Outreach and Education (IOE)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objectives Addressed*
IOE 1 - Develop an education and outreach program for landowners in the watershed regarding water quality protection, invasive species, shoreline/stream bank protection, household hazardous substances use and storage, and other watershed BMPs	HIGH	$8,000/year for 10 years	Develop and disseminate signage, brochures and 2 presentations/ year	X	X	X	X	X	X	X	X	X	***BCD,** MDEQ, EPA, MSUE, LAs	1.2, 2.1, 4.1, 4.2, 4.4
IOE 2 - Develop communication strategy for watershed users in the watershed regarding water quality protection, invasive species, shoreline/stream bank protection, household hazardous substances use and storage, and other watershed BMPs	HIGH	$1,000/year for 10 years	Develop strategy and implement strategy by 2017	X	X	X	X	X	X	X	X	X	***BCD,** MDEQ, EPA, MSUE, Las	4.1, 4.2, 4.3
IOE 4 - Assist local land use decision makers to include water quality and natural resources protection as regular practice in site plan and/or special land use review processes.	MEDIUM	$1,000/year for 10 years	Regularly attend planning commission and board meetings regularly	X	X	X	X	X	X	X	X	X	***BCD,** MSUE, Las	2.6, 4.1, 4.2, 4.3, 4.4, 4.6, 6.1, 6.2, 6.3

**Bold* *indicates lead project partner per task category.*

Table 53 (cont'd): Information and Education Tasks for the Herring Lakes Watershed Information, Outreach and Education (IOE) (Cont'd)

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objective(s) Addressed*
IOE 5 - Provide water quality information and news about implementation tasks progress to local and regional media.	MEDIUM	$1,500/year for 10 years	Publicize watershed protection progress, updates to the watershed plan in lake association annual reports, in newspaper and on websites.	X	X	X	X	X	X	X		X	BCD, MSUE, LAs, MEDIA	4.1, 4.2, 4.4, 4.5, 4.6
IOE 6 - Advocate for zoning, master plans and ordinances that protect water quality, human health and natural resources	MEDIUM	$1000/yr.	Attend at least 2 meeting annually	X	X	X	X	X	X	X	X	X		1.1, 1.2, 1.4, 1.5, 1.7, 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.3

**Bold* *indicates lead project partner per task category.*

Table 53 (cont'd): Information and Education Tasks for the Herring Lakes Watershed Other I & E related tasks

Categories/Tasks	*Priority: HIGH, MED, LOW*	*Estimated Cost*	*Milestone*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*Potential Project Partners*	*Objective(s) Addressed*
BMP 4 - Work with willing landowners and provide financial incentives to install and maintain BMPs to protect/improve riparian corridors, especially areas in agriculture along degraded tributaries in the watershed	HIGH	$20,000/site for 3 sites	Obtain cost-share funds by 2018. Complete treatment on 3 priority sites by 2020.	X	X	X	X	X	X	X	X	X	X	MDARD, NRCS, MDEQ, CRA, BCD, MSUE	1.3, 1.7, 2.1, 2.3, 2.6, 6.2, 6.3
BMP 5 – Provide information and incentives to promote the secondary containment and proper handling, application and disposal of hazardous and potentially polluting substances, including agricultural fuels and other inputs	MEDIUM	$8,000/year	Hire watershed program coordinator within the BCD by 2017. Ongoing work with willing landowners.				X	X	X	X	X	X	X	MDARD, NRCS, MDEQ, BCD, MSUE	2.1, 2.3, 2.6, 2.9, 5.1, 6.2, 6.3
IS-1- Implement an education program to inform watershed landowners and users about invasive species and create a yearly status report on the current conditions of	HIGH	$5,000/year	Hire a watershed coordinator at BCD by 2017. Seek funding and program	X	X	X	X	X	X	X	X	X	X	MDNR, MLSA, MDEQ, EPA, USFWS, GTB,	1.6, 2.3, 2.8, 3.4, 4.1, 4.2, 4.3, 6.1, 6.3

CHAPTER 11: EVALUATION PROCEDURES

An evaluation strategy will be used to measure progress during the Herring Lakes Watershed Protection Plan's implementation phase and to determine the degree to which water quality is improving. The frequency for the evaluation is approximately every five (5) years, with ongoing evaluation efforts completed as necessary. The first aspect of the evaluation strategy measures how well we are doing at actually *implementing* the watershed management plan and assesses if project milestones are being met. The second aspect is to evaluate how well we are doing at *improving water quality* in the watershed. The following sections address each of these issues.

Evaluation Strategy for Plan Implementation

This aspect of the evaluation strategy was developed to measure progress during the implementation phase of the watershed management plan and to provide feedback during implementation. The evaluation will be ongoing and will be conducted through the existing Steering Committee. The Steering Committee will meet two times a year to assess progress on plan implementation and to learn and share information about existing projects throughout the watershed. In addition, plan tasks, priorities, and milestones will be assessed every five (5) years to ensure that the plan remains current and relevant to the region and that implementation is proceeding as scheduled and is moving in the right direction.

The evaluation will be conducted by analyzing the existing watershed plan goals and objectives, as well as the implementation tasks and "milestones" in Chapter 8 to determine progress. Key milestones include conducting necessary research and water quality monitoring, protecting priority land areas, and assisting townships with enacting ordinances to protect water quality. The proposed timeline for each task will also be reviewed to determine if it is on schedule. Other anecdotal evidence (i.e., not attached to specific plan milestones) also will be noted that indicates the protection plan is being successfully implemented, such as an increase in the number of updated or new zoning ordinances adopted that deal with water quality and natural resource protections in watershed townships and municipalities.

Additionally, a number of other evaluation tasks will be completed due to the variety of tasks involved in the watershed plan. They will include, but not be limited to, the following:

- Use the Steering Committee to evaluate specific projects throughout plan implementation as needed.
- Conduct targeted surveys of project partners by direct mail, phone or by website to assist in information gathering.

- Maintain a current list of future target projects, the status of ongoing projects, and completed projects, along with their accomplishments. Keep track of the number of grants received and the money committed in the watershed region to implement aspects of the plan.
- Document the effectiveness of BMP implementation by taking photographs, completing site data sheets and gathering physical, chemical and/or biological site data.

The purpose of the evaluation strategy is to provide a mechanism to the Steering Committee to track how well the plan is being implemented and what can be done to improve the implementation process. Additional development of the strategy will occur as the implementation phase unwinds.

Measuring and Evaluating Social Milestones

Chapter 9 outlines an Information and Education Strategy that addresses the communication needs associated with implementing the watershed protection plan. The strategy is important because developing and carrying out a vision for stewardship of the region's water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes. Residents, local officials, homeowners, and the like must be educated and motivated to adopt behaviors and implement practices that result in water quality improvements.

In this respect, it is important to measure and keep track of the social impacts of the Herring Lakes Watershed Protection Plan. The Lake Associations, BCD, and other organizations conducting outreach must find out what types of outreach are working in the community and what types are not, along with how people's attitudes and behaviors are impacted. Just how much is social behavior changing because of the plan implementation? To answer this question, social impacts must be included when evaluating the progress of plan implementation.

Key social evaluation techniques that will be used to assess the implementation of the IE Strategy, as well as other watershed BMPs, include:

- Continued cooperation between area organizations submitting proposals to implement aspects of management plan.
- Social surveys (and follow up surveys) for homeowners, local officials, etc. to determine watershed and water quality awareness.
- Determining any increases in "watershed friendly" design and construction (anecdotal evidence will be used).

- Increased awareness (i.e., from both the general public and local government officials) regarding the necessity of water quality protection.
- Increase in the number of townships implementing water quality protection related ordinances.
- Incorporating feedback forms into educational and public events and posting them on various websites.
- Maintaining a list of ongoing and completed projects protecting water quality, along with their accomplishments and who is completing/completed the project.

Short-term Information and Education Task Implementation Strategy

The ongoing highest priority task for the Information and Education Strategy will focus on continuing progress of IOE-1 by the BCD and Lake Associations. Regular communication on progress of WQA-1 to all stakeholders through implementation of IOE-1 will be the most important way to utilize ongoing efforts and existing resources to initiate HLWPP implementation success.

Evaluation Strategy for Determining Water Quality Improvement

The US EPA dictates that watershed management plans must outline a set of criteria to determine whether proposed load reductions in the watershed are being achieved over time and that substantial progress is being made towards attaining water quality standards. The evaluation strategy is based on comparing established criteria with future monitoring results. The evaluation strategy will help identify whether water quality monitoring strategies are effectively documenting the progress of implementation tasks toward achieving measurable water quality improvement. The tasks discussed on page 238 for water quality outline the monitoring work that will be done to measure the majority of the water quality parameters. Much of the proposed tasks are dependent on future grant funding. The following criteria were developed to determine if the proposed pollutant reductions in the Herring Lakes Watershed are being achieved and that water quality is being maintained or improved:

1. Annual average total phosphorus concentrations in Upper and Lower Herring lakes remain below 10.0 mg/m3. Assuming constant rates of phosphorus release from anaerobic bottom sediments, atmospheric deposition and direct shoreline input, achieving annual average concentrations of >10.0 mg/m3 for Upper and Lower Herring lakes will be important to help prevent human induced eutrophication that could artificially advance the trophic status for each lake.

2. The annual average nitrogen concentration of Upper and Lower Herring lakes should remain above 80 mg/m3 to discourage preferential conditions that would give nitrogen fixing blue green algae such as *Anabeana spp*. and *Microcystis spp*. a competitive advantage over all other phytoplankton. Nitrogen levels are not regulated in surface waters by the State of Michigan or US EPA the maximum levels should

remain within statewide averages for inland lakes with a similar trophic status index as Upper and Lower Herring lakes.

3. Maintain high dissolved oxygen levels in the Upper and Lower Herring lakes and their tributaries. Dissolved oxygen concentrations in Upper and Lower Herring lakes and their tributaries should remain above the 7 mg/L standard that is required by the State of Michigan for waterbodies that support cold water.

4. Reduce storm water sediment loads draining into the Upper and Lower Herring lakes and their tributaries. Maintain annual turbidity levels below 5.7 NTU for all sampling locations except WS-4, which should remain below 9.0.

5. Maintain pH levels within range of 6.5 to 9.0 in Upper and Lower Herring lakes and tributaries as required by the State of Michigan.

6. Herring Creek above Upper Herring Lake should maintain water temperatures below 75.2° Fahrenheit (24° Celsius) to sustain its cold water. Water temperatures below the thermocline in Upper and Lower Herring lakes should not exceed 64.4° Fahrenheit (18° Celsius) throughout summer months. This is critical to maintaining cold water ecosystems in all waterbodies in the Herring Lakes Watershed that are designated cold water.

7. Documented *Microcystis* and Cladaphora colonies do not increase in size or density along Upper and Lower Herring lakes shorelines. *Microcystis* and Cladaphora algae occurs naturally in varying amounts along the shorelines of northern Michigan lakes, but grows more extensively and densely as nutrient availability increases. Individual colonies of both should be measured to determine area and rated by a qualitative density index (i.e., heavy, medium, light). Baseline survey results for Upper and Lower Herring lakes should be compared to future surveys to determine if *Microcystis* and Cladaphora colonies are expanding in size or density.

8. Chlorophyll-a concentrations should remain within normal ranges for similar lakes in northern Michigan to prevent problems associated with large phytoplankton blooms that can cause low dissolved oxygen levels. Peak chlorophyll-a concentrations for Upper and Lower Herring lakes should remain below 3 mg/m^3.

9. Minimum summertime secchi depth should be greater than 10 feet for both Upper and Lower Herring lakes.

10. *E. coli* levels in all water bodies in the Herring Lakes Watershed should not exceed 130 colonies/100 ml.

Herring Lakes Watershed Plan Update

The frequency for a complete evaluation of the HLWPP will be approximately every five (5) years. If updates to the Plan are needed prior to five years, the Steering Committee will coordinate with the DEQ and collect public input on any proposed changes.

CHAPTER 12: CONCLUSIONS

The Herring Lakes Watershed Protection Plan was developed to help guide efforts to protect water quality of Upper and Lower Herring lakes and their surrounding watershed. The watershed planning process to update the plan from the 2003 version was initiated in 2015 and allowed key decision-makers, organizations, resource management agencies and the public to learn about the watershed, what issues confront it and what they can do to protect it. The watershed plan was prepared by Grobbel Environmental & Planning Associates and the Herring Lakes Watershed Steering Committee with collaboration and input from major watershed stakeholders including the Upper and Lower Herring Lakes Associations, Benzie Conservation District, Grand Traverse Regional Land Conservancy, Michigan State University Extension, and local units of government.

In 2015 these committed partners initiated a watershed planning process and formed a steering committee. This 2018 watershed plan includes significant information on the watershed, pollutant concentrations, pollutant sources, and load reduction estimates of various BMPs, measurable task milestones to guide plan implementation progress, and a set of criteria to evaluate the effectiveness of implementation efforts. The Herring Lakes Watershed Protection Plan is meant to assist decision-makers, resource managers, landowners, residents and visitors in the watershed in making sustainable decisions to help maintain, improve and protect water quality. The success of the Herring Lakes Watershed Protection Plan will depend on continued support and participation from key partner groups, along with the availability of monies for implementation of the identified tasks. Partners responsible for the implementation of the plan are encouraged to review the plan and act to stimulate progress where needed and report to the larger partnership.

REFERENCES CITED

Ardizone, Katherine A. and Mark A. Wyckoff, FAICP. 2003. Filling the Gaps: Environmental Protection Options for Local Governments. Michigan Department of Environmental Quality Coastal Management Program with financial assistance from National Oceanic and Atmospheric Administration, authorized by the Coastal Zone Management Act of 1972. June 2003.Benzie County Open Space and Natural Resources Protection Plan (2002).

Biodiversity Project. October 2003. Great Lakes Basin Communications and Public Education Survey, Final Report.

Brown, et al. Michigan Department of Environmental Quality (DEQ). 2000. Developing a Watershed Management Plan for Water Quality: Introductory Guide.

Center for Watershed Protection (CWP). 1994. The Importance of Imperviousness. Watershed Protection Techniques. 1,3:100-107.

Center for Watershed Protection (CWP). 1998. (Reprint 2001.) Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds. Center for Watershed Protection: Ellicott City, MD.

De Walle, F.B. 1981. "Failure Analysis of Large Septic Tank Systems." Journal of Environmental Engineering. American Society of Civil Engineers.

Diana, James. 1995. Biology and Ecology of Fishes. Cooper Publishing Group LLC: Carmel.

Glarum, Sivert N. 1983. Our Land and Lakes. Table 49: Summary Task Table. Michigan, Benzie County, Lower Herring Lakes. West Graf, J.B. Publications, Manistee, Michigan.

Houghton, J.T., Y. Ding, D.J. Griggs, P.J. van der Linnen and V. Xiasou, eds. 2001. Climate Change 2001: The Scientific Basis Intergovernmental Panel on Climate Change: Working Group. Cambridge University Press, Cambridge, U.K.

Luttenton, Mark R. PhD. Lower Herring Lake Ecological Assessment. December 1, 2009.

Mehan, G. 1996. Mercury Pollution Prevention in Michigan: Summary of Current Efforts and Recommendations for Future Activities. University of Michigan Press, Ann Arbor, Michigan Department of Environmental Quality (DEQ). 1998. (Reprint 2001) Guidebook of Best Management Practices for Michigan Watersheds. Lansing, Michigan.

Michigan Department of Environmental Quality (DEQ). 1999. Pollutants Controlled Calculation and Documentation for Section 319 Watersheds – Training Manual. Lansing, MI.

Michigan Department of Environmental Quality (DEQ). 2010. Water Quality and Pollution Control in Michigan. 2008 Sections 303(d), 305(b), and 314 Integrated Report. MI/DEQ/WB-08/007.

NW Michigan Council of Governments (NWMCOG). 2012. Benzie County Guide to Permitting and Zoning.

Ohrel, R. 2000. Dealing With Septic System Impacts, Article 123 in The Practice of Watershed Protection. Center for Watershed Protection. Septic System Fact Sheet – www.stormwatercenter.net

Poff, N.L., M.M. Brinson, and J.W. Day, Jr. 2002. Aquatic ecosystems and global climate change: Potential impacts on inland freshwater and coastal wetland ecosystems in the United States. Pew Center on Global Climate Change. 45pp.

Sills, R. ed. 1992. Mercury in Michigan's Environment: Causes and Extent of the Problem. Michigan Department of Natural Resources, Surface Water Quality Division.

United States Environmental Protection Agency (USEPA). 2008. Handbook for Developing Watershed Management Plans to Restor and Protect our Waters.

United States Environmental Protection Agency (USEPA). 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. USEPA, Office of Water, Washington, D.C.

US Inspect. 2010. Septic System Terminology, http://www.usinspect.com/resources-for-you/house-facts/basic-components- and-systems-home/septic-systems/septic-terms

Waschbusch, R., W. Selbig, and R. Bannerman. 1999. Sources of phosphorus in storm water and street dirt from two urban residential basins in Madison, Wisconsin, 1994-95. USGS Water-Resources Investigations Report 99-4021.

Waters. 1995. Sediment in Streams: Sources, Biological Effects, and Control. American Society.

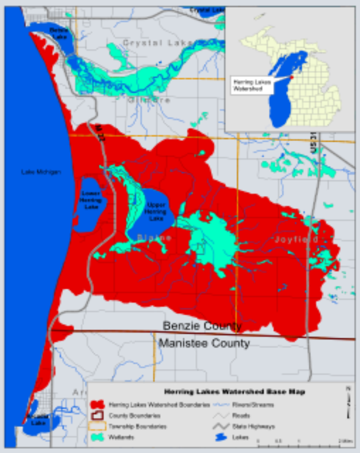
Wetzel, R.G. 2001. Limnology, Lake and River Ecosystems. Third Edition. Academic Press, Boston. pp1006.

Wolin, J. 1996. Late Holocene lake-level and lake development signals in Lower Herring lake, Michigan. Journal of Paleolimnology, Vol. 15, pp. 19-45.

Appendix A- Herring Lakes Watershed Questionnaire

Herring Lakes Watershed Questionnaire:

The Herring Lakes Watershed Steering Committee has been formed to create a watershed protection plan for the land and waters that empty into Herring Lakes. This area includes Upper Herring Lake, Lower Herring Lake, a portion of the Lake Michigan shoreline as well as all streams, creeks and wetlands in this area that eventually feed the Herring Lakes-Lake Michigan. The goal of the plan is to preserve and improve this area for future generations. The Committee is working with multiple stakeholders (i.e., Grand Traverse Regional Land Conservancy, Benzie Conservation District, MSU Extension, State and Local Governments, Upper and Lower Herring Lake Associations, businesses and landowners, etc.) to create a viable plan. *We seek your input to help set our priorities, goals and action plan. Please answer the following questions to help us better understand how the watershed is being used today and what concerns users have for the watershed. Please take a few minutes to answer the following questions to help us better understand how the watershed is being used and what concerns users have for the watershed.* You can submit completed surveys in person or mail them to the Benzie Conservation District.



Mailing address:
Benzie Conservation District
280 S. Benzie Boulevard
Beulah, Michigan 49617
Phone: 231-882-4391

The survey is also available on the web via the link below:
http://www.benziecd.org/herringlakessurvey

1. What is your residential status within the Herring Lakes (HL)Watershed? Please CIRCLE ALL that apply.

   - *Full-time resident -part-time resident -seasonal visitor -first time visitor*
   - *Occasional visitor -Business Owner -Township/County Board Member*
   - *Other (please specify)*_______________________________

2. What part of the HL watershed are you most familiar with? Please CIRCLE all that apply.

   -Upper Herring Lake *-Lake MI (within HL watershed)* *-Streams/Tributaries*

   -Lower Herring Lake *-Interior of watershed*

   *Other (please specify)*_______________________________

1

3. How do you utilize or spend time in the watershed? And where in the watershed do you conduct these activities? *(Please list the location (s) using the categories in questions #2 for all that apply)*

Location

- Swimming ______________
- Motor boating ______________
- PWC (jet skiing) ______________
- Canoeing/kayaking ______________
- Ski/tubing/wakeboard ______________
- Fishing (L. Michigan) ______________
- Fishing (streams) ______________
- Fishing (Inland Lakes) ______________
- Hunting ______________
- Hiking ______________
- Sailboating ______________
- Other – (please describe)
- ______________________

4. Please rate the quality of the activities you enjoy in the watershed (Excellent, good, fair or poor) and at what frequency?. **Regularly** (>2-3 times/week), **Fairly Often** (2-4 times/month), **Sometimes** (6 times/year), **Once a year, Never**

Quality

- Swimming ______________
- Motor boating ______________
- PWC (jet skiing) ______________
- Canoeing/kayaking ______________
- Ski/tubing/wakeboard ______________
- Fishing (L. Michigan) ______________
- Fishing (streams) ______________

Quality

- Fishing (Inland Lakes) ______________
- Hunting ______________
- Hiking ______________
- Sailboating ______________
- Other – (please describe)
- ______________________

5. The HL Protection Plan Steering Committee has preliminarily identified the following threats to the watershed. Please rank the priority of these threats. Check one box per line.

	Very High	High	Medium	Low	No Opinion
Invasive species	_____	_____	_____	_____	_____
Nutrient inputs (N, P)	_____	_____	_____	_____	_____
Fluctuation of Herring Lake Levels	_____	_____	_____	_____	_____
Fluctuation of Lake Michigan Levels	_____	_____	_____	_____	_____
Sediment input	_____	_____	_____	_____	_____
Bacteria pollution	_____	_____	_____	_____	_____
Swimmers itch	_____	_____	_____	_____	_____
Thermal Pollution	_____	_____	_____	_____	_____
Aesthetic concerns in lakes *(eg, mucky sediment build up on bottomlands)*	_____	_____	_____	_____	_____

6. Have you noticed any significant changes in the watershed? And WHERE have you noticed the changes? Please check all that apply.

In the past	**5 years**	**10 years**	**20 years**	**30 years**	**50 years**
Upper Herring Lake	_____	_____	_____	_____	_____
Lower Herring Lake	_____	_____	_____	_____	_____
Lake Michigan *(within the watershed boundaries)*	_____	_____	_____	_____	_____
Streams/Tributaries	_____	_____	_____	_____	_____
Interior of watershed	_____	_____	_____	_____	_____

7. What changes specifically, if any, have you noticed since you've lived in the watershed in and WHERE you have noticed these changes?

Upper Herring Lake	____
Lower Herring Lake	____
Lake Michigan *(within the watershed boundaries)*	____
Streams/Tributaries	____
Interior of watershed	____

8. What do you feel is the greatest threat to the Herring Lakes Watershed?

9. Are there any specific sites in the watershed that deserve special attention and/or management? If yes, please list the sites below.

10. Imagine the Herring Lakes Watershed 50 years from now - What do you want it to look like?

Appendix B- Herring Lakes Watershed Questionnaire Results

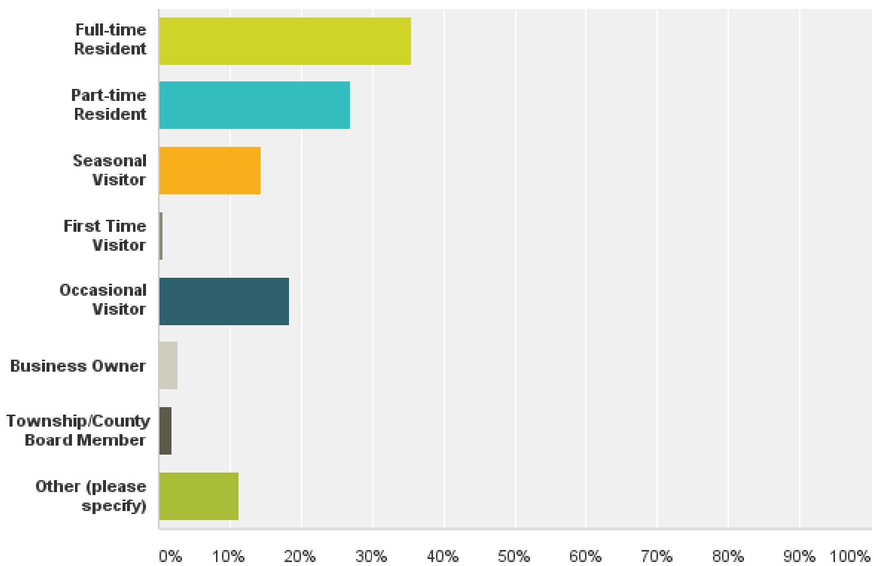
Questionnaire Summary 8-18-2016

(Login: HerringLakesWatershed Pw: waterquality)

Total responses = #153

Q-1What is your residential status within the Herring Lakes (HL) Watershed? Please check all that apply.

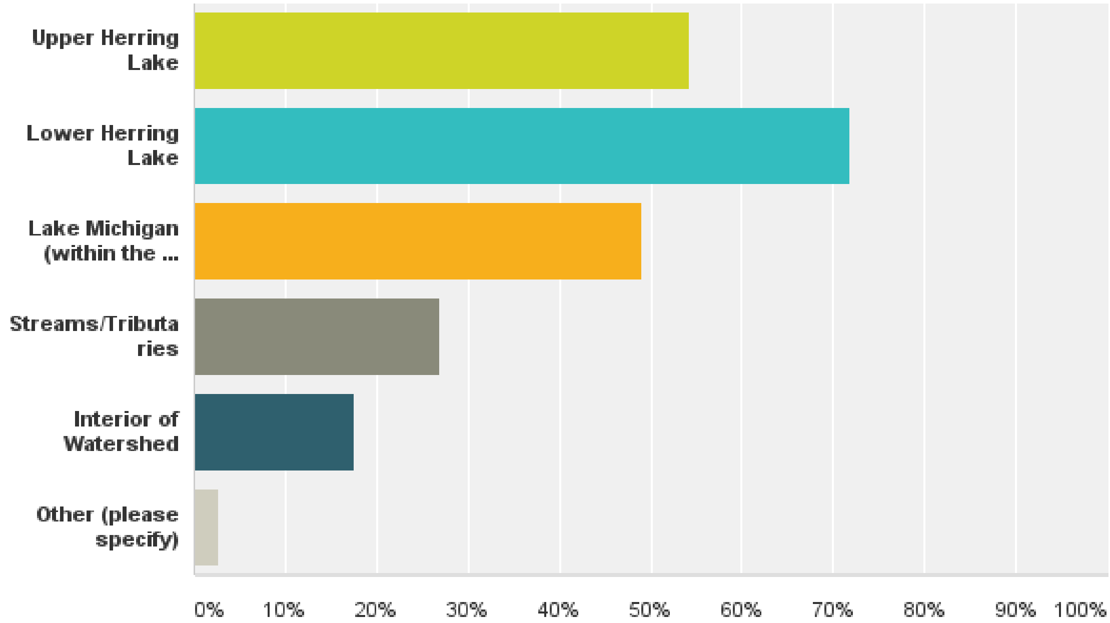
151 answered, 1 skipped



Answer Choices	Responses	
Full-time Resident	35.53%	54
Part-time Resident	26.97%	41
Seasonal Visitor	14.47%	22
First Time Visitor	0.66%	1
Occasional Visitor	18.42%	28
Business Owner	2.63%	4
Township/County Board Member	1.97%	3
Other (please specify)	11.18%	17
Total Respondents: 152		

Q2-What part of the Herring Lakes (HL)Watershed are you most familiar with. Please check all that apply.

Answered: 149   Skipped: 4

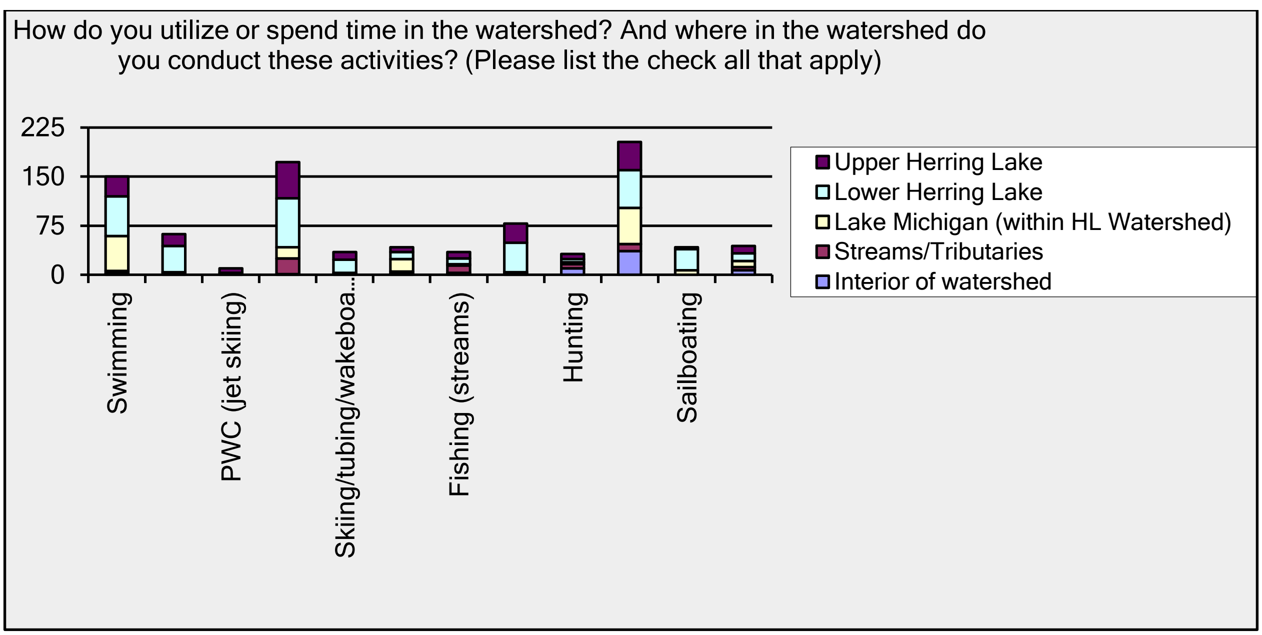


Answer Choices	Responses	
Upper Herring Lake	**54.36%**	81
Lower Herring Lake	**71.81%**	107
Lake Michigan (within the HL Watershed)	**48.99%**	73
Streams/Tributaries	**26.85%**	40
Interior of Watershed	**17.45%**	26
Other (please specify)	**2.68%**	4
Total Respondents: 149		

Q3-**How do you utilize or spend time in the watershed? And where in the watershed do you conduct these activities? (Please list the check all that apply)**

Answered: 145   Skipped: 8

	Upper Herring Lake	Lower Herring Lake	Lake Michigan (within HL Watershed)	Streams/Tributaries	Interior of watershed	Total Respondents
Swimming	**30.00%** 30	**61.00%** 61	**53.00%** 53	**4.00%** 4	**2.00%** 2	100
Motor boating	**32.73%** 18	**72.73%** 40	**7.27%** 4	**0.00%** 0	**0.00%** 0	55
PWC (jet skiing)	**77.78%** 7	**22.22%** 2	**0.00%** 0	**11.11%** 1	**0.00%** 0	9
Canoeing/kayaking	**56.12%** 55	**76.53%** 75	**17.35%** 17	**24.49%** 24	**1.02%** 1	98
Skiing/tubing/wakeboarding	**38.71%** 12	**64.52%** 20	**9.68%** 3	**0.00%** 0	**0.00%** 0	31
Fishing (Lake MI)	**23.33%** 7	**36.67%** 11	**63.33%** 19	**10.00%** 3	**6.67%** 2	30
Fishing (streams)	**43.48%** 10	**39.13%** 9	**8.70%** 2	**47.83%** 11	**13.04%** 3	23
Fishing (inland lakes)	**49.15%** 29	**76.27%** 45	**3.39%** 2	**1.69%** 1	**1.69%** 1	59
Hunting	**40.00%** 8	**25.00%** 5	**15.00%** 3	**30.00%** 6	**50.00%** 10	20
Hiking	**41.75%** 43	**56.31%** 58	**53.40%** 55	**10.68%** 11	**34.95%** 36	103
Sailboating	**8.11%** 3	**86.49%** 32	**18.92%** 7	**0.00%** 0	**0.00%** 0	37
Other (please specify)	**47.83%** 11	**52.17%** 12	**39.13%** 9	**21.74%** 5	**30.43%** 7	23



Q4- **Please rate the quality of the activities you enjoy in the watershed (Excellent, good, fair or poor)**

Answered: 133 Skipped: 20

	Excellent	Good	Fair	Poor	(no label)	Total Respondents
Swimming	**30.53%** 29	**50.53%** 48	**12.63%** 12	**6.32%** 6	**0.00%** 0	95
Motor boating	**50.00%** 25	**44.00%** 22	**4.00%** 2	**2.00%** 1	**0.00%** 0	50
PWC (jet skiing)	**44.44%** 4	**44.44%** 4	**0.00%** 0	**0.00%** 0	**11.11%** 1	9
Canoeing/kayaking	**57.78%** 52	**37.78%** 34	**3.33%** 3	**1.11%** 1	**0.00%** 0	90
Skiing/tubing/wakeboarding	**52.94%** 18	**41.18%** 14	**2.94%** 1	**5.88%** 2	**0.00%** 0	34
Fishing (Lake MI)	**40.74%** 11	**44.44%** 12	**11.11%** 3	**3.70%** 1	**0.00%** 0	27
Fishing (Streams)	**13.64%** 3	**54.55%** 12	**27.27%** 6	**4.55%** 1	**0.00%** 0	22
Fishing (Inland Lakes)	**22.45%** 11	**53.06%** 26	**24.49%** 12	**0.00%** 0	**0.00%** 0	49
Hunting	**21.05%** 4	**47.37%** 9	**26.32%** 5	**0.00%** 0	**5.26%** 1	19
Hiking	**63.83%** 60	**32.98%** 31	**3.19%** 3	**0.00%** 0	**0.00%** 0	94
Sailboating	**58.82%** 20	**38.24%** 13	**2.94%** 1	**0.00%** 0	**0.00%** 0	34
Other (please specify)	**75.00%** 12	**25.00%** 4	**6.25%** 1	**0.00%** 0	**0.00%** 0	16

Q5-**Please rate the frequency of which you enjoy the activities in the watershed (Regularly, Fairly Often, Sometimes, Once a Year, Never)**

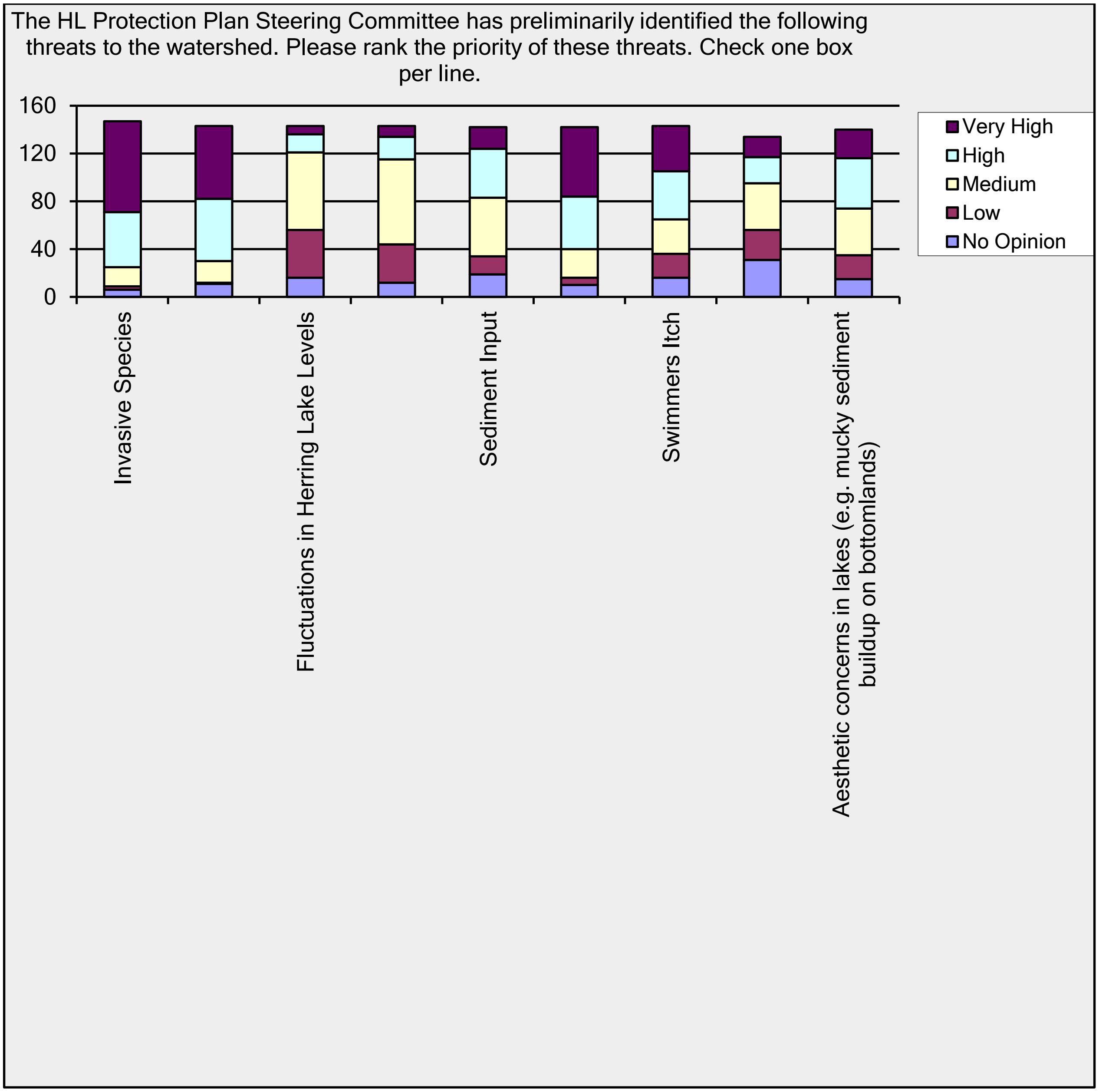
Answered: 142 Skipped: 11

	Regularly (>2-3 times/week)	Fairly Often (2-4 times a Month)	Sometimes (6 times/year)	Oncea Year	Never	Total Respondents
Swimming	20.19% 21	25.00% 26	36.54% 38	13.46% 14	5.77% 6	104
Motor boating	29.17% 21	12.50% 9	27.78% 20	12.50% 9	18.06% 13	72
PWC (jet skiing)	5.88% 2	11.76% 4	8.82% 3	0.00% 0	73.53% 25	34
Canoeing/kayaking	18.18% 18	28.28% 28	36.36% 36	13.13% 13	4.04% 4	99
Skiing/tubing/wakeboarding	12.24% 6	12.24% 6	22.45% 11	24.49% 12	28.57% 14	49
Fishing (Lake MI)	4.76% 2	14.29% 6	26.19% 11	16.67% 7	38.10% 16	42
Fishing (Streams)	0.00% 0	9.76% 4	24.39% 10	26.83% 11	39.02% 16	41
Fishing (Inland Lakes)	10.94% 7	18.75% 12	32.81% 21	23.44% 15	14.06% 9	64
Hunting	10.26% 4	7.69% 3	25.64% 10	12.82% 5	43.59% 17	39
Hiking	24.04% 25	33.65% 35	32.69% 34	6.73% 7	2.88% 3	104
Sailboating	22.22% 12	14.81% 8	20.37% 11	12.96% 7	29.63% 16	54
Other (please specify)	33.33% 7	28.57% 6	19.05% 4	0.00% 0	19.05% 4	21

Q6- **The HL Protection Plan Steering Committee has preliminarily identified the following threats to the watershed. Please rank the priority of these threats.**

Answered: 150 Skipped: 3

	Very High	High	Medium	Low	No Opinion	Total
Invasive Species	**51.70%** 76	**31.29%** 46	**10.88%** 16	**2.04%** 3	**4.08%** 6	147
Nutrients (N, P)	**42.66%** 61	**36.36%** 52	**12.59%** 18	**0.70%** 1	**7.69%** 11	143
Fluctuations in Herring Lake Levels	**4.90%** 7	**10.49%** 15	**45.45%** 65	**27.97%** 40	**11.19%** 16	143
Fluctuations in Lake MichiganLevels	**6.29%** 9	**13.29%** 19	**49.65%** 71	**22.38%** 32	**8.39%** 12	143
Sediment Input	**12.68%** 18	**28.87%** 41	**34.51%** 49	**10.56%** 15	**13.38%** 19	142
Bacteria Pollution	**40.85%** 58	**30.99%** 44	**16.90%** 24	**4.23%** 6	**7.04%** 10	142
Swimmers Itch	**26.57%** 38	**27.97%** 40	**20.28%** 29	**13.99%** 20	**11.19%** 16	143
Thermal Pollution	**12.69%** 17	**16.42%** 22	**29.10%** 39	**18.66%** 25	**23.13%** 31	134
Aesthetic concerns in lakes (e.g. mucky sediment buildup on bottomlands)	**17.14%** 24	**30.00%** 42	**27.86%** 39	**14.29%** 20	**10.71%** 15	140



To compare with Steering committee ranking:

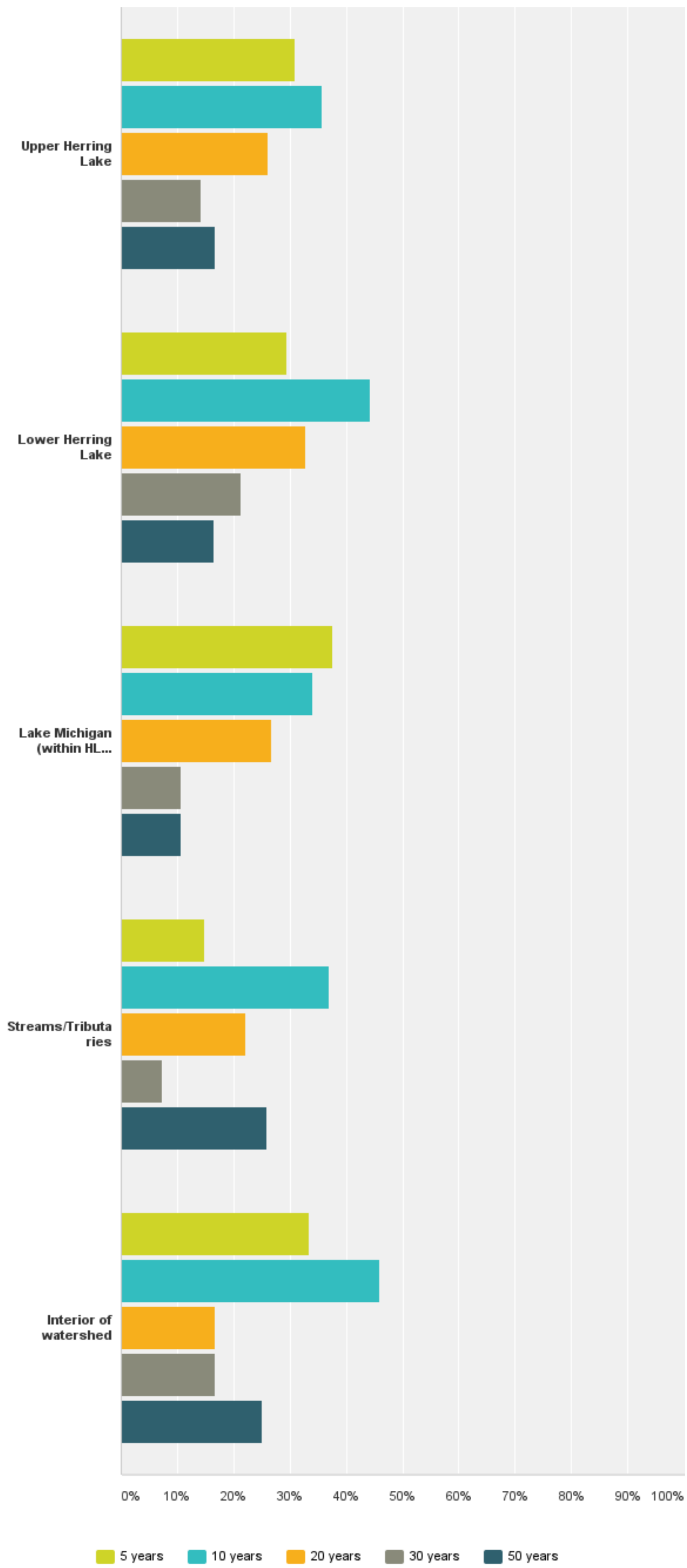
Pollutant	Rating
Invasive Species	High
Nutrients (N, P)	High
Aesthetic concerns in lakes (e.g. mucky sediment buildup on bottomlands)	High
Bacteria Pollution	High
Swimmers Itch	High

Fluctuations in Herring Lake Levels	Medium
Fluctuations in Lake Michigan Levels	Medium
Sediment Input	Medium
Thermal Pollution	Low

Q7-**Have you noticed any significant changes in the watershed? And WHERE have you noticed the changes? Please check all that apply.**

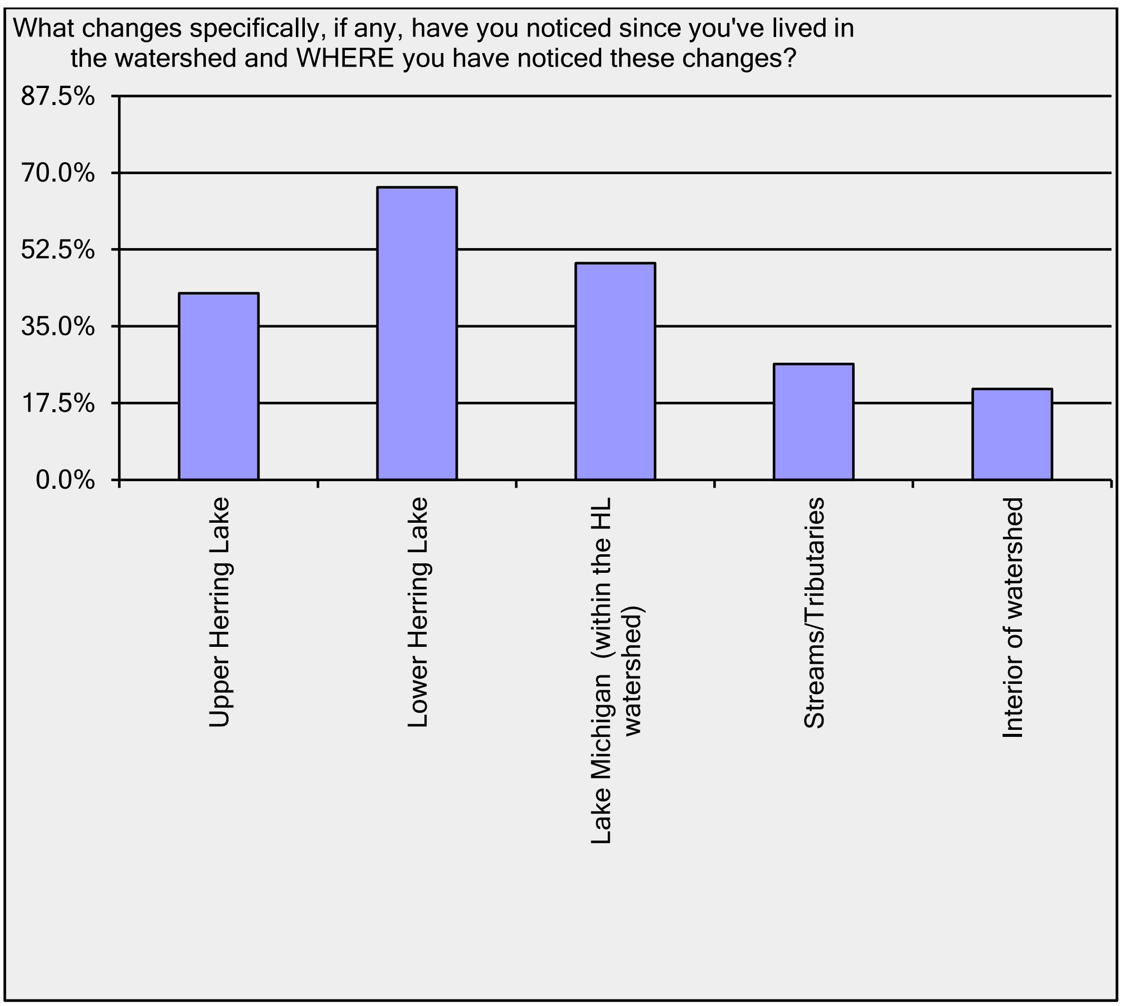
Answered: 91 Skipped: 62

	5 years	10 years	20 years	30 years	50 years	Total Respondents
Upper Herring Lake	**30.95%** 13	**35.71%** 15	**26.19%** 11	**14.29%** 6	**16.67%** 7	42
Lower Herring Lake	**29.51%** 18	**44.26%** 27	**32.79%** 20	**21.31%** 13	**16.39%** 10	61
Lake Michigan (within HL Watershed)	**37.50%** 21	**33.93%** 19	**26.79%** 15	**10.71%** 6	**10.71%** 6	56
Streams/Tributaries	**14.81%** 4	**37.04%** 10	**22.22%** 6	**7.41%** 2	**25.93%** 7	27
Interior of watershed	**33.33%** 8	**45.83%** 11	**16.67%** 4	**16.67%** 4	**25.00%** 6	24


Upper Herring Lake
Lower Herring Lake
Lake Michigan (within HL...
Streams/Tributaries
Interior of watershed
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
5 years
10 years
20 years
30 years
50 years

Q8-What changes specifically, if any, have you noticed since you've lived in the watershed and WHERE you have noticed these changes?

Answer Options	Response Percent	Response Count
Upper Herring Lake	42.5%	37
Lower Herring Lake	66.7%	58
Lake Michigan (within the HL watershed)	49.4%	43
Streams/Tributaries	26.4%	23
Interior of watershed	20.7%	18
	answered question	87
	skipped question	66



Upper Herring Lake	Lower Herring	Lake Michigan (within the HL watershed)	Streams/Tributaries	Interior of watershed
More populations/homes along lake	E.coli from septics	invasives	Weeds	more farming/animal
weed growth	less water plants	Increased bottom growth	less farming (animals), more vegetation	larger populatio area
more boats on the lake; larger population living on the lake, more weeds; clearer water	invasive species	lack of alewives	green filamentous algae in Herring Creek	
water is more clear	Foaming stuff	Low levels		
Increased new construction along shore (lawns to shoreline)	Aquatic plants (east side of lake)	Weeds		\
Zebra mussels	Zebra Mussels	Algae		
more boats on the lake	Swimmers Itch	more garbage from Wisconsin		
-	larger population living on the lake	Lake Level fluctuations		
-		Much diminished beach		
	more boats on lake	Trash		
	more weed growth	Increased new construction along lakeshore		
	More sediment near the shoreline	Sand dunes disturbed		
	no minnows			
	Increased new construction along shore (lawns to shoreline)	-	-	-
	Muckier bottom	-	-	-

Q9-What do you feel is the greatest threat to the Herring Lakes Watershed?

Response Text	Count
invasive species	52
humans/development	21
septics	19
Pollutants	16
Nutrients	10
Runoff	7
Bacterial pollution	7
zebra mussels	6
Agriculture	6
Sediment loading	5
Fertilizer	5
animal waste	4
Algae	4
lack of buffers	4
wind turbines	2
water quality deterioration	2
Loss of habitat	2
swimmers itch	2
oil spill in the straits	2
population growth	1
lack of knowledge	1

bikes on the dirt walking trails	1
access to water for recreation	1
Erosion	1
computer hacking	1
Low water level	1
climate change	1
Ignorance	1
aesthetic concerns	1

Q10- Are there any specific sites in the watershed that deserve special attention and/or management? If yes, please list the sites below.

59 answered and 94 didn't answer

Response Text	Count
Education the public	2
Invasive Species	2
Cattle operation(s) where Keillor Rd merges with Herring/Gorivan Rds north of Putney Corners.	3
channel- closing up by storms and weeds	3
land protection of remaining undeveloped parcels, especially wetlands that act as buffers from nutrient runoff on agricultural or residential lands	3
Upper and Lower Herring Lake (inlets/outlets)	4
access site	1
algae	1
Better manage both lakes for fishing opportunities	1
Chica Love's Lot	1
clear Herring Creek of brush to be able to kayak between lakes	1

Determine E. coli sources in swamp & tributaries & in L.H.L. Reduce E. coli levels	1
Direct access of cattle to streams	1
farms upstream of Upper Herring Lake	1
Gilroy farm,	1
Homes built only a few feet above lake levels.	1
Increasing access to Lake Michigan at Watervale road	1
Lower Herring Lake and outlet	1
Septic systems on Lower Herring Lake.	1
Septics in Elberta Resort	1
Smeltzer orchard company	1
Streams that cross cow pastures and lake shores.	1
Swamp Perimeter	1
swimmers itch	1
The walking trails need to be kept clear and safe to walk.	1
Tributaries	1
Watervale	1