Gun River Watershed Management Plan

Updated August 2024

EGLE Project No. 2020-0113

Prepared by the Allegan Conservation District

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DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY
KALAMAZOO DISTRICT OFFICE

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September 27, 2024

VIA EMAIL

Brian Talsma, Executive Director
Allegan Conservation District
1668 Lincoln Road
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Dear Brian Talsma:

Thank you for submitting your watershed management plan titled "Gun River Watershed Management Plan" to the Department of Environment, Great Lakes, and Energy (EGLE) for review with respect to meeting criteria for: (1) the state Clean Michigan Initiative (CMI) Nonpoint Source Pollution Control program, and (2) the U.S. Environmental Protection Agency (EPA) Section 319 program of the federal Clean Water Act. The efforts and support of the Allegan Conservation District and your partners to preserve and protect Michigan's surface water resources are appreciated.

As you may know, the CMI program criteria are specified in Administrative Rules promulgated pursuant to Part 88, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, effective October 27, 1999. The EPA requires that all implementation projects funded under Section 319 be supplemented by a watershed management plan that meets nine required elements as described in the EPA's document titled, "Nonpoint Source Program and Grants Guidelines for States and Territories (April 12, 2013)." Our review of the "Gun River Watershed Management Plan", dated August 2024, indicates that the plan meets both the CMI criteria and the EPA criteria, and is hereby approved for the purposes of the CMI Nonpoint Source Pollution Control program and the federal Section 319 program.

Please note that EGLE watershed management plan approvals are only good for the effective life of the plan. In this case, the Gun River Watershed Management Plan describes actions that are proposed to be implemented over a ten-year period, after which an updated plan will likely need to be submitted to EGLE for review and approval to maintain eligibility for both CMI and 319 funds. In addition, the plan approval is effective as long as the underlying assumptions within the plan remain relevant. Underlying assumptions would include, but are not limited to, things like designated use impairment, land use distribution, and stakeholder's goals and objectives. Updates of approved watershed management plans are expected to be endorsed by the entity that developed and received approval of the plan. For information regarding funds that may be available in EGLE's Nonpoint Source Grant Program, please monitor our web site at www.michigan.gov/nps.

Feel free to contact me if you have questions about the plan approval.

Sincerely,

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CHAPTER 1 – WATERSHED DESCRIPTION

1.1 GEOGRAPHIC SCOPE

The Gun River Watershed is situated in southwestern Michigan's lower peninsula between the metropolitan areas of Grand Rapids and Kalamazoo and is within the greater Kalamazoo River Basin. The Watershed comprises 73,272 acres in Allegan and Barry Counties. The village of Martin and the city of Plainwell are within the watershed boundary. It stretches through the townships of Wayland, Martin, Gun Plain, and Otsego in Allegan County and Thornapple, Yankee Springs, Orangeville, and Prairieville Townships in Barry County (Figure 2). The Gun River is formed from the outflow of the largest Inland lake in southwestern Michigan, Gun Lake. It flows 12 miles south from Gun Lake through agricultural and urbanizing areas before entering the Kalamazoo River in Otsego, where it flows northwest to its convergence with Lake Michigan.

1.2 TOPOGRAPHY

The underlying bedrock of the Gun River Watershed is composed of Coldwater Shale and Marshal formation deposited 300 million years ago in ancient seas that occupied the Michigan Basin. On top of these geological formations, there are 50 to 400 feet of glacial drift deposited when the last glaciers retreated 14,000 years ago. Rolling landscapes, gently rolling plains, wetlands, and open water are glacial features that are present within the watershed as evidence of the last glaciation.

The topography of the watershed ranges in elevation from 893 feet above sea level at the northeastern boundary of the Watershed to 671 feet above sea level at the mouth in Otsego Township (Figure 3). The land in the western portion of the Watershed is nearly level or slightly undulating while the eastern portion of the watershed contains much more hills. Runoff varies with the degree of slope, which averages 3.4% across the watershed but reaches 40% in the eastern portion of the watershed where the topography is much more varied (Diana, 2017).

1.3 SOILS

The debris left behind from the retreating glaciers formed the parent material of the soils throughout the watershed. Soil types vary based on topography and microclimate conditions but are primarily deep, well-drained sands and sandy loams. Soils can be differentiated by location within the watershed: the level western region, the more sloping eastern region and the lowland floodplain areas.

The soils in the western portion of the Watershed are predominantly fine sands, sandy loams, and loamy sands of the Chelsea-Ockley-Oshtemo association which are well- to excessively drained. These soils are common in outwash plains and stream terraces.

The soils in the eastern portion of the watershed are a mixture of Houghton and Adrian muck soils in lowland areas and Coloma, Boyer, and Spinks loamy sand complexes in more upland areas. Houghton and Adrian mucks are formed in thick herbaceous material in depressions and drainage ways and have very poor drainage with seasonal ponding. Coloma, Boyer, and Spink soils are well- to excessively well-drained soils formed on moraines and till plains.

Soils that predominate in the lowland floodplain of the Gun River are of the Glendora-Adrian-Granby association, characterized by nearly level, poorly drained, and very poorly drained soils. These soils are formed in sandy alluvium of floodplains and have a high seasonal water table.

Soils can be classified into hydrologic soil groups based on their runoff potential and infiltration rates. Total acres and percent of watershed represented for each hydrologic soil group are shown in Table 1.1 The majority (67%) of the watershed has low runoff potential with moderate to high (>0.49 in/hr) infiltration rates. Only a small percentage (11%) of soils within the watershed have a high runoff potential and slow (<0.28 in/hr) infiltration rates (Figure 4).

Table 1.1 - Hydrologic Soil Groups in the Gun River Watershed (USDA-SCS, 1987; USDA-SCS, 1990)

Hydrologic Soil Group	Acres in Allegan County	Acres in Barry County	Total Acres in Watershed	Percent in Watershed
A	11,361	14,852	26,214	36%
A/D	8,778	4,425	13,203	18%
B	16,147	6,319	22,466	31%
B/D	2,775	136	2,910	4%
C	1,971	234	2,204	3%
C/D	36	0	36	<1%
D	589	5,650	6,239	8%
TOTAL	41,615	31,657	73,272	100%

A - High infiltration rate, low runoff potential. Well-drained to excessively drained sands or gravely sands. High rate of water transmission.
B - Moderate infiltration rate. Moderately well- to well-drained. Moderately fine to medium coarse texture. Moderate rate of water transmission.
C - Slow infiltration rate. Has layer that impedes downward movement of water. Moderately fine to fine texture. Slow rate of water transmission.
D - Very slow infiltration rate, high runoff potential. Clays with high shrink/swell potential. Permanent high water table. Clay pan or clay layer at or near surface. Shallow over nearly impervious material. Very slow rate of water transmission.
/ = if drained/if natural.

1.4 CLIMATE

The climate of an area is a representation of the general weather conditions over a long period of time. The Gun River Watershed experiences a typical Great Lakes area climate, much of which is influenced by lake effect. The Watershed is approximately 30 miles inland of Lake Michigan which generates elevated humidity and snowfall and moderates temperatures year-round. The mean temperature of the watershed ranges from 23°F in January to 72°F in July. Average annual precipitation is approximately 32 inches and about half falls as snowfall which approaches 100 inches annually. The climatic influence of Lake Michigan provides niche habitat for certain species of native plants and ideal growing conditions for orchards. The average growing season for the Watershed is 168 days (Kalamazoo River Watershed Council, 2011).

It is important to consider the potential impacts of climate change when planning for the future of water quality. There is a growing body of research that indicates climate change has already begun to impact the climate of the Great Lakes Region. Increased temperatures and precipitation over the last century provide evidence of climate change.These trends are forecast to accelerate into the future. Climate projections of the water resources in the Great Lakes Region include increased rainfall and extreme weather events resulting in flooding, increased nutrient loading, and soil erosion. Extreme flows put stress on water treatment infrastructure, which has the potential to result in an increase in the number of water-borne pathogens flowing into our lakes and rivers. Temperatures are expected to rise between 2.7°F and 7.2°F by the end of the 21st century. Increased temperatures coupled with an increase in storm events and precipitation can alter the natural ecology of inland lakes and make water bodies more susceptible to invasive species. (ELCP, 2019). Challenges already posed to the watershed are likely to be exacerbated by the effects of climate change.

1.5 LAND USE

The land use within a watershed greatly influences nonpoint source (NPS) pollution and the quality of water resources. The conversion, fragmentation, and general degradation of the natural landscape dramatically impacts groundwater and lakes and streams by altering the hydrology and introducing sediments, nutrients, pathogens, and chemicals from agricultural and urban runoff.

Prior to widespread European settlement in the 1800's, the dominant vegetation in the Gun River Watershed was oak-hickory forest (39%), beech-sugar maple forest (20%) concentrated in the southwest, and mixed forest and shrub swampland in the floodplain (20%) The remaining types of pre-settlement vegetation were scattered throughout the watershed including lakes/rivers (6%), mixed oak and white-pine white oak forest (5% and 4%, respectively), mixed oak savanna (4%), wet prairie (1%), and oak/pine barrens (1%).

The landscape of the Gun River Watershed has changed significantly since pre-settlement times. Agriculture is now the dominant land use with the watershed (49%). However, a significant amount of land (25%) remains as forested land cover. This is mostly concentrated in the eastern portion of the watershed which contain sections of the Barry State Game Area and the Yankee Springs Recreation Area, which are, and will remain, as woodlands (Figure 5). Wetlands make up 10% of land cover within the watershed. Developed areas make up 8% of the watershed and are concentrated surrounding Gun Lake, in residential areas, and roadways. The remaining 8% of the land cover in the watershed is classified as "other" which includes water bodies and barren land.

Most of the agricultural land within the watershed is used for row crop production. The major grains produced include corn, soybeans, wheat, and oats. Substantial portions of land within the watershed are used for pasturing and growing alfalfa. Apple orchards are scattered throughout the watershed. A variety of animal agriculture enterprises are located within the watershed including dairy and beef cattle, pigs, sheep and some poultry farms producing chickens, turkeys, and eggs. (Kalamazoo River Watershed Council, 2011).

Most of the land in the watershed is zoned agricultural or rural residential. These zoning areas contain most homes within the watershed. Other residential zones are concentrated in town centers and vary in density. Commercial and light industrial zones make up a few small pockets of land within the watershed.

Most land within the watershed is privately owned. Publicly owned land includes 2,108 acres of Barry State Game Area, 3,729 acres of Yankee Springs Recreation Area, and two boat launches on Gun Lake operated by the Michigan DNR and the Allegan County Parks Department.

1.6 HYDROLOGY

1.6.1 Lakes

The Gun River Watershed has many small- and medium-sized lakes scattered throughout the watershed as remnants of its previously swampy conditions, however, the largest is Gun Lake. Gun Lake is in the northeastern region of the watershed and covers an area of approximately 2,680 acres. Gun Lake is a popular recreation destination of residents in Michigan and attracts many tourists every year due to its proximity to the nearby cities of Grand Rapids and Kalamazoo. The Lake has 17.8 miles of shoreline, with an additional 1.4 miles of island shoreline. Payne Lake, Long Lake, Hall Lake, Fawn Lake, and other small unnamed lakes and ponds drain into Gun Lake.

Gun Lake is composed of two basins that significantly differ in their depth and structure. The east basin has a steep shoreline and varying depths with a maximum depth of 68 feet. It has a marl bottom with some areas of peat and gravel sediment. There are many submerged and emergent islands surrounded by gravel bars and boulders. The shoreline of this basin was developed earlier than the west basin and has many bulkheads and seawalls. The west basin is primarily uniformly shallow with a maximum depth of only 5-10 feet except for two coves that have a depth of 25 and 34 feet. This basin has a marl bottom with a mostly sandy shoreline. Historically, this shoreline was wooded, but development has significantly altered the vegetation, including the elimination of most of the submerged and emergent vegetation (Diana, 2017).

Good water quality has always been the attraction to Gun Lake for users from around the State of Michigan. Water quality suffered in the past from bacterial contamination but has vastly improved after the installation of a sewer system in 1980 that services the Gun Lake community. A more detailed description of the water quality analysis can be found in Chapter 3.

Numerous lakes in the watershed provide recreational opportunities and desired home sites for residents. Table 1.2 provides information about the lakes in the Watershed, including whether the homes are served with sanitary sewers and if they have a hydrologic connection to Gun River.

Table 1.2 – Lakes Information

Lake Name	Sewer/ Septic	Connection to Gun River	Description	Township
Barlow	Sewer	Yes		Yankee Springs
Cobb	Sewer	Yes		Yankee Springs
Payne	Sewer	Yes		Yankee Springs
Little Payne	Septic	Yes		Yankee Springs
Baker	Septic	Yes		Yankee Springs
Chief Noonday	Septic	Yes		Yankee Springs
McDonald	Septic	No		Yankee Springs
Williams	Septic	No		Yankee Springs
Hall	Septic	No		Yankee Springs
Long	Sewer	Yes		Yankee Springs
Gun	Sewer	Yes		Yankee Springs/Orangeville
Round	Septic	No		Wayland
Boot	Septic	Yes		Wayland
Mill 1 (W of Gun)	Septic	Yes		Wayland
Sixteen	Septic	Yes		Martin
Fenner	Septic	Yes		Martin
Pratt	Septic	Yes		Martin
Bullhead	Septic	No		Orangeville
Fish	Septic	Yes		Orangeville
England	Septic	Yes		Orangeville
Crystal	Septic	No		Orangeville
Wiley	Septic	No		Orangeville

Orr	Septic	No		Orangeville
Blue	Septic	No		Orangeville
Adams	Septic	No		Orangeville
Angle	Septic	No		Wayland
No name 1	Septic	No	East of Round Lake	Wayland
No name 2	Septic	No	Southeast of Round Lake	Wayland
No name 3	Septic	No	North of Martic	Martin
No name 4	Septic	No	Northeast of Martin	Martin
No name 5	Septic	No	East of Martin	Martin
No name 6	Septic	No	South of Martic	Martin
No name 7	Septic	No	Northeast of Wiley Lake	Orangeville
No name 8	Septic	No	Corner of Keller and Norris Rds.	Orangeville
Fawn	Septic	Yes		Orangeville

1.6.2 Impoundments

Gun Lake has one dam just north of Patterson Road, built in 1905, that maintains the lake level. Due to recreational demands, the lake level is set at a higher than natural water level. Prior to dam construction the lake was able to contain and store stormwater runoff. Consistent artificially high lake levels have prevented the lake's natural ability to store rainwater, resulting in increased flooding downstream during storm events.

1.6.3 Rivers, Streams, and County Drains

The Gun River is approximately 12 miles long, originating from Gun Lake and flowing into the Kalamazoo River in Otsego Township. Most of the drainage ditches in the watershed were created by settlers of the area in the early 1900s. There are approximately 162 miles of streams, including constructed drains, within the Watershed. Gun River is a designated county drain and was straightened, widened, and deepened in 1903 to increase the drainage of the area and expose the rich, organic soil for farming. Tributaries to the Gun River constructed through county drainage projects include Gregg Brooks Drain, Fenner Lake Drain, and Orangeville Drain. The historical meanders were mapped from old plat books, and more recently, aerial photographs. Changes in the location of the Gun River are illustrated in Figure 6. Table 1.3 lists the names and lengths of the drains. Other designated county drains are illustrated in Figure 6A.

The MDNR Fishing Guide includes a section containing color-coded maps that were developed to assist anglers in locating waters that contain trout and salmon, and to explain the regulations that pertain to these lakes and streams. The MDNR has designated the Gun River a Type 4 coldwater stream from 122nd Ave. downstream to US-131. Tributaries downstream of 118th Ave. and streams entering Fish Lake are classified as Type 1 coldwater streams. Details and maps can be found at the MDNR website: https://www.michigan.gov/dnr/things-to-do/fishing/fishing-regulations . Figure 18 shows the designated coldwater streams in the Gun River Watershed.

Table 1.3 – Designated County Drains

Allegan County Drains	Length (ft)	Allegan County Drains	Length (ft)
Adams	157	Fenner Lake	14,221
Airport Park Plat	3,269	Gardiner	6,147
Andrews	4,810	Gilger	7,839
Bellingham	3,723	Gratop	4,616
Boot Lake	7,323	Greggs Brook	21,661
Boss	2,226	Gun River	47,664
Boyle	1,361	Hardin	4,493
Boysen	3,656	Holland	4,013
Br No. 1 of Culver	2,873	Holt	1,550
Br of Holbrook	3,928	McVean	5,332
Br of Monteith	2,404	Monteith	12,411
Br of N Town Line	1,620	N Town Line	17,374
Br of Scott and Whitcomb	7,084	North Town Line	894
Briggs	8,439	Orangeville Creek	3,237
Brown and Staley	7,341	Pratt	5,077
Cuddy	7,923	Reno Inter-County	7,253
Culver	17,725	Richmond	1,630
Deal Inter-County	4,045	Robins	541
Allegan County Drains	**Length (ft)**	**Allegan County Drains**	**Length (ft)**
Dean	8,587	Saddler	3,046
Divine	3,918	Scott and Whitcomb	4,681
Doster	3,857	Smith	5,187

Ext of Bellingham	2,874	Sutherland	7,173
Ext of Culver	6,366	Sutherland and Branch	2,959
Ext of Dean	2,389	Tawsley and Holbrook	7,330
Ext of Gun River	15,216	Vida	2,631
Ext of Hardin	1,315	Williams	5,532
Ext of McVean	3,767	Wolf Plat	133
Total Allegan County	**342,821 (65 miles)**		

Barry County Drains	Length (ft)	Barry County Drains	Length (ft)
Beck	2,582	Lewis and Johnson	2,832
Bray	5,061	Livingston	7,010
Chalker	3,251	Orangeville Creek	7,046
Clem	3,084	Orangeville Mill Creek	4,595
Cuddy	6,761	Pryon	1,113
Deal	7,289	Saddler	1,162
Fish Lake	1,165	Townline 3	6,663
Gun Lake	8,212	Williams Lake	3,913
Kaechele	12,032		
Total Barry County	**83,771 (16 miles)**		

1.6.4 Groundwater

Groundwater is a crucial part of a watershed. The groundwater in the Gun River Watershed is in an aquifer beneath the surface of the land. The water is contained in unconsolidated sediments left behind by glacial advance and retreat. The residents of the Watershed rely on groundwater for household drinking water, year-round public water supply, irrigation, and industry. While this watershed management plan is mainly focused on NPS pollution in surface waters, groundwater and surface water are connected and influence each other greatly. Groundwater and surface water interact in discharge and recharge zones. According to the Michigan Groundwater Mapping Project, The Gun River Watershed contains many groundwater recharge areas for the surrounding region. Groundwater recharge areas are more susceptible to contamination by surface pollution as rain or snow that falls on these areas infiltrates down into the aquifer. These areas are vital to protecting drinking water, and are also important for maintaining the health of our lakes and streams.

1.6.5 Wetlands

The geological characteristics of the Gun River Watershed include many low-lying areas of wetlands and bogs. In pre-settlement conditions the Gun River meandered through thousands of acres of wetlands before emptying into the Kalamazoo River. Today only a fraction of these wetlands remain. Nearly all the floodplains have been drained to expose the rich organic soils that support the area's agricultural economy. Pre-settlement vegetation is illustrated in Figure 7.

The conversion of wetlands to other land uses, especially in the Gun River floodplain, has dramatically affected drainage patterns in the watershed. The result has been flashy stream flows, flooding, and a general loss of wildlife habitat. The hydrology in many of these drained areas could be restored by simply breaking drain tiles or plugging ditches.

1.7 DEMOGRAPHICS

The Gun River Watershed is contained within parts of both Allegan and Barry Counties. The majority of the Watershed is included in the Allegan County Townships of Gun Plain, Martin, and Wayland and the Barry County Townships of Orangeville, Yankee Springs, and Thornapple. Small portions of Leighton, Watson, and Otsego Townships in Allegan County, and Prairieville Township in Barry County are also included. It is estimated that the Gun River Watershed is home to 14,366 residents based on land area of each municipality in the Watershed (Table 1.5). The Gun River Watershed is primarily a rural area with pockets of higher population. The Village of Martin, in the western central portion of the Watershed, is an area of concentrated population with 537 people per square mile. The average concentration of people in the municipalities of the Watershed is 175 people per square mile. The population growth in Allegan and Barry Counties is higher than the Michigan average (Table 1.4), with the highest population growth occurring in Leighton, Thornapple, and Yankee Springs Townships (41.9%,18.4%, 30.9%, respectively; Table 1.4). Ethnic diversity is generally low in the Watershed where 94.7% of Allegan County and 96.2% Barry County of the population is White. Homeownership and median household income are both higher in Allegan and Barry Counties than in the greater state of Michigan.

Table 1.4 - Year 2020 Census Data

Category	Allegan County	Barry County	Michigan
Population	120,502	62,423	10,077,331
Population % change, 2010-2020	8.2%	5.5%	1.96%
% White persons	94.7%	96.2%	79.0%
% Black or African American persons	1.6%	0.8%	14.0%
% American Indian and Alaskan Native persons	0.7%	0.6%	0.7%
% Asian persons	0.9%	0.6%	3.4%
% Persons reporting two or more races	2.1%	1.8%	2.7%
% Persons of hispanic or Latino origin	7.9%	3.5%	5.6%
% Persons age 25+ who are highschool graduates	91.3%	93.4%	91.6%
% Persons age 25+ who have a bachelor's degree or higher	23.7%	24.1%	30.6%

% Persons age 5+ who speak a language other than English in the home	6.6%	2.8%	9.9%
Homeownership rate	85.1%	85.9%	72.2%
Persons per household	2.67	2.55	2.48
Median household income	$70,269	$68,779	$63,202
% Persons below poverty	9.4%	8.9%	13.1%

Table 1.5 - Acres and Population of the Gun River Watershed

Local Unit	Total Square Miles	Square Miles in Watershed	% of Watershed	Watershed % of Unit	2010 Total Population	2020 Total Population	2020 Population per Square Mile	Estimated 2020 Population in Watershed	% Change 2010-2020
Allegan County	**827**	**65**	**56.9%**	**7.9%**	**111408**	**120502**	**146**	**7839**	**8.2%**
Gun Plain Township	35	22	19.4%	63.5%	5895	6148	176	3904	4.3%
Leighton Township	35.6	0	0.0%	0.1%	4934	7001	196	7	41.9%
Martin Township	35.3	29	25.6%	82.9%	2629	2710	77	2246	3.1%
Martin Village	.76	0	0.3%	50.0%	409	407	537	203	-0.5%
Otsego Township	34.3	2	1.3%	4.5%	5594	5903	172	266	5.5%
Watson Township	34.46	0	0.1%	0.3%	2063	2173	60	7	5.3%
Wayland Township	33.7	12	10.1%	34.3%	3088	3516	104	1205	13.9%
Barry County	**556**	**49**	**43.1%**	**8.9%**	**59173**	**62423**	**112**	**6477**	**5.5%**
Orangeville Township	35.7	26	22.7%	72.8%	3311	3393	95	2470	2.5%
Prairieville Township	36.5	1	0.5%	1.6%	3404	3382	93	54	-0.6%
Thornapple Township	35.6	5	4.3%	13.8%	7884	9331	262	1287	18.4%
Yankee Springs Township	35.8	18	15.7%	50.1%	4065	5322	149	2666	30.9%
Total (not including county populations)	**1,383**	**213**	**N/A**	**N/A**	**43276**	**49286**	**175**	**14,366**	**11.33%**

CHAPTER 2 – SIGNIFICANT NATURAL FEATURES

2.1 INTRODUCTION

A Natural Feature Inventory (NFI) is an important tool in planning for watershed development. It identifies areas within a watershed with unique or rare features that warrant protection and preservation. An accurate understanding of land use within a watershed will identify corridors or links between habitats and allows planning that minimizes fragmentation of these communities. Intelligent land use planning requires comprehensive knowledge of the natural features present within a watershed.

Information regarding the plant and animal communities within the Watershed was obtained from various sources, including Michigan State University's (MSU) NFI database, the Michigan Department of Environment, Great Lakes and Energy (EGLE), and the Michigan Department of Natural Resources (MDNR).

2.2 NATURAL FEATURES, COMMUNITIES, AND SPECIES OF CONCERN

MSU maintains a NFI database of known occurrences of endangered, threatened, and special concern plant and animal species and communities throughout Michigan. Both endangered and threatened species are protected under Michigan's Endangered Species Act (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act). Special concern species are not protected under the Endangered Species Act but would be recommended for threatened or endangered status if the species continues to decline.

The Gun River Watershed is home to two federally listed endangered species, the rusty-patched bumble bee (*Bombus affinis*) and Mitchell's satyr (*Neonympha mitchellii*). The prairie white-fringed orchid (*Platanthera leucophaea*) and eastern massasauga (*Sistrurus catenatus*) are federally listed threatened species in the Watershed. Species in the Watershed that are listed at the state-level as endangered include pugnose shiner (*Notropis anogenus*), king rail (*Rallus elegans*), side-oats grama grass (*Bouteloua curtipendula*), spotted pondweed (*Potamogeton pulcher*), kitten-tails (*Besseya bullii*), Mitchell's satyr (*Neonympha mitchellii*), prairie white-fringed orchid (*Platanthera leucophaea*), and Henslow's sparrow (*Centronyx henslowii*). There are several species listed as threatened and of special concern at the state level. See table 2.1 for an exhaustive list of species in the Watershed.

The Gun River Watershed has 14 types of natural communities present according to MSU's NFI. These natural communities include prairie fen, wet prairie, wet-mesic prairie, hillside prairie, dry-mesic northern forest, southern shrub-carr, bog, hardwood-conifer swamp, rich tamarack swamp, dry southern forest, southern wet meadow, poor fen, submergent marsh, and intermittent marsh.

Table 2.1 - Rare Species in the Gun River Watershed and Natural Communities.

Common Name	Scientific Name	State Status	Federal Status	First Observed	Last Observed	Element Category
Three birds orchid	Triphora trianthophora	T		1880	8/9/1880	Plant
Long-bracted spiderwort	Tradescantia bracteata	X		4/21/1905	6/17/1938	Plant
Pugnose shiner	Notropis anogenus	E		1946	8/29/1946	Animal
False boneset	Brickellia eupatorioides	SC	PS	1949	10/29/2011	Plant
King rail	Rallus elegans	E		1949	12/4/1949	Animal
Eastern box turtle	Terrapene carolina carolina	SC		1951	7/30/2021	Animal
Blanchard's cricket frog	Acris blanchardi	T		1952	7/14/2021	Animal
Eastern massasauga	Sistrurus catenatus	SC	LT	1960	5/26/2021	Animal
Whiskered sunflower	Helianthus hirsutus	SC		1960	7/21/1960	Plant
Prairie indian-plantain	Arnoglossum plantagineum	SC		1965	8/8/2012	Plant
Ottoe skipper	Hesperia ottoe	T		1967	1982	Animal
Persius dusky wing	Erynnis persius persius	T		1968	1971	Animal
Spotted turtle	Clemmys guttata	T	UR	1968	4/7/2020	Animal
Side-oats grama grass	Bouteloua curtipendula	E		1969	8/19/1980	Plant
Beaked agrimony	Agrimonia rostellata	T		1971	1971	Plant
Prairie Fen				1974	9/20/2012	Community
Wet Prairie				1974	8/23/2012	Community
Leadplant	Amorpha canescens	SC		1975	8/19/2013	Plant
Wet-mesic Prairie				1975	8/12/2010	Community
Tall beakrush	Rhynchospora macrostachya	SC		1976	9/12/2012	Plant
Spotted pondweed	Potamogeton pulcher	E		1979	8/1/1985	Plant
Hillside Prairie				1980	5/15/2002	Community
Kitten-tails	Besseya bullii	E		1980	5/29/1991	Plant
Henry's elfin	Incisalia henrici	T		1986	1987	Animal
Small skullcap	Scutellaria parvula	T		1986	6/17/1986	Plant
Osprey	Pandion haliaetus	SC		1996	2020	Animal
Tamarack tree cricket	Oecanthus laricis	SC		1999	8/29/2002	Animal
Angular spittlebug	Lepyronia angulifera	SC		2000	10/2/2013	Animal

Common Name	Scientific Name	State Status	Federal Status	First Observed	Last Observed	Element Category
Cerulean warbler	Setophaga cerulea	T		2006	6/20/2013	Animal
Lake herring or Cisco	Coregonus artedi	T		2006	2009	Animal
Bald eagle	Haliaeetus leucocephalus	SC	DL	2014	2019	Animal
Purple wartyback	Cyclonaias tuberculata	T		2017	2017	Animal
Pickerel frog	Lithobates palustris	SC		7/5/1919	5/28/2014	Animal
Bigmouth shiner	Notropis dorsalis	SC		7/27/1951	7/27/1951	Animal
American bumble bee	Bombus pensylvanicus	SC	UR	7/16/1955	9/4/1963	Other
Rusty-patched bumble bee	Bombus affinis	SC	LE	7/16/1955	8/3/1965	Animal
Mudpuppy	Necturus maculosus	SC		5/16/1958	5/18/1958	Animal
Black and gold bumble bee	Bombus auricomus	SC		8/18/1960	6/4/2019	Other
Calico crayfish	Faxonius immunis	SC		6/21/1965	6/21/1965	Other
Mottled duskywing	Erynnis martialis	SC		5/31/1968	6/6/1968	Other
Spotted gar	Lepisosteus oculatus	SC		6/13/1983	5/14/2018	Animal
Creeping whitlow grass	Draba reptans	T		6/17/1986	5/29/1991	Plant
Mitchell's satyr	Neonympha mitchellii	E	LE	7/10/1986	6/26/2012	Animal
Dry-mesic Northern Forest				7/2/1989	9/20/2012	Community
Southern Shrub-carr				7/2/1989	9/28/2011	Community
Prothonotary warbler	Protonotaria citrea	SC		6/21/1992	5/29/1993	Animal
Regal fern borer	Papaipema speciosissima	SC		9/25/2000	9/25/2000	Animal
Blanding's turtle	Emydoidea blandingii	SC	UR	5/22/2002	4/9/2021	Animal
Gray ratsnake	Pantherophis spiloides	SC		9/3/2002	9/3/2002	Animal
Purple milkweed	Asclepias purpurascens	T		7/6/2004	7/1/2006	Plant
Bog				9/27/2005	9/15/2009	Community
Leafhopper	Dorydiella kansana	SC		7/31/2007	7/31/2007	Animal
Bog bluegrass	Poa paludigena	T		6/23/2008	6/23/2008	Plant
Hardwood-Conifer Swamp				6/23/2008	6/23/2008	Community
Prairie white-fringed orchid	Platanthera leucophaea	E	LT	7/17/2009	6/30/2016	Plant

Common Name	Scientific Name	State Status	Federal Status	First Observed	Last Observed	Element Category
Hooded warbler	Setophaga citrina	SC		5/25/2010	6/20/2013	Animal
Ginseng	Panax quinquefolius	T		8/13/2012	8/13/2012	Plant
Rich Tamarack Swamp				8/28/2012	8/28/2012	Community
Dry Southern Forest				8/29/2012	8/29/2012	Community
Southern Wet Meadow				8/29/2012	8/29/2012	Community
Poor Fen				9/4/2012	9/12/2012	Community
Submergent Marsh				9/4/2012	9/4/2012	Community
Intermittent Wetland				9/12/2012	9/12/2012	Community
Marsh wren	Cistothorus palustris	SC		6/4/2013	6/4/2013	Animal
Dickcissel	Spiza americana	SC		6/10/2015	6/10/2015	Animal
Henslow's sparrow	Centronyx henslowii	E		6/15/2015	6/15/2015	Animal
Watermeal	Wolffia brasiliensis	T		10/7/2017	10/7/2017	Plant
Creek heelsplitter	Lasmigona compressa	SC		7/24/2018	7/24/2018	Other
Paper pondshell	Utterbackia imbecillis	SC		7/24/2018	7/24/2018	Animal
Rainbow	Villosa iris	SC		7/24/2018	7/24/2018	Animal
Flutedshell	Lasmigona costata	SC		8/13/2018	7/27/2000	Other
Common gallinule	Gallinula galeata	T	PS	7/24/2019	7/24/2019	Animal
Northern harrier	Circus hudsonius	SC		1980 pre	1980 pre	Animal
Watercress snail	Fontigens nickliniana	SC		1990 pre	5/13/1996	Animal
Elktoe	Alasmidonta marginata	SC		2000-07	8/24/2000	Animal
Bald-rush	Rhynchospora scirpoides	T		2006-09	9/19/2012	Plant

Source: Michigan State University's Natural Features Inventory Database

Federal status:
LE = listed endangered
LT = listed threatened
UR = under review
PS = partial status
DL = delisted

State Status:
E = Endangered
T = Threatened
SC = Special Concern
X = Presumed extirpated

2.3 SPECIES INVENTORY

Mr. Dan Keto of the Kalamazoo Nature Center completed an informal survey of the plant and bird species present along the Gun River between 110th and 107th Avenues. He conducted the survey by canoe on May 6, 2001, between 2:30 p.m. and 4:30 p.m. Table 2.2 summarizes the species he observed on that day. The noted plant species are commonly found in rich woods, forested wetlands, and scrub-shrub wetlands. The bird species are generally common in wooded and wetland areas. The blue-winged warbler prefers brushy meadows and secondary growth woodlands. The presence of the black-headed grosbeak was unexpected. This western bird is rarely observed in Michigan.

Table 2.2 – Inventory of Plant and Bird Species Along the Gun River from 110th and 107th Avenues

Birds	Wildflowers	Trees	Shrubs
Great Blue Heron	Tall Meadow Rue	Common Hackberry	Elderberry
Wood Duck	Wild Ginger	Slippery Elm	Red Osier Dogwood
Mallard	Wild Geranium	Red Maple	Dogwood
Turkey Vulture	Blue Violet	Silver Maple	Vibernum
Mourning Dove	Trillium	Elm	Serviceberry
Black-billed Cuckoo	Wild Leek	Red Oak	Honeysuckle
Belted Kingfisher	Nettle	Sycamore	
Red-bellied Woodpecker	Mayapple	Basswood	
Downy Woodpecker	Jack-in-the-Pulpit	Wild Cherry	
Northern Flicker	Skunk Cabbage	Ash	
Eastern Phoebe	False Solomon Seal	Box Elder	
Blue Jay	Wild Phlox	Walnut	
Black-capped Chickadee	Daisy Fleabane	Sandbar Weeping Willow	
Tufted Titmouse	Equisetum	Honey Locust	
White-breasted Nuthatch	Sensitive Fern	Cottonwood	
Blue-gray Gnatcatcher	Avens	Beech	
American Robin	Spring Beauty	Musclewood	
Gray Catbird	Virginia Creeper		
Red-eyed Vireo			
Blue-winged Warbler			
Common Yellowthroat			
Northern Cardinal			
Rose-breasted Grosbeak			
Black-headed Grosbeak			
Indigo Bunting			
Rufous Sided Towhee			
Chipping Sparrow			
Song Sparrow			
Red-winged Blackbird			
Common Grackle			
Baltimore Oriole			
American Goldfinch			

Source: Mr. Dan Keto, Kalamazoo Nature Center, 2001

2.4 FISHERIES

Status of the Fishery Resource Report 2017-236: Gun Lake **(Diana, 2017).**

This report presents and discusses the results and trends from fish surveys conducted in Gun Lake from 1945 through 2015.

The earliest survey records indicate an abundance of yellow perch, bluegill, largemouth, and smallmouth bass in 1890. It was also noted at this time that stocking of walleye, white bass, and American eels was recommended. Surveys in the 1950s indicated that northern pike, yellow perch, walleye, smallmouth bass, largemouth bass, bluegill, and rock bass were common through the lake.

The first record of stocking in Gun Lake was with Atlantic salmon in 1873 and 1874, and later American eel in 1881. There has been a regular history of stocking since 1921 when yellow perch, bluegill, and walleye were stocked in the lake. In 1925, three one-acre rearing ponds were constructed by damming a stream from Hall Lake into Gun Lake. These ponds are the main contributor to long term stocking of the lake and have been operated by the Gun Lake Protective Association from their construction through present.

Early stocking in 1921 through 1954 was primarily largemouth bass, smallmouth bass, and bluegill. Northern strain Muskellunge were stocked briefly in the early 60’s and again in the late 70’s. Initial stocking of walleye occurred briefly in the early 20’s and then not again until the 70’s, and has remained the focus of stocking efforts to date.

In the most recent surveys in 2015, it was found that panfish (bluegill, black crappie, pumpkinseed, rock bass, warmouth, yellow perch and hybrid sunfish) composed 27% of the total biomass collected, while carp and bullheads made up only 20%. Bluegill was found to be the most abundant species caught other than minnows and shiners. Bluegill catch rates have increased since 1960, but the size has shifted smaller with most fish under 8 inches. A large number of yellow perch were collected during the survey and make up one of the larger fisheries in Gun Lake. Their populations have not changed through time and are maintained by natural recruitment.

Predators made up 44% of total biomass caught, made up of northern pike, walleye, largemouth bass, smallmouth bass, longnose gar, and bowfin. Largemouth bass, however, was found to be the most abundant predator in the lake. This is close to the maximum recommended proportion of predator species (20%-50% is balanced).

It is estimated that there were almost 1000 walleye in Gun Lake at the time of survey. This is a low number when compared to northern Michigan Inland lakes, but Gun Lake still supports a popular fishery for walleye, although stocking will can be used to maintain their populations. Additionally, due to shoreline development, there is low density of wood and vegetative habitat resulting in limited habitat for a number of species, specifically largemouth bass, bluegill, northern pike, and Muskellunge.

2.5 INVASIVE SPECIES

Invasive species are abundant and widespread in the Gun River Watershed. The more pervasive invasive species in the watershed are zebra mussels, purple loosestrife, Eurasian milfoil, starry stonewort, phragmites, and tree of heaven. See table 2.3 for a complete list of invasive species in the watershed.

Table 2.3 - Invasive Species in the Gun River Watershed

Common Name	Scientific Name	Kingdom	Type
Amur honeysuckle	*Lonicera maackii*	Plantae	Shrub
Autumn olive	*Elaeagnus umbellata*	Plantae	Tree
Bittersweet nightshade	*Solanum dulcamara*	Plantae	Herbaceous Plants
Black locust	*Robinia pseudoacacia*	Plantae	Tree
Brittle water-nymph	*Najas minor*	Plantae	Aquatic Plants
Brown marmorated stink bug	*Halyomorpha halys*	Animalia	Insect
Canada bluegrass	*Poa compressa*	Plantae	Herbaceous Plants
Garlic mustard	*Alliaria petiolata*	Plantae	Herbaceous Plants
Glossy buckthorn	*Frangula alnus*	Plantae	Shrub
Houndstongue	*Cynoglossum officinale*	Plantae	Herbaceous Plants
Hybrid cattail	*Typha xglauca*	Plantae	Herbaceous Plants
Japanese barberry	*Berberis thunbergii*	Plantae	Shrub
Japanese hedgeparsley	*Torilis japonica*	Plantae	Herbaceous Plants
Japanese knotweed	*Fallopia japonica*	Plantae	Herbaceous Plants
Morrow's honeysuckle	*Lonicera morrowii*	Plantae	Shrub
Multiflora rose	*Rosa multiflora*	Plantae	Shrub
Narrowleaf bittercress	*Cardamine impatiens*	Plantae	Herbaceous Plants
Narrowleaf cattail	*Typha angustifolia*	Plantae	Herbaceous Plants
Oriental bittersweet	*Celastrus orbiculatus*	Plantae	Woody Vines
Phragmites (Invasive)	*Phragmites australis*	Plantae	Herbaceous Plants
Purple loosestrife	*Lythrum salicaria*	Plantae	Herbaceous Plants
Siberian elm	*Ulmus pumila*	Plantae	Tree
Starry stonewort	*Nitellopsis obtusa*	Plantae	Aquatic Plants
Tree of Heaven	*Ailanthus altissima*	Plantae	Tree
Winged burning bush	*Euonymus alatus*	Plantae	Shrub

2.6 WETLANDS

The National Wetlands Inventory (NWI) is a record of wetlands in the U.S completed by the Fish and Wildlife Service. This inventory was prepared primarily by stereoscopic analysis of high altitude aerial photographs. Stereoscopic analysis is the use of two photographs taken of the same object at slightly different angles that when viewed together, create an impression of a 3D image. Wetlands were identified on the photographs based on vegetation, visible hydrology, and geography. NWI maps are not typically field verified and therefore contain a margin of error. The Gun River contains mostly forested and emergent wetlands according to the NWI.

Wetlands play a crucial role in protecting water quality. Wetlands provide flood water storage and sustain streamflows by absorbing water during rain events and then releasing it slowly back into streams and rivers. Wetlands, especially vegetated wetlands, act as filters for pollutants like excess nutrients, sediment, and heavy metals. They stabilize shorelines and protect them from erosion. Wetlands also provide essential habitat for fish and wildlife.

There has been significant wetland loss in the Gun River Watershed since pre-settlement times. According to EGLE's Landscape Level Assessment, the Gun River Watershed has lost 74% of its original wetlands. Any further loss should be discouraged and watershed management efforts should include restoration of historic wetlands and protection of remaining wetlands. The majority of wetland loss has been concentrated along the Gun River.

Regulations have been put in place at the state and federal level to protect wetlands. The state of Michigan regulations put in place are in Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act of 1994. According to Part 303, wetlands are regulated if they are any of the following:

- Connected to one of the Great Lakes or Lake St. Clair.
- Located within 1,000 feet of one of the Great Lakes or Lake St. Clar.
- Connected to an inland lake, pond, river, or stream.
- Located within 500 feet of an inland lake, pond, river, or stream.
- More than 5 acres in size
- Determined that they are essential to the preservation of the state's natural resources

A permit from the state is required before any person conducts any of the following activities:

- Deposit fill material in a wetland
- Dredge or remove soil or minerals from a wetland.
- Construct, operate, or maintain any use or development in a wetland.
- Drain surface water from a wetland.

More information about state and federal wetland regulations can be found on EGLE's website. EGLE's wetlands program is using cutting edge geographic information technology to improve the evaluation of wetlands on a watershed scale in a cooperative effort supported by multiple agencies and organizations. A current approach uses a computer model to integrate wetland maps, updated with current aerial photography, with hydrologic data, site topography, and other ecological information to evaluate the wetland functions provided by each mapped wetland area. The resulting analysis can be used to provide a generalized map of current wetland functions within a watershed, the loss of wetland function associated with past land use changes, and potential wetland restoration areas.

EGLE's Wetlands Map Viewer allows the public to access the Landscape Level Assessment data online. Potential wetland restoration areas can be determined based on locations of historic wetlands, shown in green, and locations with hydric soils, shown in yellow. Areas with both historic wetlands and hydric soils are shown with a green and yellow striped pattern. According to this resource, the Gun River Watershed has 13,560 acres of land that may be suitable for wetland restoration.

The Status and Trends Report for the Gun River Watershed shows that it has lost 74% of its historic wetlands. Wetlands play a crucial role in the landscape and their destruction impacts water quality, habitat, and flood control. Where the Watershed used to have 18,204 acres of wetlands, it now only has 4,644 and has lost the associated functions and benefits they provide. The Watershed has lost 74% of its wetlands providing floodwater storage, 43% for streamflow maintenance, 63% for nutrient transformation, 74% for sediment retention, and 70% for shoreline stabilization. Additionally, wetlands historically providing habitat have been lost at the following percentages: fish habitat has declined by 56%, waterfowl by 35%, shorebird by 44%, forest bird by 75%, and amphibians by 79%.

2.7 PRIME FARMLAND

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) defines prime farmland as land with the best combination of physical and chemical characteristics for producing crops. This land must be available for agricultural use in order to receive a prime farmland designation. Prime farmland has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming practices.

The USDA NRCS has compiled lists of prime farmland soils for Allegan and Barry Counties (USDA-SCS, 1987, USDA-SCS, 1990). Figure 10 notes the locations of prime farmland within the Watershed. The majority of the prime farmland is located in Martin and Gun Plain Townships. The northern tip of the Watershed also contains a concentration of prime farmland. The Watershed contains approximately 10,771 acres of prime farmland: 8,742 acres in Allegan County, and 2,027 acres in Barry County. The acres and types of soils in each county are calculated in Table 2.4.

The presettlement vegetation map indicates that most of the prime farmland areas formerly contained hardwood forest/savanna and forested wetlands. The prime farmland areas contain a low frequency of endangered, threatened, and special concern species.

Table 2.4 - Prime Farmland Soils in the Gun River Watershed in Allegan and Barry Counties

Allegan County Prime Farmland Soils		
Soil Mapping Symbol	**Soil Name**	**Acres**
8B	Glynwood clay loam	32
12B	Ockley loam	2,232
16B	Capac loam*	771
17	Brookston loam*	66
Soil Mapping Symbol	**Soil Name**	**Acres**
19A	Brady sandy loam	1,341
22A	Matherton loam*	113

23	Sebewa loam*	1,135
27B	Metea loamy fine sand	389
29	Cohoctah silt loam*	35
30	Colwood silt loam*	602
31B	Tekenink loamy fine sand	112
33A	Kibbie fine sandy loam	138
36	Corunna sandy loam*	115
41B	Blount silt loam*	417
42B	Metamora sandy loam*	237
45	Pewamo silt loam*	36
63B	Riddles loam	35
65	Cohoctah silt loam*	467
75B	Marlette-Capac loams	469
TOTAL		**8,742**
Barry County Prime Farmland Soils		
Soil Mapping Symbol	Soil Name	Acres
7A	Brady sandy loam	108
9B	Capac fine sandy loam*	3
13	Colwood loam*	4
20B	Tekenink fine sandy loam	4
22B	Kalamazoo loam	441
24B	Marlette loam	164
26B	Matherton loam*	65
31B	Oshtemo sandy loam	405
33	Parkhill loam*	2
36	Sebewa loam*	73
37B	Selfridge loamy sand	4
47B	Perrinton loam	13
50B	Kibbie silt loam*	14
60A	Schoolcraft loam	409
60B	Schoolcraft loam	6
63B	Elston sandy loam	164
67B	Marlette-Oshtemo complex	148
TOTAL		**2,027**

*Prime farmland where drained

2.8 PUBLIC LANDS

Public lands serve an essential role in the conservation and preservation of natural resources, wildlife habitat, and the protection of water quality. The Gun River Watershed contains two large public land areas adjacent to Gun Lake: Yankee Springs Recreation Area and Barry State Game Area. Yankee Springs Recreation Area is a state-managed area of land in Yankee Springs

Township encompassing 5,200 acres. The recreation area's rugged terrain, bogs, marshes, and streams make it a popular recreation destination as well as an indispensable resource for water quality in the Watershed. The Barry State Game Area has portions of its 17,000 acres, the second largest game area in the state, within the Watershed. The game area is managed by the DNR wildlife division for wildlife habitat and hunting. This large natural area is dominated by oak and mixed forest cover type which is essential for the reduction of NPS pollutants entering the Watershed.

CHAPTER 3 – SUMMARY OF WATER QUALITY

3.1 DESIGNATED USES AND WATER QUALITY STANDARDS

Surface waters of the state are protected under Michigan's Natural Resources and Environmental Protection Act, Act 451 of 1994, as amended (NREPA). The State of Michigan's Part 4 Rules, Water Quality Standards (of Part 31 of the NREPA) specify water quality standards which shall be met in all waters of the state and require that all designated uses of the receiving water be protected. Designated uses include: agriculture, navigation, industrial water supply, public water supply at the point of water intake, warmwater or coldwater fish, other indigenous aquatic life and wildlife, fish consumption, partial body contact recreation, and total body contact recreation from May 1 to October 31. The following descriptions of all the designated uses clarify their importance to the Watershed.

- *Agricultural Use* – Surface waters must be a consistent and safe source for irrigation and livestock watering. Irrigation is important in areas of the Watershed that have very well drained soils. Livestock producers in the Watershed rely on water that is free of pathogens that could pose health risks to the livestock.

- *Public Water Supply* – Municipal water supplies must have safe and adequate amounts of surface water. No surface water intakes for municipal water supplies exist in the Watershed, therefore this designated use is not addressed.

- *Navigation* – Reaches of waterways that are large enough for canoes or kayaks must maintain navigable conditions. Recreational users should be able to enjoy a float down the Gun River without experiencing excessive log jams, low footbridges, and other obstructions that impede navigation.

- *Warmwater Fishery* – A warmwater fishery is generally considered to have summer temperatures between 60 and 70 degrees Fahrenheit and is capable of supporting warmwater species, such as largemouth and smallmouth bass, on a year-round basis. The MDNR has stocked both the Gun River and Gun Lake with varieties of fish for many years to sustain and improve the fisheries in the area. Warmwater fisheries should maintain a minimum of 5 mg/L of Dissolved Oxygen.

- *Coldwater Fishery* – A coldwater fishery is considered to have summer temperatures below 60 degrees Fahrenheit and to be able to support natural or stocked populations of brook trout. The Michigan Department of Natural Resources (MDNR) has stocked the coldwater reaches of the Gun River to sustain and improve the fisheries. A healthy riparian habitat is essential to provide the needed shade to the streams to maintain lower temperatures. Coldwater fisheries should maintain a minimum of 7 mg/L of Dissolved Oxygen.

- *Other Indigenous Aquatic Life and Wildlife* – Aquatic plants and animals and other wildlife in the ecosystem should be considered in all management strategies. A stable and healthy habitat supports populations of wildlife that provide outdoor recreational opportunities in the Watershed.

- *Partial Body Contact Recreation* – Water quality must meet standards of no more than 1,000 E. *coli*/100 milliliters (ml) for recreational uses of fishing and boating, where complete submersion in the water is unlikely, to be safe. The popularity of fishing and boating in the Watershed necessitates the prevention of pathogens associated with feces from entering the waterbodies.

- *Total Body Contact Recreation* – Water quality must meet standards of a maximum of 300 *E. coli*/100 ml and a geometric mean no more than 130 *E. coli* /100 ml for areas to be safe for swimming. Other impediments to total body contact recreation include nuisance aquatic vegetation and algae blooms from excessive nutrient loadings to the Watershed.

- *Industrial Water Supply* – Industrial water supplies must have cool water with low turbidity. No surface water intakes for industrial water supplies currently exist in the Watershed.

EGLE assesses Michigan watersheds on a five-year rotating schedule to determine if waterbodies are attaining specific water quality standards (WQS) and supporting designated uses. Surface waterbodies are defined as impaired if they do not meet water quality standards and all applicable designated uses. It is important to mention that waterbodies are not assessed on a regular basis for all designated uses, so the lack of a waterbody being listed as impaired could mean it was not assessed and not that it is meeting water quality standards. The WQS for pollutants are defined in the State of Michigan's Part 4 Rules, Water Quality Standards of Part 31, Water Resources Protection, of Act 451.

3.2 IMPAIRED DESIGNATED USES

Gun River and its tributaries have suffered impairments over the years due to human-based land use activities. The Clean Water Act requires each state to prepare a biennial Integrated Report on the quality of the state's water resource. According to Michigan's 2022 Integrated Report, the designated uses being impaired in the Gun River Watershed are total body contact and partial body contact due to *E.coli* exceedances, and habitat for other indigenous aquatic life and wildlife impaired due to flow regime modification (Table 3.1). Waterbodies are assigned Aquatic Unit IDs (AUIDs), with specific AUIDs receiving the impairments. Figure 2A shows every AUID in the watershed. Many bodies of water and stream reaches in the Watershed were not assessed for total and partial body contact recreation, warmwater and coldwater fisheries, and other aquatic life and wildlife. Other significant water quality impairments include degraded indigenous aquatic habitat, decline of biotic diversity, and reduced fish populations caused by sedimentation and excessive nutrients. Also note that the designated use of fish consumption is impaired throughout the watershed due to PCB and mercury contamination. This designated use, however, is not covered in detail in this WMP as this pollutant is believed to be caused not by local NPS pollution, but by atmospheric deposition. This is a concern statewide in Michigan.

Table 3.1 - Gun River Watershed Areas of Impaired Use

Location; AUID	Size	Impaired Use	Cause
Gun Lake subwatershed; 040500030701 -13	4.19 mi^2	Partial and total body contact recreation	E.coli
Fenner Creek subwatershed; 040500030702-05	1.81 mi	Other indigenous aquatic life and wildlife, total body contact recreation	Flow regime modification, anthropogenic substrate modification, and E.coli
Fenner Creek subwatershed; 040500030702-06	34.92 mi	Partial and total body contact recreation	E.coli
Woodside cemetery subwatershed; 040500030703-01	35.11 mi	Total body contact recreation	E.coli

It is also important to note that Lake Allegan (AUID 040500030907-06)—an impoundment on the Kalamazoo River downstream of the Gun River confluence—also has a listed impairment and corresponding Total Maximum Daily Load (TMDL) for other indigenous aquatic life and wildlife caused by excess algae due to elevated levels of phosphorus. The Gun River ranks as the third highest contributor of phosphorus loads to the Kalamazoo River/Lake Allegan system. More information on the TMDL and Kalamazoo River Watershed Management Plan can be found on the Kalamazoo River Watershed Council's website: http://kalamazooriver.org/.

3.3 DESIRED USES

The Steering Committee members identified desired uses, which are other ways in which the Watershed is used and additional opportunities for the Watershed to provide in the future. These desired uses can be implemented through community efforts and partnerships to gain support for and increase the stewardship of the Watershed.

- *Groundwater Protection for Drinking Water* – Most residents in the Watershed rely on private wells for drinking water. The Allegan County Health Department has recorded high levels of nitrates in a few residential wells in the Watershed. Protection of groundwater used as a source for private drinking water is important to the residents in the Watershed.
- *Increase Recreational Opportunities* – Gun Lake is a popular destination for water sports in the summer months. Yankee Springs Recreation Area is also popular for its trails, which outdoor enthusiasts can enjoy in all seasons. Canoeing is popular along the lower reaches of the Gun River. Providing new, stabilized access points, one of which is barrier free, would make canoeing safer and more enjoyable.
- *Preserve Open Space and Rural Character* – Allegan and Barry Counties are experiencing rapid growth. Plans need to be put in place now to determine the future state of these counties to manage the growth. Townships are investigating techniques to preserve open space and maintain the rural character that makes them attractive to those relocating to the area. Workshops and educational programs about tools that Townships can use to manage growth should be organized and officials should be encouraged to attend.
- *Protect Prime Farmland* – The Watershed has been extensively drained in the past for agricultural use. The prime farmland soils in this area have formed the solid base for the

rural character of the Watershed, and the economic base from which many earn their living. The Watershed is a key location for development, with easy access from U.S. 131 and situated between the Cities of Grand Rapids and Kalamazoo. Community planners need to put a value on this prime farmland and institute policies that will protect this land for future generations.

- *Protect Unique Habitats for Endangered Species* – Natural Features Inventory (NFI) of the Watershed identified areas where a threatened, endangered, or special concern species or habitats have been found. The protection of these areas, most of which are in the Yankee Springs Recreation Area, is important to maintain the integrity of diversity in the Watershed.
- *Encourage Wildlife Habitats* – Programs exist that can assist landowners and agencies to preserve and enhance habitats for wildlife. Local decision-makers must be educated about these programs and have the tools available to promote these programs and encourage landowners to participate. The United States Department of Agriculture (USDA) Conservation Reserve Program (CRP) will provide technical assistance and funding to restore habitats on agricultural lands. The Southwest Michigan Land Conservancy can acquire land or negotiate permanent easements to protect the land in the future. The Conservation Districts have access to many programs that can be implemented on smaller, residential properties.

3.4 WATER QUALITY SUMMARY

3.4.1 Previous Studies

BIOLOGICAL SURVEY OF THE GUN RIVER (1989)

The MDNR completed a biological survey of the Gun River in July 1989. The objective of the survey was to document the physical, chemical, and biological effects of the Gun Lake Wastewater Treatment Plant's (WWTP) discharge and nonpoint source runoff to the Gun River. This data was compiled and compared to previous surveys to evaluate the effects pollution has on the Watershed. Qualitative macroinvertebrate sampling and surface water sampling were conducted at five locations along the Gun River between Patterson Road and 10th Street. The results of the survey were compared to surveys conducted in 1977 and 1979. The report concluded that water chemistry was good in Gun River, with little change since 1980. Water chemistry was similar to that found in other suitable trout waters in Michigan.

The concentration of metals in sediment was slightly elevated at sampling locations downstream of Gun Lake. The metal concentrations had increased from levels measured in an earlier survey. The Gun Lake WWTP may have been releasing water with metals from sources within their service district.

Macroinvertebrate communities had declined since 1980 in the lower reaches of Gun River. The report noted that high water levels in 1986 eroded streambanks. It is likely that the eroded soil was deposited downstream, causing the decline in the macroinvertebrate communities.

EGLE BIOLOGICAL SURVEY OF THE KALAMAZOO RIVER (1999)

This survey contains information specific to the Gun River. The report noted that macroinvertebrate sampling and habitat evaluations were conducted at seven locations within the Watershed. Table 3.2 summarizes the sampling locations and the results of the survey.

Table 3.2 - 1999 Biological Survey Sampling Results in the Gun River Watershed

Sampling Location	Habitat Evaluation	Macroinvertebrate Community Rating
Lake Sixteen Outlet at 6th Street	None	Acceptable
Greggs Brook Drain at 122nd Avenue	None	Acceptable
Gun Lake Outlet at 122nd Avenue	Poor, severely impaired	Poor
Orangeville Creek at Saddler Road	Good, slightly impaired	Acceptable
Fenner Creek at 2nd Street	Poor, severely impaired	Poor
Gun River at 7th Street	Fair, moderately impaired	Acceptable
Gun River at 110th Avenue	Fair, moderately impaired	Acceptable

The Gun Lake outlet and the Fenner Creek locations were impaired due to channel manipulation to support agricultural drainage. The lack of hard substrate materials and sedimentation and/or embedded substrates were the most common detriments to habitat scores.

2001 GUN RIVER WATERSHED INVENTORY

An assessment of the condition of the Watershed is most accurate when conducted by visual, in-the-field observation. The Watershed was field inventoried to identify NPS pollution sites during the months of July through November 2001. The Gun River was canoed from the Gun Lake dam to the southernmost bridge at 107th Avenue, before the outlet to the Kalamazoo River. All tributaries to the Gun River were walked, if shallow enough, heading upstream so as not to disturb the sediment and decrease visibility.

At each site where a pollution problem was evident, a data sheet was completed. Basic information was recorded about the size of the stream, surrounding land use, buffers, and weather conditions. Seven categories were described on the sheets: debris and trash, construction sites, stream crossings, rill and gully erosion, tile outlets, streambank erosion, and others. Within each category, characteristics were described, which could be used to group and rank these sites. Each site was recorded geographically with a Global Positioning System unit, when available, or drawn on a map. A photograph was taken at each site.

The sites were numbered for field inventory using a code that consisted of four parts. The first part was based on the EPA s Reach File 3 numbering system. Streams that were not numbered by the EPA were given a number based on the major tributary it fed into plus an extension number. For example, an unnumbered stream that flowed into reach number 867 could be numbered 8671. Unnumbered streams were given extension numbers in a consecutive manner heading upstream. The second part of the site number was the first three letters of the township. The third portion was the two-digit section number. The final part was a two-digit number indicating the sequence in which the sites were investigated on that reach. For example, the first site on reach 234 in Martin Township, Section 22, would be numbered 234MAR2201.

The data was verified and checked for inconsistencies, then converted to a DBF(IV) file and entered as a point file into ArcView 3.2 Geographic Information System (GIS). Figure 12 displays the sites that were identified as contributing NPS pollution as points on the map. The photographs of each site were linked to the points. The data was sorted by category and ranked according to severity as recorded on the data sheets.

All the road/stream crossings were inventoried according to the EGLE procedures. The standard EGLE stream crossing data sheets were used to document the physical and habitat conditions as well as surrounding land use and cover on both the upstream and downstream sides of the road. Digital photographs were taken facing both upstream and downstream from the crossings.

Using the characteristics within each category, the sites were ranked by severity (Table 3.3). Multiple characteristics could be recorded at each site. The most sites identified in a category in the Watershed was streambank erosion, with a total of 54 sites. The majority of the sites had mostly bare banks. Stream crossings were characterized with erosion at 42 sites. Problems were mainly due to degraded condition of the structure, flow blockage, or embankment erosion. Many of the 33 sites in the debris category were log jams, which blocked flow or diverted water to cause erosion. Two major types of problems were associated with the 32 sites in the tile outlet category: erosion and discharge. The placement of the tile outlet causes erosion if the outlet is too high causing splash pools and eddy currents. Some outlets were discharging water with unnatural color and odor. The 23 sites in the rill or gully erosion category occurred predominantly in agricultural areas. Some erosion was the result of improperly functioning culverts or tiles, and many gullies were contributing large amounts of sediment.

Other problems that could not be specifically included in any one category are summarized under the “Other” category. Items in this category included construction sites that were not adequately controlling for erosion and sedimentation under Part 91 of the NREPA. Soil erosion and sedimentation control (SESC) regulations require the use of proper SESC management practices. Additional items in the “Other” category were leaking fuel tanks on irrigation pumps and the spread of exotic or invasive species. More details about the location and description of these sites can be found in Chapter 5.

Table 3.3 - Summary of 2001 Inventory Data in the Gun River Watershed

Sources of Pollutants	Characteristic	Number
Streambank Erosion	Total	54
	Washout	13
	Mostly bare bank	27
	> 100'	13
Crossings	Total	42
	Condition = poor	9
	Condition = fair	11
	Erosion = severe	10
	Erosion = moderate	8
	Erosion = minor	12
Debris	Total	33
	Extensive	5
	Moderate	12
	Slight	16
Tile Outlets	Total	32
	Eroding	15
	Discharge color	2
	Discharge odor	2
Upland Source	Total	27
	Crop related	19
	Livestock related	3
	Residential related	3
Rill And Gully	Total	23
	>10' long	16
	>2' wide	10
	>2' deep	8
Livestock Access	Erosion	1
Other	Construction sites	1
	Zebra mussels	1
	Hydrocarbons	2
	Foamy water	1
	Wetland destruction	1
	Unknown source	2

2001 HYDROLOGIC AND HYDRAULIC ANALYSES

Introduction

Hydrologic and hydraulic analyses were performed for the Gun River in Allegan and Barry Counties as an additional study component of the Gun River Watershed Management Plan. An understanding of the hydrologic and hydraulic characteristics of the Watershed is consistent with the goal of reducing nonpoint source pollution. The information provided by this study is related to nonpoint source pollution issues in the following ways.

- Determination of the 100-year floodplain will reduce the risk of new development locating not only buildings, but septic systems and other potentially hazardous facilities where they may be inundated by flood waters, thus causing health concerns and/or transport of the associated pathogens/toxics.
- Storm water design criteria adapted at the county level that incorporates stream protection volume for all headwater streams based on numerous urban storm water studies and supported by the conclusions of this analysis, will help maintain more stable channel forming flows and reduce the amount of sediment deposited in the waters of the state from accelerated streambank erosion.
- An understanding of the hydrology of a watershed, the hydraulics of a river or stream and the effects that proposed land use changes and Best Management Practices (BMPs) may have on flow rates, volumes, and velocities is directly related to surface water quality by virtue of maintaining the dynamic equilibrium of the stream and preventing degradation of the water body.

Methodologies

Hydrologic analysis is performed using a computational model to determine storm water discharges from individual subbasins for various frequency rainfall events. The software used for the hydrologic model is the U.S. Army Corps of Engineers program HEC-HMS. This program computes subbasin hydrographs (a relationship between flow rate and time for a particular rainfall event), which are used as inputs into a hydraulic model to compute river hydrographs, flow velocities, and water surface elevations. The initial analysis is completed based on current land use conditions in the Watershed. Storm water detention alternatives to minimize negative impacts from projected future land use changes are also evaluated.

Hydraulic analysis is performed to predict flow rates, velocities, and water surface elevations in a river. This analysis uses the U.S. Army Corps of Engineers computer program HEC-RAS. The recent release of this computer program is able to model time varying flows. Instead of using steady state flow rates based on peak hydrograph values from the hydrologic analysis, this version of the program takes the subbasin hydrographs, as determined by HEC-HMS, and accurately combines and routes the hydrographs in a downstream progression along the river system. The model is also able to account for available storage in the floodplain.

Conclusions of the Study

Conclusions from the Hydrologic and Hydraulic (H&H) Analysis of the Gun River can be summarized as follows:

- Overall, the Gun River appears to be relatively stable due to the non-flashy nature of the Watershed.
- The hydrology of the Watershed is such that development upstream of Gun Lake will have minimal impact on the Gun River due to the large amount of storage available in Gun Lake. Low, broad hydrographs are characteristic of the discharge from Gun Lake (i.e., the upper watershed).
- The most significant contribution to the Gun River downstream of Gun Lake is via three major tributaries that enter at about midpoint along the Gun River. The large contribution of discharge from Greggs Brook, Orangeville Drain, and Fenner Creek will actually cause reverse flow in the upper portion of the Gun River during flood events. However, the land use trend over the last 40 years (as indicated on land cover maps) has been from intense agricultural use toward more fallow and open space, which would tend to result in lower runoff rates and volumes.
- A storm water detention policy release rate restriction of 0.06 cfs per acre was determined to keep the post development flow and water surface elevation at the same levels as predevelopment for a 25- year flooding event.
- Storm water runoff criteria that control larger flood events (25-year storm) are not effective for controlling smaller channel forming flows (2-year storm). Therefore, separate design criteria are needed to protect the tributary streams from new developments.
- The most significant changes in land use between existing zoning and future land use plans are in the lower portion of the Watershed in Otsego and Gun Plain Townships. However, urban sprawl is occurring throughout the Watershed regardless of current zoning that indicates an agricultural use.
- The only structures that would be expected to overtop during the 100-year flood are the approaches to the bridges at 9th Street and 106th Avenue. However, it is apparent from the water surface profiles that the culverts at 116th and 118th Avenues cause the greatest rise in water surface elevations and directly impact the predicted elevation of the floodplain upstream.

It is important that this effort on behalf of the Gun River not stop here if water resource goals are to be met for both the Gun River and Lake Allegan, which has a Total Maximum Daily Load for phosphorous. Implementation of low impact development techniques should be pursued along with quantitative storm water design criteria for flood control, which is substantiated by the modeling performed during this study. BMPs for water quality should be included in county stormwater rules and township land use ordinances.

KALAMAZOO RIVER REMEDIAL AND PREVENTIVE ACTION PLAN

The Kalamazoo River was officially recognized as an Area of Concern (AOC) by the governments of Canada and the United States in 1987. The lower portion of the Kalamazoo River was identified as an AOC because of the presence of PCBs, discharged primarily from historic de-inking operations at local paper mills.

A Public Advisory Council (PAC) for the Kalamazoo River AOC drafted a Remedial Action Plan

(RAP) as required by the Great Lakes Water Quality Agreement for each AOC. The goals of the RAP are to restore and protect the Kalamazoo River aquatic ecosystem and protect public health. The implementation of the recommendations in the WMP will contribute toward reaching the overall goals of the Kalamazoo River RAP.

Currently, eight use impairments are recognized in the Kalamazoo River AOC. Three problems on the list are shared in the Watershed; degradation of fish and wildlife populations, degradation of the benthos, and loss of fish and wildlife habitat. The PAC has declared these problems as plaguing the entire Watershed. For every problem, recommendations have been made for the required actions to remedy the problems. Recommendations for restoring habitat and increasing fish and wildlife populations include erosion control, sediment removal, and public education.

KALAMAZOO RIVER/LAKE ALLEGAN TMDL (2001)

Phosphorus concentrations were measured in the Kalamazoo River and selected tributaries in 1998 by EGLE. The Lake Allegan/Kalamazoo River TMDL has identified the Gun River Watershed as the third largest contributor of phosphorus loads to the Kalamazoo River. The Watershed is characterized as an example of a predominantly agricultural area for the type of NPS pollution it receives. Additional modeling determined the nonpoint source phosphorus loading predictions for the Gun River Watershed as 6,117 lbs/season (April 1 September 30, 1998) and 11,119 lbs/year (Kieser & Associates, 2001).

The Gun Lake Wastewater Treatment Plant’s permitted point source load was 915 pounds of phosphorus during the months of April to September 1998. The plant had an actual load of 63 pounds.

Agriculture is the foremost land use in addition to the largest contributor of phosphorus loading in the Watershed. The TMDL Implementation Committee invited three representatives of the agricultural areas in Allegan, Calhoun, and Kalamazoo Counties to serve as stakeholders in a series of sessions. During the sessions a series of Best Management Practice (BMP) recommendations from agricultural producers for phosphorus reduction was synthesized.

Three key components to implementing reductions were formed; nutrient management, conservation practices, and manure and fertilizer storage. Discussion on these components formulated a few key concepts to reducing phosphorus delivery. One was the need for a systems approach on farms. Many of the farmers' concerns about the environmental degradation effects that plague their production can be remedied to result in lower phosphorus use and runoff.

A second topic was the need for government supported conservation programs. Too often the technical assistance for implementing BMPs is not available. A third concern was lack of funding for phosphorus reduction practices in addition to standard BMPs. Many agricultural users are interested in limiting use of fertilizers to reduce total production cost at the same time reducing phosphorus delivery. However, soil and manure testing is very expensive and funding opportunities or agencies to perform these tests are limited.

AQUATIC SURVEY OF GUN LAKE

A private water testing lab was hired in 1997 to conduct water quality sampling in Gun Lake. Samples were focused on Gardiner Drain, where elevated *E. coli* levels were suspected. A total of 13 sites were sampled. The parameters tested included total phosphorus, nitrogen as nitrate, temperature, dissolved oxygen, pH, conductivity, and *E. coli*. Secchi disk readings ranged from 11 feet to 12 feet. Two public swimming areas on the west and east side of Murphy's Point were tested for *E. coli*. Both samples were below the Michigan minimum water quality standards of 300 count per 100 ml for total body contact, measured at a slightly elevated level of 100 count per 100 ml, and 0 count per 100 ml, respectively (Krueger, 1997). Additionally, vertical profiles of the lake were measured for all parameters except conductivity and *E. coli*. Supplemental sampling included testing for *E. coli* at various locations along the Cuddy and Gardiner Drains.

The results of the sampling indicated that the high concentration of phosphorus at the bottom of the lake was caused by years of nutrients settling into the sediment. Nitrates were not at elevated levels and very little changes in the nitrate levels occur throughout the water column. Dissolved oxygen levels were sufficient to support fish to a depth of 50 feet. *E. coli* was tested during a rainfall, and then again the next day when the rain had subsided. The *E. coli* levels were elevated during the rain event, indicating that *E. coli* could be entering the drain from stormwater runoff.

FISHERY STUDIES IN THE GUN RIVER WATERSHED

The MDNR conducted a stream general survey and trout evaluation of the Gun River on September 13, 2000. The field crew used a Smith Root Intermediate Boom shocker to stun the fish, which enabled the crew to collect and record information about the trout population. The crew surveyed areas in the vicinity just downstream of 110th Avenue, downstream of 7th Street, and upstream of the Gun River Conservation Club. The habitats of all three areas were described as having logs, some brush, a few pools, and nice stump holes. The gradient of the stream was more pronounced near the Gun River Conservation Club. Eel grass was very sparse in all areas. Very few minnows and sculpins were observed. The water was clear at the time of the survey. Typical stream bottom consisted of 80% fine sand (0.1 to 0.3 mm), 10% gravel, 8% silt, and 2% rock. Table 3.4 presents the information collected on the trout population.

Table 3.4 - MDNR General Survey and Trout Evaluation of the Gun River

Species	Number	Percent by Number	Weight (lb.)	Percent by Weight	Length range (in.)*	Average Length (in.)	Percent legal size **
Brown Trout (boom shock 2.41 acres)	50	54.9	11.7	100	6 - 14	8.4	48
White Sucker (boom shock 0.42 acres)	41	45.1	0	0	0	0	0
Total	91	100	11.7	100	-	-	-

* Note some fish may be measured to 0.1 inch, others to 1.0 inch group, e.g., 5 = 5.0 to 5.9 inches

** Percent legal or acceptable size for angling

A 1989 study of Gun Lake, conducted by the MDNR, concluded that the composition of the fish population has not changed significantly in 50 years. The abundance of game species, however, has varied over the years resulting in diverse management strategies for the Lake. Presently, the

Lake provides a good fishery for walleye and the northern pike fishery has been steadily improving. The muskellunge population has declined to only a small fraction of the once popular fish. Bass anglers have success with both smallmouth and largemouth bass. Panfish and perch are both average fisheries (Duffy, 1991). Management recommendations are to maintain a diverse fishery, improve fish habitat, and continue walleye stocking.

The report includes tables of the species and relative abundance of fishes, mean length and age of fish, and a stocking summary from 1921 to 1989 (Duffy, 1991).

A similar study occurred on Fish Lake, east of Orangeville in Barry County. The overall fish populations are good, especially for bluegill, walleye, and northern pike. Stocking of walleye and brown trout was not successful, and the MDNR published a report in 2000 that recommended stocking be discontinued. The Lake is currently being managed as a self-sustaining warmwater fishery (Wesley, 2000).

A 2015 study of the Gun Lake fishery found limited littoral habitat due to shoreline development to be the limiting factor to fish communities in the lake. An increase in hard shoreline stabilization and a lack of cover limit recruitment and survival of some fish species. The presence of Eurasian Milfoil and other invasive vegetation has led to herbicide treatments within the lake which can damage native aquatic vegetation. Bluegill and Largemouth Bass were found to be abundant, while Walleye catch rates were below average compared to other similar lakes. Management recommendations are to continue Walleye stocking, maintain a diverse fishery, and promote native vegetation.

WATER QUALITY SAMPLING ON THE GUN RIVER (2004)

The Gun River Watershed Steering Committee (Steering Committee) in 2004 desired more information about the quality of the water in the Watershed, which the previous studies could not provide. The Gun River Sewer & Water Authority volunteered to conduct preliminary water quality sampling to determine what areas might need further and more in-depth investigation. A commitment was also received from the Menasha Corporation, a paperbound product plant in Otsego, to provide additional analysis on the water samples collected. The purpose of the sampling was to get information about general ambient phosphorus concentrations, which would provide an insight into the productivity of the system. The Sewer & Water Authority agreed to run tests for phosphorus (ortho and total), TSS, and nitrite and nitrate. Dissolved oxygen, temperature, and pH were measured in the field. A total of five locations were visited once a month to collect the data. Menasha ran the same tests on the Greggs Brook Drain, Orangeville Drain, and Fenner Creek Drain sampling locations to calibrate the results. Additional tests run by Menasha included conductivity, nitrate, nitrite, and ammonia. The results of the testing were used to inform the Steering Committee of potential problems in the Watershed, and to assist in determining the critical areas in which to focus BMP implementation. The complete results of testing done are compiled in Tables 3.6 and 3.7.

Total Suspended solids (TSS) are any particulate matter that is carried in stream flow. These solids may be the result of stormwater runoff from urban or agricultural sources or from in-stream erosion. TSS harms aquatic life when levels become high enough to block light penetration, fill riffle areas, or cover spawning grounds. The conditions created by TSS promote bacterial growth and low dissolved oxygen levels, due to increased water temperature and lack of photosynthesis that occurs when turbidity increases.

Phosphorus is only slightly toxic to aquatic life; however, the increased eutrophication that results, weakens fisheries and causes impairments to recreational use. Phosphorus forms a strong organic bond to clay particles thus making it a limiting nutrient in aquatic ecosystems. However, increased levels of TSS from agricultural runoff facilitates nutrient loading. Table 3.5 illustrates the levels of phosphorus measured at the sampling sites. Once in the water column, a pound of phosphorus can produce 500 pounds of aquatic plants. When aquatic biomass becomes high, the likelihood of a fish kill rapidly increases.

The Gun River is the third highest contributor of phosphorus in the greater Kalamazoo River Watershed, which has a TMDL goal for total phosphorus of 0.06 mg/L within Lake Allegan. Lakes begin eutrophication when phosphorus levels increase above 0.025 mg/L and rivers begin to suffer from dissolved oxygen depletion when levels are above 0.1 mg/L. Levels of phosphorus in the sampling sites show a downward trend over the winter. This could be due to decreased runoff and the subsidence of manure spreading outside of the growing season.

Game fish, especially brown trout, are highly sensitive to changes in temperature and will leave an area in search of more suitable habitat when temperatures are as little as two degrees above or below their optimum. Michigan Water Quality Standards suggest that temperatures for coldwater fisheries never exceed 20°C and warmwater fishery temperatures never exceed 32°C. Coldwater fish species require dissolved oxygen levels at or above 7 mg/L, and colder water temperatures allow higher dissolved oxygen concentrations. Dissolved oxygen levels are shown in Table 3.5. Warmer water temperatures also enhance the toxic effects of cyanides, phenol, and zinc.

Based on the findings of this study, it was suggested that the designated uses of coldwater and warmwater fisheries were impaired in the Watershed, although no impairment has been listed. Temperature data gathered over the 2 years of sampling (Table 3.6) show water temperature exceeding 20°C at the outlet of Gun Lake, which is to be expected. Additional sampling sites downstream are required to judge the level of impairment to the coldwater fishery.

Table 3.5 - Water Quality Sampling (GLASWA)

pH

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03
Gun Lake Outlet	8.6	7.9	7.8	8.3	8.2	8	7.6	7.7	8.3	7.3	7.2	7.4	7.6	7.7	7.5	7.6	7.7	7.6	7.6	7.3	7.7	8.1	8.2	8.2
Discharge Ditch		7.5	7.3	7.7	7.9	7.8	7.5	7.2	7	6.9	7.2	7.1	7.3	7.3	7.5	7.6	7.4	7.5	7.4	6.9	7.3	7.3	7.5	7.7
Greggs Brook	8.3	7.6	7.2	7.8	8.1	7.9	7.7	7.2	7.1	7	7.2	7.3	7.5	7.4	7.6	7.6	7.5	7.5	7.6	7.5	7.2	7.4	7.4	7.6
Orangeville Drain	8.3	7.8	7.7	8.1	8.2	7.9	7.6	7.6	7.4	7.1	7.3	7.4	7.6	7.6	7.7	7.7	7.6	7.6	7.5	7	7.4	7.4	7.7	7.2
Fenner Drain		7.5	7.6	8.1	8.1	7.8	8	7.8	7.5	7.1	7.2	7.4	7.6	7.6	7.5	7.6	7.6	7.5	7.3	7.2	7.5	7.6	7.8	7.7

Phosphorus (mg/L)

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03
Gun Lake Outlet	0.014	0.021	0.009	0.007	0.013	0.01	0.011	0.012	0.013	0.012	0.022	0.007	0.027	0.022	0.009	0.006	0.006	0.012	0.01	0.012	0.013	0.022	0.015	0.004
Discharge Ditch	0.055	0.041	0.032	0.024	0.015	0.02	0.018	0.024	0.083	0.065	0.037	0.043	0.061	0.038	0.067	0.093	0.031	0.024	0.021	0.049	0.037	0.074	0.026	0.027
Greggs Brook	0.127	0.146	0.104	0.035	0.06	0.102	0.045	0.067	0.122	0.111	0.049	0.071	0.083	0.116	0.037	0.099	0.077	0.035	0.046	0.124	0.054	0.099	0.061	0.055
Orangeville Drain	0.052	0.079	0.016	0.011	0.009	0.013	0.015	0.012	0.015	0.012	0.012	0.007	0.046	0.012	0.011	0.013	0.011	0.011	0.011	0.023	0.016	0.016	0.013	0.054
Fenner Drain	0.087		0.052	0.031	0.01	0.015	0.021	0.033	0.051	0.012	0.022	0.016	0.026	0.048	0.015	0.018	0.028	0.017	0.015	0.024	0.002	0.024	0.022	0.061

Dissolved Oxygen (mg/L)

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03
Gun Lake Outlet	8.48	8.77	9.84	9.4	10.7	7.8	6.16	4	4.6	4.6	2.1	8.2	14.3	14.8	13.9	15	13.2	9.3	9.1	6.1	7.6	8.6	10.9	10.1
Discharge Ditch		4.48	4.77	6.3	7.6	8.5	4.45	2.2	4.2	4.1	5	6.7	11.2	8.1	10	9.4	7.7	10.1	7.6	5.7	0.5	6.5	9.8	9
Greggs Brook	7.43	8.27	8.32	9.1	10.8	10.5	6.18	5.4	4.9	5.8	7.1	8.1	12.6	11.1	9.8	10.4	12.9	11.8	10.4	12.9	3.4	8.5	9	9.2
Orangeville Drain	8	8.62	8.88	8.5	9.52	7.2	5.75	4.7	4.9	5.5	6.7	8.5	14.1	13.7	16.6	15.9	13.5	10.3	15.9	7.9	8.3	8.1	10	9.8
Fenner Drain	8.01	8.46	8.95	9.96	10.57	8.9	6.32	5.4	5.6	5.3	7.4	9	13.5	13.6	13.9	13.4	13.5	11.8	9.9	8.7	8.5	8.4	10	9.9

Temperature (Celsius)

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03
Gun Lake Outlet	6.9	2.6	3.3	5.2	0.1	12	20.6	26.9	26	23	16.1	5.8	2.6	1.7	2.7	1.6	5.6	15.3	18.4	22.8	24.9	26	13.6	8.9
Discharge Ditch		6.7	7.3	9.3	4.8	11.8	14	16.2	16	13.9	11.3	7.9	7.8	7.6	5	3.3	5.5	9.4	10.5	12.8	19.5	18.4	12.9	9.4
Greggs Brook	7.5	3.9	4	6.9	1.9	10.4	14.6	17.4	18	14.6	10.7	5.7	4.1	3.9	1.5	1.4	4	10.3	1.4	4	16.7	19.2	10.3	6.9
Orangeville Drain	7.8	4.1	3.7	6.2	2.4	13.3	18.5	22.4	23.6	20.2	15.5	6.8	4.1	2.7	0.5	0.3	4	12.8	14.4	18.2	22.1	23.3	13.6	7.4
Fenner Drain	7.7	4.5	3.8	6.8	2.3	12.8	16	19.4	20.5	16.3	10.9	5.2	3.9	3.7	1.1	1.4	3.1	9.9	11.6	15.9	18.4	18.7	11	6.8

Table 3.6 - Water Quality Sampling (Menasha)

pH

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03
Gun Lake Outlet	6.6																						
Greggs Brook	7.6	7.7	7.3	7.9	N/A	7.9	7.5	7.6			8.1	8											
Orangeville Drain	7.8	7.7	8	8	N/A	7.9	7.7	8.2			8.3	8.3											
Fenner Drain	7.6	7.6	7.7	7.9	N/A	7.9	7.7	7.8			8.2	8.1											

Conductivity

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	
Gun Lake Outlet	330																						
Greggs Brook	610	630	590	600	N/A	590	610	570			560	580											
Orangeville Drain	440	440	440	440	N/A	450	430	410			410	430											
Fenner Drain	730	730	730	720	N/A	770	760	810			810	800											

Nitrate (mg/L)

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02											
Gun Lake Outlet	0.3																						
Greggs Brook	2	2.8	8	11	N/A	N/A	3.1	2.1			1.1	2.4											
Orangeville Drain	0.3	0.3	2	1	N/A	N/A	0.2	0.3			0.2	0.2											
Fenner Drain	2.7	3.9	13	11	N/A	N/A	4.5	4.2			4.9	4.4											

Nitrite (mg/L)

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02											
Gun Lake Outlet	0.0039																						
Greggs Brook	0.0705	0.033	0.09	0.08	N/A	N/A	0.09	0.15			0.06	0.07											
Orangeville Drain	0.0037	0.004	0.02	0.02	N/A	N/A	0.01	0.01			0.01	0.01											
Fenner Drain	0.0328	0.034	0.11	0.1	N/A	N/A	0.05	0.06			0.02	0.04											

Ammonia (mg/L)

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02											
Gun Lake Outlet	0.167																						
Greggs Brook	0.414	0.375	0.36	0.23	N/A	0.14	0.28	0.35			0.14	0.45											
Orangeville Drain	0.158	0.175	0.21	0.16	N/A	0.12	0.18	0.18			0.06	0.08											
Fenner Drain	0.269	0.224	0.21	0.12	N/A	0.08	0.15	0.22			0.13	0.11											

Ortho-P (mg/L)

Sampling Site	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02											
Gun Lake Outlet	0.023																						
Greggs Brook	0.066	0.08	0.04	0.06	N/A	0.02	0.03	0.06			0.05	0.1											
Orangeville Drain	0.019	0.05	0.05	0.06	N/A	0.01	0.03	0.03			0.03	0.04											
Fenner Drain	0.037	0.05	0.05	0.05	N/A	0.01	0.03	0.05			0.05	0.03											

Table 3.6 - Water Quality Sampling (Menasha); continued from previous page

Total P (mg/L)																							
Sampling Site	**Nov-01**	**Dec-01**	**Jan-02**	**Feb-02**	**Mar-02**	**Apr-02**	**May-02**	**Jun-02**	**Jul-02**	**Aug-02**	**Sep-02**	**Oct-02**	**Nov-02**	**Dec-02**	**Jan-03**	**Feb-03**	**Mar-03**	**Apr-03**	**May-03**	**Jun-03**	**Jul-03**	**Aug-03**	
Gun Lake Outlet	0.052																						
Greggs Brook	0.185	0.22	0.05	0.04	0.04	0.07	0.05	0.07	0.13	0.11	0.2	0.09	0.1	0.24	0.05	0.11	0.06	0.05	0.06	0.08	0.05	0.09	
Orangeville Drain	0.135	0.05	0.02	0.01	0.02	0.09	0.02	0.02	0.03	0.02	0.09	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.02	
Fenner Drain	0.578	0.12	0.07	0.04	0.03	0.08	0.04	0.04	0.04	0.03	0.08	0.02	0.03	0.1	0.03	0.04	0.04	0.03	0.02	0.03	0.03	0.03	
Suspended Solids (mg/L)																							
Sampling Site	**Nov-01**	**Dec-01**	**Jan-02**	**Feb-02**	**Mar-02**	**Apr-02**	**May-02**	**Jun-02**	**Jul-02**	**Aug-02**	**Sep-02**	**Oct-02**											
Gun Lake Outlet	2																						
Greggs Brook	20.4	18.8	7	5.6	N/A	4	8	12.8			4	1.6											
Orangeville Drain	0.4	3.6	2	1.2	N/A	3	4	2.4			4	1											
Fenner Drain	25.6	30.4	16	10.8	N/A	3	8	16			5	4											

Chart 3.1 - Gun River Total Phosphorus

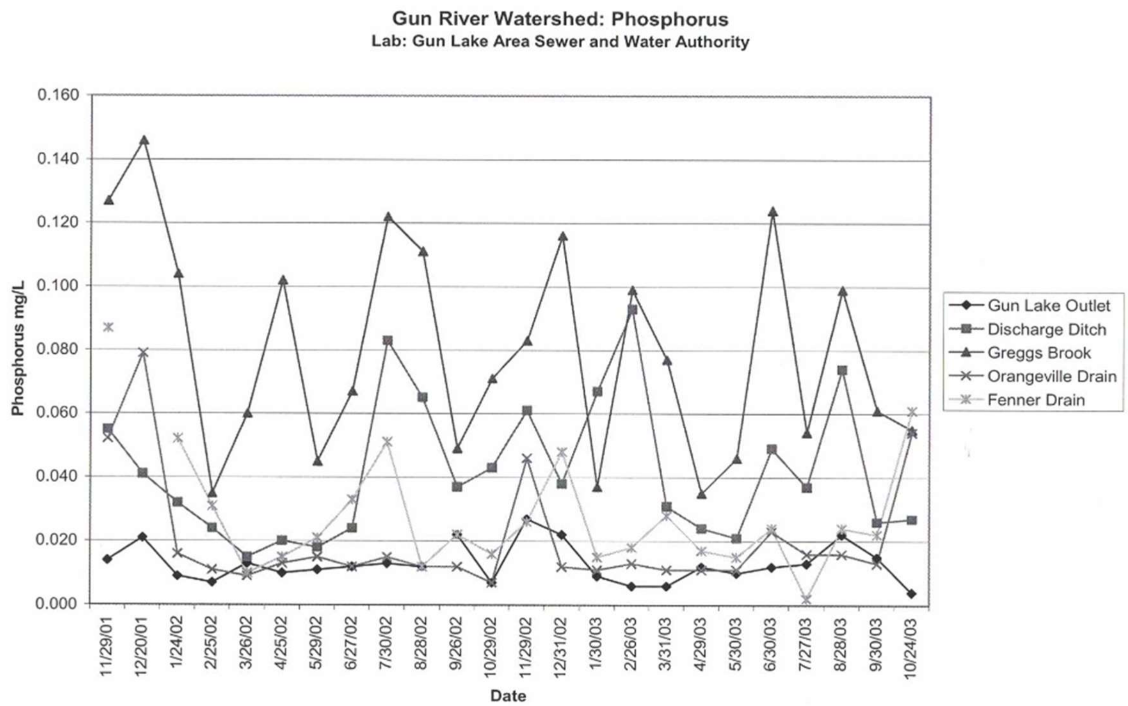


Chart 3.2 - Gun River Dissolved Oxygen

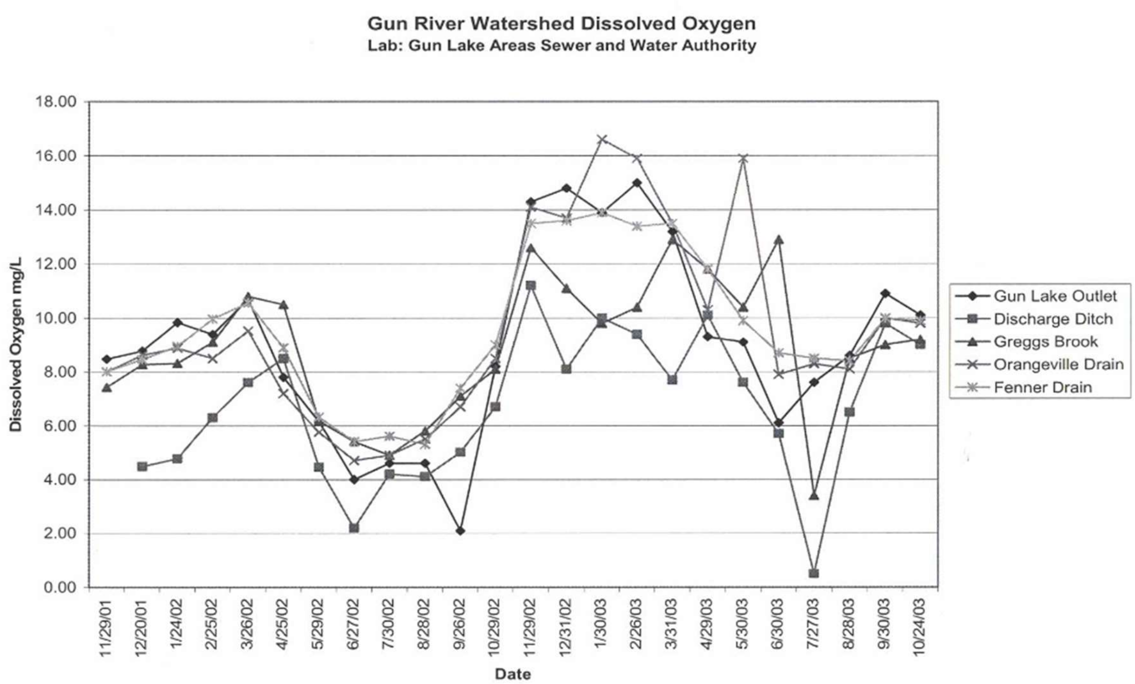
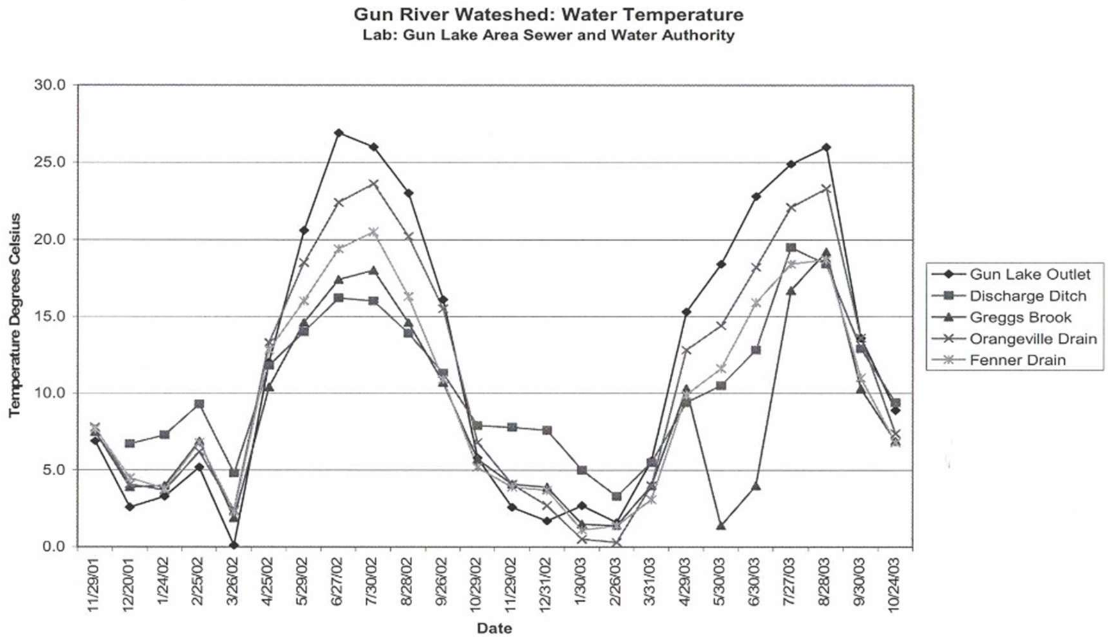


Chart 3.3 - Gun River Water Temperature



BIOLOGICAL SURVEY OF THE KALAMAZOO RIVER (2004)

Qualitative biological surveys of the Kalamazoo River watershed were conducted by staff oF EGLE, Surface Water Assessment Section, during July-September 2004 to characterize overall watershed status and trends. Three locations were sampled in the Gun River Watershed.

Greggs Brook, a tributary to the Gun River was one of the stream reaches sampled. This section of stream is an unmaintained agricultural drainage ditch that supports a macroinvertebrate community rated at the low end of acceptable. Noted at this location was surprisingly cool stream temperatures indicative of the presence of potentially significant quantities of groundwater. The benthic community here were unremarkable; typical of frequent disturbance.

The two additional locations sampled in the Watershed were on the mainstem of the Gun River, 122nd Avenue and 110th Avenue. It was reported that the river at these locations was relatively unchanged since the previous biological surveys in 1999. At both locations, macroinvertebrate densities were very low and taxa present were pollutant and disturbance tolerant. It was reported that overall biological communities at these sites should be considered depressed and predictable and that stream modification and adjacent land use are much more of a factor in this than the WWTP upstream.

BIOLOGICAL SURVEY OF SITES IN THE KALAMAZOO RIVER WATERSHED (2009)

Qualitative biological surveys of the Kalamazoo River watershed were conducted by staff of EGLE, Surface Water Assessment Section, during the summer of 2009 to assess point and nonpoint source pollution in the Kalamazoo River Watershed. Three locations were sampled in the Gun River Watershed.

All three had acceptable macroinvertebrate scores. Gun River upstream of 11th Street had a negative score tending toward poor that would be considered moderately impaired due to dredging in this section of stream. It was noted, however, that the stream channel and riparian zone were recovering and that this sample took place during a storm event making it hard to sample all available stream habitat. Stream habitat was rated marginal-good.

Table 3.7 - 2009 Biological Survey Sampling Results in the Gun River Watershed

Water Body	Location	Habitat Rating	Macroinvertebrate Rating
Gun River	11th Street	Good	Acceptable
Gun River	2nd Street	Marginal	Acceptable
Fenner Creek	2nd Street	Marginal	Acceptable

BIOLOGICAL SURVEY OF THE KALAMAZOO RIVER WATERSHED 2014

Qualitative biological surveys of the Kalamazoo River watershed were conducted by staff of EGLE, Surface Water Assessment Section, during June-September 2014 to characterize overall watershed status and trends. Two locations were sampled in the Gun River Watershed.

Gun River at 11th Street was meeting water quality standards with an Acceptable for macroinvertebrate and Good habitat score. This stretch of the river has mostly sand substrate, some cobble, and plentiful large woody debris of varying sizes. The dominant taxa was hydropsychids with mayflies and caddisflies present.

The other location, Gun River via a drainage ditch downstream of the Gun Lake WWTP, had Poor macroinvertebrates and Marginal habitat. This location was impacted by steep banks with no vegetated cover along agricultural fields on each side of the ditch. There was additionally a sharp 90-degree turn in the water body impacting flow. The dominant taxa found were isopods. The presence of Cladophora indicated that this reach had higher nutrient levels than other areas in the watershed. Stoneflies, mayflies, and caddisflies were all absent from this location.

EGLE MONITORING OF THE GUN RIVER WATERSHED

EGLE conducts periodic monitoring of the watersheds in Michigan. In the Gun River, macroinvertebrate and *E. coli* monitoring has been conducted to evaluate the status of water quality impairments.

Macroinvertebrate and habitat monitoring was conducted in 2009, 2014, and 2019 to evaluate the status of the impairment to other indigenous aquatic life and wildlife. The survey site immediately downstream of Gun Lake received a poor rating for macroinvertebrates and a marginal rating for habitat, sites at the Fenner Creek confluence and upstream of 11th St. received acceptable and marginal ratings, and the site at 2nd street received good and acceptable ratings. Results from the 2019 draft report are found in table 3.8, the final report has not been released at the time of this writing. Macroinvertebrate and habitat monitoring will happen again in 2024. Reports can be found at: https://www.michigan.gov/egle/about/organization/water-resources/glwarm.

Table 3.8 - 2019 Biological Survey Sampling Results in the Gun River Watershed

Water Body	Location	Habitat Rating	Macroinvertebrate Rating
Orangeville Creek	9 Mile Road	Good	Acceptable
Fenner Creek	2nd Street	Marginal	Acceptable
Gun River	11th Street	Good	Acceptable

E. coli data was collected in 2014, 2018, and 2019. Table 3.9 contains survey locations and 30-day geometric means in colony forming units (cfu)/100 ml. Total body contact recreation is protected during May-October for which the water quality standard is a daily limit of 300 CFU per 100 ml, and 130 CFU per 100 ml as a 30 day geometric mean. Partial body contact recreation is protected year-round with a limit of 1000 CFU per 100 ml based on a geometric mean of 3 samples within a 7 day period. The remediation of impairments caused by *E. coli* is described under Michigan's Statewide *E. coli* TMDL approved in 2019. Water bodies that do not attain this standard fall under the TMDL which outlines broadly the potential sources of *E. coli* and provides recommendations for the reduction of nonpoint sources. Legal point sources are directly regulated through State permitting, but illicit discharges may exist and need to be addressed. Information about the Statewide *E. coli* TMDL can be found at https://www.mi.gov/ecolitmdl and in Appendix 4.

Table 3.9 - *E. coli* Levels in the Gun River Watershed

Site Description	AUID	Survey Period	30 Day Mean
Cuddy Drain - Chief Noonday	040500030701-13	Aug - Sep 2014	550.57
Cuddy Drain - Timber Creek Drive	040500030701-13	Aug - Sep 2014	509.32
Tawsley and Holbrook Drain	040500030701-13	Aug - Sep 2014	371.00
Cuddy Drain u/s Tawsley and Holbrook Drain	040500030701-13	Aug - Sep 2014	1001.94
Cuddy Drain - Patterson Rd	040500030701-13	Aug - Sep 2014	1109.67
Gardner u/s Timber Creek	040500030701-13	Aug - Sep 2014	839.80
Cuddy Drain - Patterson Rd	040500030701-13	Sep - Oct 2018	1220.65
Gun River - 116th Ave	040500030702-06	Jul - Aug 2019	719.37
Gun River - 10th St	040500030703-01	Jul - Aug 2019	552.92
Gun River - Near Lake Outlet - Patterson Rd	040500030702-05	Jul - Aug 2019	173.30

These values highlight the use impairments in the watershed. AUID 040500030701-13 exceeds the standards for both partial body contact and total body contact, at 130 cfu/100 ml and 1000 cfu/100 ml respectively. For partial body contact, two of the sites recorded 30-day geometric means above 1000 cfu/100 ml, and six of the seven sites recorded single day values above 1000 cfu/100 ml. For total body contact, all seven sites had single day values and 30-day geometric means above the standards.

Three locations were surveyed in the Gun River, with all three surpassing the standard for total body contact of 130 cfu/100 ml as a 30-day geometric mean and single day values above 300 cfu/100 ml. The site at 116th Ave had one day above the safe partial body contact threshold of

1000 cfu/100 ml as well.

3.4.2 Studies Completed as a Part of the 2024 Update

WATER QUALITY MONITORING ON BOOT LAKE

Boot Lake is located in the southwest corner of the Gun Lake subwatershed—flowing into Cuddy Drain and then Gun Lake. The Match-E-Be-Nash-She-Wish Band of Potawatomi Indians, or Gun Lake Tribe (GLT), has property abutting the lake and performs routine water quality monitoring in the lake. The GLT Environmental Department can be contacted to request access to the full data set.

Boot Lake is a mesotrophic, cold water lake with suitable habitat conditions for a variety of aquatic life. During seasonal stratification, dissolved oxygen drops below 5 mg/L below 3 meters but remains acceptable in shallower waters and during mixing periods. Temperature has remained fairly stable year to year, with monthly average water temperatures never rising more than 4 °C above the average of the previous 5 years. Phosphorus levels starting in 2018 have been elevated above desired levels, and total Kjeldahl nitrogen has shown an increasing trend since 2018.

AGRICULTURE INVENTORY (2021-2023)

To gain an understanding of the current agricultural practices being used in the watershed and to identify areas of water quality concerns, an agriculture inventory was conducted from 2021 to 2023. During this inventory, the entire watershed was driven and each field observed from the vehicle for tillage practices in the fall and planting practices in the spring. Additionally, all animal feeding operations (AFO) in the watershed were identified as part of the agriculture inventory. This was completed using aerial photographs and observing farms during windshield surveys to note any potential pollution concerns. The Quality Assurance Project Plan (QAPP) followed for this inventory is in Appendix 5.

There are 28,892 acres of fields in or touching the watershed boundary. The major crop being produced in the Watershed is corn followed by soybeans, hay, small grains, and vegetables. Note, all corn in 2023 is listed as grain corn because these crops were only observed in the spring, and the harvest method was not observed. Approximately 526 acres in the Watershed are used as pasture. Agriculture Inventory results can be seen in Tables 3.11 - 3.14. Additionally, between 10% and 12% of crop land had visible evidence of manure application at time of survey.

Table 3.10 - Agricultural fields of the Gun River Watershed

Crop	Percent of Field Acreage	
	2022	2023
Corn	61%	56%
Soybean	13%	13%
Hay	11%	11%
Skipped	6%	8%
Vegetables	3%	2%
Not Currently Farmed	2%	2%
Small grain	2%	4%
Pasture	2%	2%
Unknown	1%	1%
Other	0%	0%
Developed	0%	0%
N/A	0%	0%

Table 3.11 - Fall Tillage practices of the Gun River Watershed

Fall Tillage	Percent of Field Acreage	
	2021	2022
None	53%	35%
N/A	15%	16%
Chisel Plowed	12%	23%
Planted	10%	17%
Skipped	7%	6%
Mulch Till	2%	3%

Table 3.12 - Cover Crop use in the Gun River Watershed

Cover Crop	Percent of Field Acreage	
	2022	2023
No	69%	75%
N/A	14%	15%
Yes	11%	5%
Skipped	7%	5%

Table 3.13 - Spring Residue in the Gun River Watershed

Spring Residue	Percent of Field Acreage	
	2022	2023
Greater than 30%	6%	5%
0%	52%	36%
N/A	17%	16%
Less than 30%	12%	22%
Skipped	7%	8%

Spring Residue	Percent of Field Acreage	
	2022	2023
Planted	6%	10%
Not Planted	1%	3%

Based on this inventory, there are approximately 70 AFOs in the Watershed, including 5 CAFOs. The majority of AFOs in the Watershed were beef and dairy farms. The remaining AFOS were for horse, mink, poultry, swine, hobby farms, and one petting zoo. 5 AFOs identified from aerial photographs were no longer operational when viewed during windshield survey. 57% of AFOs identified were found to have potential manure or runoff concerns. These AFOs were identified as possible areas of concern due to their proximity to a waterbody, evidence of drainage into a waterbody, improper manure storage and management, and/or clear signs of erosion.

AGRICULTURAL CONSERVATION PLANNING FRAMEWORK (ACPF)

The ACPF is an ArcGIS toolbox that uses high resolution elevation data to identify slopes and overland flow paths on farm fields within a watershed. These data then are used to produce potential locations for specific best management practices such as grassed waterways and tile line control structures. The results of the ACPF were used in conjunction with tillage and residue survey results to identify agricultural fields that are a high priority for BMPs due to their potential for contributing to NPS pollution. ACPF results were reviewed, and incompatible BMPs were removed. The results of this analysis can be found in Chapter 5 of this plan.

NONPOINT SOURCE INVENTORY AND WATER QUALITY MONITORING

In November 2022, an inventory was completed to document possible sources of NPS pollutants in the Gun River Watershed. This inventory employed the use of aerial photography and in-person survey consisting of driving, walking, and kayaking reaches of the Watershed. This survey followed a QAPP that can be found in Appendix 5.

The inventory identified 48 sites of streambank erosion, 20 sites with concerns at road-stream crossings, 11 tile outlets, 9 sites of agriculture runoff, 6 road runoff locations, 5 gully erosion sites, and an inadequate riparian buffer. Figure 19 shows the NPS sites surveyed for this project. Of the streambank erosion sites, 7 of them were sites that were also identified in the 2001 Watershed Inventory. Additionally, within the section of the Gun River inventoried, 10 sites of streambank erosion from the 2001 study were no longer identified as possible sources of NPS pollution. See Appendix 2 for 2001 Watershed Inventory data sheets, Appendix 2B for 2001 Inventory data, and Appendix 2C for 2022 Inventory data. Additionally, Vernier water quality monitoring sensors were installed on kayaks used during the inventory to take continuous temperature, dissolved oxygen, and conductivity data on the 5.5 miles of the Gun River from 122nd Street to 112th.

Throughout this stretch, undercutting of the bank was common in addition to many areas of sparse vegetation. Water quality parameters remained relatively stable with the only significant variation near the Fenner Creek confluence. Conductivity rose dramatically at the outlet, and dissolved oxygen dropped at a location just downstream (Figure 15). The elevated conductivity is likely due to sediment inputs from Fenner Creek. The cause of the low dissolved oxygen is unknown. The readings are from a site that was recorded due to erosion from what appeared to be a wildlife and human access trail. It is possible that the sensor was inadvertently submerged in sediment while measuring the site. The inventory was not well-timed to test previous concerns regarding water temperature with an average air temperature of 12.79 °C the week of the inventory. However, the observed temperature is comparable to previous November temperatures. SOP for the kayak-mounted sensor survey can be found in Appendix 5.

Table 3.14 - Summary Statistics of Kayak-mounted Sensors

Parameter	Mean	Standard Deviation	Range
Temperature (°C)	11.68	0.19	10.94 - 12.28
Dissolved Oxygen (mg/L)	9.23	0.51	5.35 - 16.75
Conductivity (S/cm)	560.96	52.83	473 - 830

While findings from the NPS inventory were helpful in identifying and quantifying pollutants impairing the Watershed, it is not an exhaustive list of all pollutant sources. The in-person survey could only include sites that were visible from public roads and a portion of the Gun River. Additionally, this inventory excludes sources of pollution that would not be identifiable by rapid assessment such as failing or leaking septic systems. Not all reaches of the Gun River were accessible by kayak due to water levels, lack of public access, and downed trees in the waterway. While the size of riparian buffers was not easily observable from kayaks due to high banks. These shortcomings are in-part addressed by aerial photo analysis and modeling from the ACPF.

3.5 POLLUTANTS AND CONCERNS

The above studies taken together reveal a number of pollutants that should be addressed in order to restore current impairments and prevent future impairments to designated and desired uses.

3.5.1 Sedimentation

The deposition of sediment into waterways harms aquatic habitats by altering streambeds and increasing water turbidity. Sediments decrease habitat for macroinvertebrates and fish spawning and can damage fish gills. High turbidity results in less light penetration and subsequent decrease in DO and water temperatures. Bacteria, nutrients, pesticides, and other pollutants bind to soil particles and easily enter water bodies with sediment. The input of excess sediment into waterways is often from agriculture, road-stream crossings, altered stream hydrology, and construction/development. Additionally, sediment can interfere with the efficient functioning of irrigation systems.

The investigation of the Watershed found that sources of sediment entering the Gun River included agricultural operations, road/stream crossings, rill and gully erosion, streambank erosion, livestock access sites, erosion at tile outlets, and a few construction sites. The causes of the sources include conventional tillage, lack of filter strips, undersized culverts with steep side slopes and degraded bridges, obstructions in the stream channel, flashy flows, improperly installed tiles, and ineffective SESC measures. Estimated sediment loss was modeled with EGLE's *Pollutant Load Estimation Tool* (PLET) using land cover statistics. The total sediment load estimated using PLET for the Gun River and its tributaries was 18,175 tons/year, or .248 tons/acre/year. The suspected sources of sediment for Gun Lake are urban runoff from impervious surfaces and landscaped shoreline properties.

3.5.2 Nutrients

Nutrients are necessary for plant growth, but an overabundance is detrimental to aquatic ecosystems. Nitrogen and phosphorus are often limited resources in an unaltered landscape but can quickly become excessive in developed watersheds. In abundance, these nutrients cause eutrophication in water bodies, impacting ecological communities and recreational opportunities. The growth and subsequent decomposition of excessive algae that flourishes in nutrient-rich water decreases dissolved oxygen. The process destroys the balance of water chemistry and food webs.

These algal blooms can become harmful to human health if they include cyanotoxins. Harmful Algal Blooms (HABs) can occur during periods of high temperatures, sunlight, and high nutrient levels. HABs come from cyanobacteria, also known as blue-green algae. They are frequently described as looking like green paint or pea soup, although they can vary in color. Swallowing lake water, or skin contact with HABs can cause adverse effects on human health and pet health. More information about HABs can be found on EGLE's website: https://www.michigan.gov/egle/about/organization/water-resources/glwarm/harmful-algal-blooms

Additionally, an excess of nutrients allows invasive species to better compete with native vegetation. Sources of nutrients include agricultural and residential fertilizers and organic waste carried within water runoff. Nutrients in the Gun River are originating from agricultural operations, residential lawns, and dumping of yard wastes. Improper use and application of fertilizers on cropland and lawns cause excessive nutrients to enter the waterways. The lack of composting and knowledge of how yard wastes add nutrients to surface water results in illegal dumping of yard waste into streams. A 2001 report prepared by Keiser & Associates for the Kalamazoo River/Lake Allegan TMDL estimated the annual phosphorus loading to the Gun River to be 11,119 pounds/year in 2001; this estimate uses a modeling approach prescribed in the State of Michigan Draft Part 30 - Water Quality Trading Rules. In 2024, estimated phosphorus and nitrogen deliveries were modeled with EGLE's *Pollutant Load Estimation Tool* using land cover statistics. The total phosphorus delivery estimated using PLET for the Gun River and its tributaries was 56,820 pounds/year, or .775 pounds/acre/year. The total nitrogen delivery estimated using PLET for the Gun River and its tributaries was 249,916 pounds/year, or 3.41 pounds/acre/year. Suspected sources of nutrients in Gun Lake include urban runoff from pet waste and populations of geese.

3.5.3 Hydrology

The altered hydrology is a high-priority concern to the Gun River Watershed and is listed as an impairment by EGLE in the Gun River. Modifications to the natural environment have disrupted the natural hydrologic process in the Watershed. These modifications include the draining of wetlands, removal of native vegetation, straightening and dredging of stream channels, increased artificial drainage and impervious surfaces. These actions have dramatically altered the natural process in the watershed causing flashy flows, habitat alterations, changes in aquatic communities, and erosion. The hydrology of the Watershed has been altered by the drainage networks and the changes of land uses within the Watershed. The establishment of drains and traditional maintenance techniques of drain improvements have changed the natural hydrology of the Gun River system. The conversion of wetlands into other land uses and the increase of impervious surfaces in the Watershed result in greater volumes of runoff and decreased infiltration of stormwater.

3.5.4 *E. coli* / Pathogens

Bacteria and pathogens enter water bodies from unmaintained septic systems, improper application of manure, barnyards or feedlots, improper disposal of pet waste, and waterfowl. High concentrations of bacteria and pathogens in surface waters pose a severe health risk and thus can impair body contact recreation in water bodies. Fecal coliform bacteria are often monitored as they are an indicator of pollution from animal and human waste and are accompanied by other pathogens and disease-carrying organisms.

Pathogens associated with fecal matter are among the highest priority pollutants in the watershed due to impairment listing by EGLE under the Statewide *E. coli* TMDL. High concentrations of bacteria and pathogens in surface waters pose a severe health risk and thus can impair body contact recreation in water bodies. Total and partial body contact designated uses are not being attained in areas of the Gun River Watershed and are therefore putting human health at risk.

Bacteria and pathogens enter water bodies from unmaintained septic systems, improper application of manure, barnyards or feedlots, improper disposal of pet waste, and waterfowl. *E. coli* is spread through the feces of warm blooded-animals, and its detection often indicates that other dangerous bacteria are present. Livestock with access to streams, large populations of wildlife, failing septic systems, and inadequate manure storage facilities are sources of *E. coli*. The lack of fencing along streams to keep out livestock allows waste to enter the stream. Poorly sited and maintained septic systems and manure storage facilities also release *E. coli.* Leaching or overflowing manure storage areas and improper land applications of manure can also add bacteria to the stream.

3.5.5 Temperature

Heated runoff from impervious surfaces and the removal of riparian vegetation can result in temperature pollution. Impervious surfaces such as driveways and parking lots increase the temperature of water crossing the surface before entering a waterbody. The removal of vegetation reduces the shading of the waterbody and can lead to an increase in temperature. Surges of heated water during storm events can stress aquatic organisms that are adapted to typical temperatures. Thermal pollution can also increase the rate of photosynthesis and further increase eutrophication as well as the metabolic rate of aquatic organisms.

3.5.6 Chemical Pollutants

Common chemical pollutants include gasoline, oil, and pesticides. Oil and gasoline can enter water bodies from roads, parking lots, and boating. Approved permitted herbicide application to prevent the growth of aquatic nuisance plants can be a source of chemical pollutants. Pesticides and other herbicides employed in agricultural, municipal, or residential uses constitute other sources of chemical pollutants. Stormwater runoff causes high concentrations of these pollutants to enter water bodies. Hydrocarbons were observed entering the Gun River from irrigation pumps and other machinery along its banks. Old, leaking, and inefficient machines allow petroleum by-products to enter the watercourse.

Michigan has statewide TMDLs for Mercury and PCB contamination. Both pollutants can enter water bodies due to atmospheric deposition, and impair the designated use of fish consumption. PCBs are synthetic organic chemicals used mainly for insulation that were banned in 1979 due to toxic properties. While PCB concentrations in water have been declining, some water bodies remain impacted. Mercury is a naturally occuring metal in the environment whose presence has been amplified by industrial activities to higher concentrations. Mercury concentrations in wildlife can increase by trophic level through biomagnification to unsafe levels for human consumption. Mercury emissions have been decreasing since the 1990’s, but some water bodies may remain impacted.

CHAPTER 4 – IMPLEMENTATION PLAN

4.0 GOALS AND OBJECTIVES FOR THE GUN RIVER WATERSHED

The implementation of this Watershed Management Plan (WMP) requires a combination of strategies that include community outreach/education, construction/installation of Best Management Practices (BMPs), and supporting local policy. The goals of the Watershed community to improve water quality to meet designated uses will not be realized without this multi-faceted approach. This chapter will outline the plan's goals and objectives based on input from stakeholders and existing plans, followed by a summary of the BMPs, policy, and educational efforts necessary to achieve those objectives. Details of critical areas, BMPs, and policies are discussed in Chapter 5. Specific outreach steps, audience, and objectives are presented in Chapter 6.

The Steering Committee defined the goals and objectives for the Watershed at a working meeting in April 2002. A summary of the impairments to the designated uses was presented to the committee. The committee members also examined inventory results to determine which pollutants were most abundant and what impact those pollutants had in the Watershed. The committee members were assigned the task of completing a worksheet to determine the goals and objectives that would address the impairments. Once the goals were established, the committee formulated specific objectives to meet each of the goals. These goals were reviewed and updated by the Steering Committee in October 2023. The goals and corresponding objectives supporting the restoration and protection of designated uses are listed below.

1. Stabilize hydrology to reduce instream erosion and facilitate improved habitat for macroinvertebrates and fish.
    a. Moderate stream flows by intercepting runoff and increasing infiltration.
    b. Restore natural variability in stream flow and depth through the creation of meanders, addition of large woody debris, and other natural channel design techniques.
    c. Increase floodplain capacity through reconnecting existing floodplain, restoring wetlands, and using two-stage ditches.
2. Reduce nonpoint source sediment, nutrient, and pathogen loading from agricultural fields by stabilizing sediment and minimizing runoff volume and pollutant load.
    a. Prevent wind and water erosion by minimizing soil disturbance, promoting year-round vegetative cover, and strategic planting in critical areas.
    b. Reduce the volume of tile discharge directly entering surface water.
    c. Encourage proper timing, rate, and placement of pesticides, fertilizers, and manure.
    d. Increase the use of riparian buffers and vegetation.
3. Minimize pathogen and nutrient pollution from animal agricultural sources.
    a. Engage producers in risk assessment and management.
    b. Limit direct livestock access to surface water.
    c. Ensure all manure is stored in a manner that prevents contamination of surface and groundwater.

4. Reduce nonpoint source pollution caused by runoff from urbanized areas.
    a. Encourage proper maintenance, monitoring, and siting of septic systems.
    b. Increase the use of riparian buffers and vegetation.
    c. Reduce stormwater runoff and discharge from existing developed areas.
    d. At new development sites, maintain site runoff volume and peak flow rate at or below pre-development levels for all storms up to the 2-year, 24-hour event.

The community and the Steering Committee also identified goals that primarily support the desired uses of the watershed which are not directly related to water quality. These goals may have some indirect impact on designated uses, but are not considered to be substantial enough to be prioritized in water quality efforts.

5. Improve habitat quality and connectivity.
    a. Prevent the introduction of invasive species.
    b. Preserve and expand existing habitat corridors.
    c. Increase biodiversity.
    d. Monitor and protect species of concern.
6. Improve recreational opportunities.
    a. Partially remove obstructions inhibiting water flow or navigation. Note: some woody debris is desirable for habitat.
    b. Expand recreational infrastructure such as trails and supporting facilities.

4.1 RECOMMENDATIONS

4.1.1 Technical Assistance

All implementation efforts will involve some level of technical assistance which will vary based on practice, site, and cooperator capacity (i.e. the abilities of the person or organization implementing the recommendation). To reflect the range of these costs, technical assistance has been classified into tiers that can serve to guide planning around funding and staff needs for implementation (Table 4.1).

Table 4.1 - Technical Assistance Tiers

Tier	Description	Example Actions
Tier 1	No specialized assistance needed. Staff with basic natural resources education can reasonably be expected to plan implementation with the help of existing tools.	Basic education, program applications, use of basic planning tools
Tier 2	Some specialized assistance needed. Staff should have a relevant certification or substantial experience to plan implementation.	Prepare construction specifications (non-engineered), interpret soil test results
Tier 3	Significant specialized assistance needed. Most planning and implementation assistance should be done by specialized staff.	Engineering, surveying, legal or legislative work
Tier 4	A team of specialized staff is required.	Large infrastructure projects

There are numerous organizations which can provide technical assistance. Agricultural practices may be supported by conservation districts, Michigan Department of Agriculture and Rural

Development, Natural Resources Conservation Service, Michigan State University Extension, Pheasants Forever, and agronomy consultants. Organizations that may provide assistance for hydrology stabilization practices include the Michigan Department of Environment, Great Lakes, and Energy, Michigan Department of Natural Resources, Trout Unlimited, Drain Commissions, and outside engineering consultants. Assistance for policy and planning practices may come from conservation districts, local planning officials, county health departments, and outside legal services. Because costs can vary dramatically from project to project, technical assistance organizations should be contacted for cost information before seeking funding for a project.

4.1.2 Implementation Costs and Financial Assistance

Estimates of implementation costs are taken from a number of sources. Where available, costs were taken from the 2024 Environmental Quality Incentives Program payment schedule and multiplied by 1.33 to account for landowner contributions (this program estimates 75% of the cost will be covered with the remaining 25% contributed by the landowner). These costs are only for establishment of the practice and do not account for incentives such as land rental or foregone income payments. The other practices were estimated using a variety of outside sources, or barring that, professional best judgment based on similar projects.

Yearly Operation and Maintenance (O&M) costs for multi-year practices are site specific. For the purpose of high level budgeting and planning, practices are estimated to have an annual maintenance cost calculated by dividing the installation costs by the practice lifespan, and multiplying by 2%.

$$\text{Annual O\&M} = \text{Installation cost} \div \text{practice lifespan} * .02$$

More detailed O&M plans should be developed during the planning and site selection phase of project development. These plans should consider the value and amount of labor, fuel costs, equipment usage costs, and the lifespan and replacement costs of physical components.

A variety of local, federal, and state programs can be leveraged to provide financial assistance for the recommendations. The Farm Bill, Clean Water Act, Clean Michigan Initiative, Great Lakes Restoration Initiative, and local millages are all sources of funding that can either be applied directly or obtained through a grant application. Conservation district staff are well versed in the variety of funding mechanisms available and should be consulted for assistance.

Table 4.2 - Field Recommendations

Recommendation	Pollutant	Technical Assistance	Unit Cost Estimate	Amount	Total Cost (O&M Cost)	Estimated Pollutant Load Reduction
Contour Buffer Strips	Sediment, Nutrients, E. coli	Tier 2	$696/Ac	96 acres	$66,800 (+ $2.78/Ac/Yr)	
Grassed Waterways	Sediment, Nutrients, E. coli	Tier 2	$9/Ft	59370 ft	$534,300 (+ $.018/Ft/Yr)	
Filter Strips	Sediment, Nutrients, E. coli	Tier 1	$227/Ac	412 acres	$93,500 (+ $.45/Ac/Yr)	
Saturated Buffers	Sediment, Nutrients, E. coli	Tier 3	$14/Ft	16,421 ft	$230,000 (+ $.019/Ft/Yr)	
Denitrifying Bioreactors	Nitrogen	Tier 3	$116/Cu Yd	2550 Cu Yd	$295,800 (+ $.23/CuYd/Yr)	
Water and Sediment Control Basin	Sediment, Nutrients, E. coli	Tier 3	$4,000 - $8,000/Ac	149 acres	$894,000 (+ $12/Ac/Yr)	
Structure for Water Control (Drainage Water Management)	Nutrients, E. coli	Tier 3	$3541/structure	138 structures	$488,700 (+ $3.54/structure/Yr)	
Cover Crops	Sediment, Nutrients, E. coli	Tier 1	$83/Ac/Yr	20802 acres	$1,726,600	N: 11,224lbs/yr P: 1,460lbs/yr TSS: 796Tons/yr
No-till or Strip Till	Sediment, Nutrients, E. coli	Tier 1	$37/Ac/Yr	12712 acres	$470,300	N: 15,745lbs/yr P: 7,623lbs/yr TSS: 3,843Tons/yr
Controlled Traffic Farming	Sediment	Tier 1	$59/Ac/Yr	12712 acres	$750,000	
Nutrient Management	Nutrients	Tier 2	$38/Ac/Yr	28892 acres	$1,098,000	N: 9,038lbs,yr P: 4,281lbs/yr
Windbreaks	Sediment	Tier 1	$390/Ac	20 acres	$7,800 (+ $.52/Ac/Yr)	
Total Field Practices					**$6,655,800**	

Notes: Average bioreactor assumed to be 150CuYd.

Table 4.3 - AFO Recommendations

Recommendation	Pollutant	Technical Assistance	Unit Cost Estimate	Amount	Total Cost (O&M Cost)
Access Control	Sediment, Nutrients, *E. coli*	Tier 2	$65/Ac	526 Ac	$34,190 (+ $.13/Ac/Yr)
Watering Facilities	Sediment, Nutrients, *E. coli*	Tier 3	$4586/Each	2	$9,200 (+ $9.17/Yr)
Stream Crossings	Sediment, Nutrients, *E. coli*	Tier 3	$95/Cu Ft	750 Cu Ft	$71,250 (+ $.19/Cu Ft/Yr)
Critical Area Planting	Sediment, Nutrients, *E. coli*	Tier 1	$0.15/Sq Ft	37,000 Sq Ft	$5,550 (+ $.003/Sq Ft/Yr)
Waste Storage Facilities	Nutrients, *E. coli*	Tier 3	$3.43/Cu Ft	510,000 Cu Ft	$1,800,000 (+ $.0046/Cu Ft/Yr)
Prescribed Grazing Plans	Sediment, Nutrients	Tier 2	$35.60/Ac	526 Ac	$18,725
Risk Assessment and Planning through the Michigan Agriculture Environmental Assurance Program (MAEAP)	Sediment, Nutrients, *E. coli*	Tier 2	$2500/Farm	110 Farms	$275,000
Total AFO Practices					**$2,213,915**

Table 4.4 - Recommendations for Improving Hydrology

Recommendation	Pollutant	Technical Assistance	Cost
Bank Stabilization	Sediment	Tier 3	Costs should be estimated by a qualified engineering firm
Natural Channel Design	Sediment	Tier 4	
Two Stage Ditch	Sediment	Tier 3 - 4	
Wetland Restoration	Sediment, Nutrients, E. coli	Tier 3 - 4	

Table 4.5 - Residential Recommendations

Recommendation	Pollutant	Technical Assistance	Unit Cost Estimate	Amount	Total Cost (O&M Cost)
Green Stormwater Infrastructure	Sediment, Nutrients, E. coli	Tier 3 - 4	Costs should be estimated by a qualified engineering firm		
Natural Shoreline Design	Sediment, Nutrients, E. coli	Tier 2	$15/Ft	47520	$712,800.00 (+ $.03/Ft/Yr)
Septic Policy	Nutrients, E. coli	Tier 3	$2000/ township	6	$12,000.00
Stormwater Policy	Sediment, Nutrients, E. coli	Tier 3	$2000/ township	6	$12,000.00
Total Residential Practices					$736,800.00

4.1.3 Schedule of Implementation

Implementation of cover crops, no-till, and nutrient management has been funded for 2024-2026 through a grant. This work includes outreach to support producer recruitment and proper management of these practices. To inform this outreach work, a social survey is being conducted to gauge producer awareness and barriers to entry. The survey will also be used to update the information and education plan in Chapter 6. Table 4.6 contains a 10-year implementation timeline for the recommendations found in this plan.

Table 4.6 - Implementation Timeline

Short term 2024 - 2026	● Implementation of cover crops, no-till, and nutrient management on 1500 acres ● Conduct social surveys and update information and education plan ● Conduct annual educational workshops for agricultural practices ● Develop and distribute outreach materials from updated information and education plan ● Conduct feasibility study for two stage ditch and natural channel design on the main stem starting at the Gun Lake outlet ● Contact producers eligible for drainage water management practices and AFOs with noted manure or erosion concerns ● Seek funding for drainage water management and AFO sites
Mid term 2026 - 2028	● Drainage water management and AFO implementation project ● Continue information and education plan ● Develop model stormwater and septic policies ● Discuss septic and stormwater policies with local planning officials ● Outreach to landowners with parcels overlapping wetland restoration and channel restoration sites ● Channel and wetland restoration engineering and fund seeking ● Match cover crop, no-till, and nutrient management implementers with resources for continued implementation ● 1500 acres of new cover crop, no-till, and nutrient management implementation.
Long term 2028 - 2034	● Channel and wetland restoration implementation ● Match cover crop, no-till, and nutrient management implementers with resources for continued implementation ● Follow up with previous implementers ● Implement channel and wetland restoration projects

4.2 DESIRED USES

Activities that could support the desired uses for the watershed are listed below. More detailed work will be necessary to evaluate and prioritize these recommendations.

- Forest management plans approved through the Qualified Forest Program can decrease tax burden and incentivize the maintenance of healthy forest land. Conservation districts can assist interested participants in this program.
- The passage of ordinances allowing townships and/or counties to purchase development rights allows for the sale of farmland preservation easements and grants access to state and federal cost share programs. Currently no counties or townships in the watershed have such an ordinance
- A trail plan should be developed to identify likely trailways and guide property/easement acquisition for a recreational trail system.

CHAPTER 5 – CRITICAL AREAS AND MANAGEMENT RECOMMENDATIONS

5.0 CRITICAL AREAS

After identifying major sources of pollution or impairments in the Gun River Watershed (Watershed), the Steering Committee's focus was narrowed to the areas that contribute the majority of those sources. Focusing on these Critical Areas prioritizes concerns and results in the greatest improvements for the time and money invested into the project. These critical areas are where the implementation of Best Management Practices (BMPs) will be prioritized. Implementation work under this plan should still occur in other areas. For example, low impact stormwater practices like household rain gardens are beneficial in all residential areas and widespread implementation helps to normalize these practices so that voluntary implementation becomes more likely. However, limited funds should first be directed to implementation in the residential critical areas.

The Steering Committee identified the critical areas of the Watershed using information from inventory work and past monitoring efforts. The estimates of the pollutant loads and delivery to the stream were based on the information from the field inventory and calculated by subbasin. This information determined the soil delivery, in tons per year, and the phosphorus and nitrogen content, in pounds per year, that each subbasin is currently experiencing.

Based on the complex variety of land uses on diverse topography with many unique ecological features, no single remediation plan can cover all contingencies encountered in the Watershed. As a result, the critical areas are classified into five groups consisting of Agricultural, Residential, Wetland, Recreational, and Preservation Critical Areas. Details of the BMPs for each area can be found in Section 5.2.

5.1 DESCRIPTION OF CRITICAL AREAS

5.1.1 Agricultural Critical Areas

The agriculture critical areas can be divided into two subgroups that each have a unique set of pollutant risks—crop fields and animal feeding operations (AFOs).

The major sources of concern in crop fields are runoff and streambank erosion that result in excess amounts of sediment and nutrient loading. Tile drains are common in this area, causing rapid and sporadic peak flows. Bankfull flow levels are not uncommon to the drainage network, and as a result, much of the vegetation has been removed from bank sides allowing for unstable conditions. Once the bank sides become unstable, high flows and equipment traffic cause soil detachment, slumping, and outlet failures. Sediment removed from streambanks is usually deposited downstream causing culvert or drain blockage. Blocked culverts and diminished channel capacity exacerbate existing conditions and accelerate erosion downstream. Another source of impairment in this type of agricultural critical area is hydrocarbon contamination from irrigation pumps. BMPs will focus on practices that mitigate erosion and increase infiltration. Figure 16 shows prioritized agricultural fields in the watershed.

The second set of agriculture critical areas are animal feeding operations. The 70 AFOs in the watershed range in size from hobby farms with one or two horses, up to large CAFOs with over 2 million chickens. Manure storage and animal access to surface water are the highest priority concern for these areas. Improper storage and direct access cause significant contributions of pathogens and nutrients. Further, livestock access destabilizes the river channel and eliminates vegetation in cases of overgrazing. BMPs will focus on siting, manure storage, livestock access control and watering facilities, streambank stabilization, and grazing management. Figure 17 shows prioritized AFOs in the watershed.

5.1.2 Residential Critical Areas

The second critical area category is residential riparian zones. The area encompassing all residential areas within 200 feet from lake shorelines and the top of all streambanks and drainage ditches are included into this critical area. Residential areas are also a large contributor of nutrients and are suspected to be a significant source of *E. coli* and other pathogens—failing or inadequate septic systems are the main concerns. Drain fields located in the water table can carry nutrients and *E. coli* directly into surface water, and systems at full capacity can leach pollutants into the ground or surface water.

Secondary concerns associated with residential areas are impervious surface runoff, yard waste, and habitat destruction. High runoff volumes and velocities from impervious surfaces or areas with insubstantial vegetation contribute to unstable hydrology. Reducing impervious surfaces in residential areas is paramount to managing sporadic flows, and runoff from roads and driveways may also contain hydrocarbons and heavy metals. Runoff from rooftops and parking lots not only contains contaminants, but it has also been warmed by the sun and contributes to thermal pollution. Construction sites need to have management practices that prevent erosion and sediment from entering streams and drains. Yard waste piled on lake shorelines or in streambanks can blow, wash, or be carried by floods into the water adding nutrients and pesticide contaminants. Nuisance populations of geese can quickly create a problem in the summer months when they feed in lawns and gardens. Goose feces, up to four pounds per goose per day, wash into lakes and streams and contribute to nutrient and pathogen impairments.

Nutrients, hydrology, pathogens, hydrocarbons, exotic species, and habitat fragmentation are all contributed by residential areas. BMPs in residential critical areas will focus on public education, governance, stormwater management, and septic maintenance.

5.1.3 Wetland Critical Areas

"The sole reason to justify the expenditure of tax dollars on the channelization [of the Gun River] in the first place was to render the basin fit for agriculture and to improve the health of people living in the general area surrounding the basin" (O'Meara, 1981). The previous statement is a very good argument for the drain projects that have occurred in the Watershed. Kenneth O'Meara collected quite a number of accounts from presettlement visitors to the Watershed. They describe this area as a virtual jungle of mud, mosquitoes, and dense impassible undergrowth. In 1787, the Northwest Ordinance charged settlers with the call for rendering the wilderness tolerable to humans. Orders were followed by draining wetlands and converting the land to agriculture.

The rich soils in the Watershed are some of the best soils in the state for specialty crops of onions, beets, and celery. To convert this prime farmland back to its original state would most likely cause hardship on those that rely on the farmland. However, those farming have complained about the declining fish populations and flooding that has inundated many crops and homes. This "catch-22" has created a great controversy for those that live in this complex drainage network. The best solution has to be one of compromise.

The reason why drains create a problem for the Watershed is they work, and they work very well. A drain is cut into wetland soil to lower the water table and to speed the transfer of water from the soil to the stream channel. However, when the water runs off at greater volumes and speeds it causes higher peak flows and decreases the infiltration into groundwater. The result is very damaging to the stream's hydrology and ecology.

Wetlands contain an abundance of wildlife both above and below the surface. The huge amount of biomass in a wetland is capable of purifying outflow and storing water for a slower release to stream channels and aquifers. Restoring wetlands also has a significant impact on improving fisheries, species diversity, and water quality in the Watershed.

Restoring wetlands should only occur in areas that once were characterized by wetland vegetation, soils, and hydrology. Constructing wetlands in upland areas is not nearly as beneficial as restoring a wetland in its original location. Restoring a wetland is sometimes as simple as plugging drain tiles. Constructing a wetland can be cost prohibitive. The most simple technique to identify prior wetlands is to map the soil characteristics. Soils that were once inundated with water and have a high organic content are called hydric soils. Figure 4 shows the presence of hydric soils in the Watershed.

Wetland critical areas, shown in Figure 14, are those that have hydric soils which are feasible to restore, or have existing wetlands that need preservation. Fields that are problematic for growing crops due to flooding or saturated soils are prime candidates for wetland restoration. The wetland and soils maps are useful guides for planning restoration projects, and other tools are available through EGLE and described in Chapter 2. BMPs in the wetland critical areas will focus on landowner education programs, farmland preservation, and encouraging agricultural growers to enter more land into conservation programs for restoration or preservation.

5.1.4 Recreational Critical Areas

The recreation critical areas include Gun Lake, Fish Lake, and the Gun River at 112th Ave downstream to US 131. These areas see significant recreational use year after year. Currently, pathogens are the primary pollutant impacting recreation, but further planning around desired uses should take place to further improve the recreational opportunities in the watershed.

High traffic recreational areas can contribute pathogens and nutrients from pet and human waste, erosion from unofficial social trails for boating and fishing access, and litter. These areas are also a likely colonization point for invasive species that may hitchhike on people and their equipment while taking advantage of the disturbed areas caused by heavy traffic.

Upstream sources of pollutants impact the value of recreational critical areas, and prioritization of BMPs in other locations should account for the benefits to these critical areas. In particular, focusing stream restoration and erosion prevention practices upstream will help to stabilize hydrology and navigability in downstream areas.

5.1.5 Preservation Critical Areas

The preservation critical areas are divided into two subgroups: agriculture and biodiversity.

Michigan lost over 290,000 acres of farmland between 2017 and 2022. In an effort to provide farmers with an alternative to development of Michigan's best farmland, the state began implementing a program to purchase the development rights (PDR) on farmland. Through this program, local governments with ordinances providing for the purchase of development rights can apply for state and federal funding to preserve properties prioritized by the local unit. County programs often combine their funds with state monies, township tax dollars, and private donations to buy development rights to "prime" farmland, allowing owners to keep the property but use it for only farm-related purposes.

The Allegan County Commissioners took action in 2004 to adopt a County PDR Ordinance which was then repealed in 2019. In 2004, a resolution template was created for townships to use in passing their resolutions to participate in the County's program, but no townships have passed a PDR ordinance to date. In the Gun River, development pressure from Kalamazoo and Grand Rapids is likely to accelerate in the coming years. In addition to economic benefits, farmland can provide a number of environmental benefits relative to residential properties such as carbon sequestration in plants and soil, land area for water infiltration to recharge groundwater, and wildlife habitat. Acquisition of farmland preservation easements should be done in concert with the implementation of agricultural BMPs to ensure that there is a net environmental benefit to preserving the land.

Biodiversity critical areas are the Kalamazoo Moraine Corridor and the Barry Hub as identified in the Southwest Michigan Land Conservancy's (SWMLC) 2020 Strategic Land Conservation Plan. The Barry Hub is a biodiversity reservoir consisting of Barry State Game Area, Yankee Springs Recreation Area, and a number of adjoining parcels owned by various organizations and private citizens. The Kalamazoo Moraine Corridor runs along the east and southeast edge of the Gun River Watershed, connecting to another biodiversity hub in the Paw Paw area. Land preservation in these areas should focus on maintaining and strengthening habitat connectivity to preserve this biodiversity. The Kalamazoo Moraine Corridor in particular is in need of additional protection work.

While the acquisition of development rights is a permanent solution, it can often be cost and labor prohibitive, and the inflexibility of a permanent sale may make landowners hesitant. Other initiatives can be leveraged to incentivize the preservation of these areas such as the Qualified Forest Program and Farmland and Open Space Preservation Program. Succession planning can also give landowners the support they need to pass their land on to someone who will preserve it without the hurdles of establishing an easement.

5.2 MANAGEMENT RECOMMENDATIONS

Management recommendations have been developed for each pollutant source. Practices are prioritized differently for each pollutant source and a description of the methodology can be found in the respective sections. A summary table of the recommendations can be found in Chapter 4, tables 4.2 - 4.5.

5.2.1 Agricultural Fields

Sediments, nutrients, pathogens, and pesticides are possible pollutants contained in runoff from agricultural sites. These must be addressed at multiple stages along the way to surface water. Planning practices ensure pesticides, fertilizer, and manure are only applied as necessary at the right rate, time, and location. In-field practices stabilize the soil, prevent runoff, and allow nutrients and pesticides to be absorbed by plants, adsorbed to soil, or otherwise broken down. Edge of field practices slow runoff to allow settling of soil particles, uptake of nutrients, and water infiltration. A combination of these practices allows for more complete containment of pollutants and creates a more resilient system that can continue to function in the case of unforeseen circumstances like severe weather.

For all field practices, fields were given a prioritization score based on runoff risk, subwatershed, and current tillage and cover crop practices (Figure 16). Subwatershed -0701 received the highest priority because it contains the most critical areas for preservation, tribal lands, the most listed impairments, and pollutant load reductions benefit the rest of the watershed; -0702 was ranked second because it has significant pollutant loads from agriculture. Fields with higher runoff risk as determined through the ACPF (as described in Chapter 2) received higher priority scoring. Finally, fields with more intensive tillage practices and less frequent cover crop use received higher priority because they are more susceptible to erosion. All practices on a given field are prioritized based on the field's composite score since the combination of multiple practices is desirable. A full list of fields and priority scoring is available in Appendix 1 with higher values indicating higher priority.

Nutrient management plans (NMP) or comprehensive nutrient management plans (CNMP) are recommended for all crop fields. These plans outline the type, timing, amount, and location of nutrient applications on fields. Soil test results inform these plans in order to ensure that the appropriate nutrients are available for crops, and that nutrients are not being unnecessarily applied. CNMPs contain additional information for livestock operations regarding the utilization of manure and other management considerations. These practices reduce nutrient and pathogen runoff.

Limiting or eliminating tillage through **no-till or strip till** is recommended for all crop fields. Reducing tillage prevents erosion, improves soil structure to increase moisture and carbon storage, improves soil biotic diversity, and increases organic matter. These benefits help to reduce sediment and nutrient runoff, and pathogen runoff if manure is applied correctly on the field. Costs are lower to farmers who use this method since less fuel is used in farm operations, and the reduction in erosion reduces the need for nutrient inputs. In worst case scenarios, additional pesticides may be necessary to prevent weeds, fungus, and disease. In this case, a farmer could expect a slight cost increase for implementing no-till practices. No-till benefits greatly from implementation alongside cover crops and controlled traffic farming. In fine-textured soils, no-till can cause the creation of macropores that speed water drainage into a tile system. In this case, broadcast fertilizer can quickly be delivered to surface water. Because this risk relies on a number of variables (soil type, fertilizer application type and method, tillage methods, etc.), planners should carefully evaluate mitigation strategies on a case-by-case basis. For more information, Michigan State University Extension has a number of research publications discussing this issue and how to address it.

Controlled traffic farming is recommended in conjunction with fields implementing no-till. In this practice, equipment traffic is restricted to the same lanes year after year. This practice limits traffic compaction to improve soil health and reduce the need for tillage. The presence of compacted travel lanes reduces rutting and eases access during wet periods while supporting healthy soil structure in non-traffic lanes. While controlled traffic farming does not directly reduce pollutant loads, it may ease the transition to no-till for some producers and encourage long-term implementation.

Cover crops are recommended for all crop fields to reduce sediment, nutrient, and pathogen loads. Numerous studies have shown that incorporating cover crops into corn and soy rotations can add significant value through production increases and input savings. Cover crops decrease reliance on fertilizers and herbicides, build soil structure and organic matter, retain soil moisture, moderate soil temperatures, sequester carbon, increase habitat for beneficial insects and birds, and can directly add additional revenue if the farmer decides to harvest the cover crop to sell or for their own use. This practice is very flexible due to the number of cover crop options and can be suitable even for specialty operations like Christmas tree production. Fields with drain tile need to be intentional in selecting plant types to prevent damage to the drainage system.

Water and sediment control basins (WASCOB) are embankments constructed across minor drainageways where runoff would concentrate and cause gully erosion. Instead of forming a concentrated flow, the embankment traps water and slowly releases it through an underground outlet. This reduces the speed of field runoff and allows sediment to settle before water leaves the field, preventing sediment and nutrient loading. Fields must have suitable topography and were identified through the ACPF modeling.

Grassed waterways are drainage paths within a field that are stabilized with permanent vegetation to prevent gully erosion. The vegetation reduces sediment and nutrient loading by slowing water velocity, trapping sediment, and consuming nutrients in the runoff. The roots of the vegetation stabilize the soil and promote water infiltration. Fields must have suitable topography and were identified through the ACPF modeling.

Windbreaks are suggested to slow wind velocity and to promote the settling out of soil particles, reducing sediment and nutrient loading. Trees planted two or three rows thick with a row of shrubs beneath them provide an excellent windbreak. In some cases, herbaceous windbreaks using tall grasses and forbs may be preferred at intervals within a field. Additional benefits to windbreaks are significant decreases in pesticide drift and airborne sediments, slight increases in irrigation efficiency, and improvement in wildlife corridor structure. Windbreak establishment can be expensive, and removing land from production can make this practice difficult to implement. Land rental or easement agreements may make this practice more feasible.

Buffer or **filter strips** are recommended in all agricultural fields that are adjacent to a waterway. Filter strips reduce sediment and nutrient loading by slowing water flow and collecting contaminants in perennial vegetation strips between the field and waterway. The roots of these perennials further help to stabilize soil near waterways, improve water infiltration, and the reduction in equipment traffic in these areas prevents bank collapse. Filter strips can quickly be established in the interim before windbreaks or other managerial BMPs can be implemented. Filter strips are eligible for many state and federal programs that pay farmers rent for lands being used as buffers.

Contour buffer strips are strips within a sloped field that is farmed on the contour. These permanent vegetation strips interrupt water flowing down the hill, reducing sediment and nutrient runoff much like a filter strip at the edge of a field. Strips are not to be used for traffic, but can be hayed or grazed, meaning producers can continue to benefit from the land while it provides environmental benefit. Fields must have suitable topography and were identified through the ACPF modeling.

Drainage water management involves the control of water levels in tiled fields through the use of **structures for water control**. These structures can be used to raise or lower subsurface groundwater levels as needed based on weather or crop needs. Effective use of these structures allows for better retention of water while crops are growing, preserving soil moisture and nutrient levels while delaying tile discharge and preventing nutrient loading. Fields must have suitable topography and were identified through the ACPF modeling. A number of practices can be implemented in conjunction with drainage water management to further decrease nutrient loads from tile effluent.

Saturated buffers are areas where subsurface drainage is distributed beneath a vegetated buffer to aid in the uptake of excess nutrients from tile effluent. This practice is implemented in conjunction with drainage water management which is required to maintain appropriate water levels within the buffer. Fields must have suitable topography and were identified through the ACPF modeling.

Bioreactors are pits filled with a high-carbon material like wood chips. Tile drainage is directed through the bioreactor where microorganisms consume nitrogen in the effluent before discharging the water to a drain or stream. Drainage water management must also be implemented in order to properly control flow through the bioreactor. Fields must have suitable topography and were identified through the ACPF modeling.

5.2.2 Animal Feeding Operations

Animal feeding operations can be significant point sources of pathogens, nutrients, and sediment. Poor waste management, livestock management, and/or facility siting can create sizable pollution risks even with small numbers of animals. Management practices are prioritized at facilities with observed erosion, livestock access, or manure storage concerns during the AFO inventory (table/Figure 17).

For all practices, AFOs were given a prioritization score based on observed erosion/manure issues, subwatershed, and proximity to water bodies and wetlands. AFOs without noted issues with erosion or manure storage were not given priority scores and are considered to have the lowest priority. The proximity score is given to facilities within 500 feet of water bodies and wetlands due to the increased chance contaminated runoff enters surface water directly. A full list of fields and priority scoring is available in Appendix 1 with higher values indicating higher priority.

Access control is the practice of excluding animals from specific areas. This practice should be applied to restrict livestock access to surface water and sensitive areas (e.g. stream banks). Exclusion from these areas prevents bank and bed erosion, direct contribution of waste into surface water, and vegetation loss through trampling and overgrazing. This serves to reduce nutrient, pathogen, and sediment pollution. Access control can also be used in conjunction with prescribed grazing to limit overgrazing in pasture areas.

Watering facilities are areas away from surface water where livestock can drink. These facilities must be available when livestock are being excluded from surface water. Livestock pipelines along with other infrastructure like solar wells are used in conjunction with watering facilities to convey water to the facility from a water source. These practices should be used to support access control implementation.

Stream crossings are reinforced areas designed to limit the impacts of livestock and vehicles where a crossing is the only feasible alternative. These crossings are sited and engineered to maximize bank and bed stability, and limit access to sensitive areas that are prone to collapse or erosion. Livestock should not be given free access to the waterbody; the crossing should only be used for transit. Proper use of these areas reduces sediment loading.

Critical area planting is the use of permanent vegetation in areas prone to erosion. Non-field areas with concentrated flow, streambanks, and areas with highly erodible soils are good candidates for this practice. Drainage areas around livestock pens and manure storage facilities should be stabilized with permanent vegetation in order to capture runoff laden with pathogens and nutrients.

Waste storage facilities are engineered facilities for the storage of manure. An exposed manure stockpile or undersized storage poses a significant risk of nutrient and pathogen pollution, and manure storage should be prioritized at these operations. Proper siting away from wells, surface water, and flood zones is critical, and existing manure facilities that pose a risk to surface or groundwater should be replaced at an appropriate location. This practice can result in considerable nutrient and pathogen reductions.

Prescribed grazing plans are used to prevent overgrazing and promote healthy pasture soil and vegetation. These plans take into account herd size, forage availability, and duration of grazing. Thoughtful grazing and pasture planting can mimic natural disturbance regimes in grasslands to improve the soil and water health. Following a grazing plan can promote biodiversity, water infiltration, carbon sequestration, and wildlife habitat while reducing sediment, pathogen, and nutrient loading compared to an overgrazed pasture or feedlot.

Risk reduction through the **Michigan Agriculture Environmental Assurance Program (MAEAP)** can result in pollutant reduction through response planning and siting work. MAEAP technicians conduct a comprehensive assessment of each operation to identify risks to surface and groundwater. Participants who complete the program have not only directly addressed structural issues like well isolation distances and proper chemical containment, they are also equipped to handle emergencies like accidental manure spills. These preventative measures help to minimize nutrient, pathogen, and chemical pollution. In addition, this program frequently serves as a starting point for contacting producers about implementing other practices that may fit well on their operation.

5.2.3 River and Floodplain Restoration

Restoration of the stream and floodplain is necessary to address hydrology issues. Streambank erosion is another large contributor to sediment in the Watershed. When a stream or county drain is channelized, streambank erosion often occurs as the stream attempts to return to its original path. This streambank erosion causes impairments to agriculture drainage and irrigation, fish and macroinvertebrate communities, and recreational uses. In addition to sedimentation, stream erosion is responsible for a portion of the phosphorus (bound to soil particles) loading to the Kalamazoo River Watershed.

In the short term, bank stabilization will be needed in sites with significant erosion. Many techniques are available to reduce streambank erosion. Hard structures, such as riprap, can protect the toe of a streambank. Tree revetments, fascines, and live plantings are softer methods that are generally preferred since they absorb energy from the stream rather than reflect it downstream as riprap often does. Bioengineering, an integrated approach based in physics, chemistry, and engineering principles that uses biological methods of control, can be very effective in establishing long term and adaptable solutions to erosive problems. Bioengineered systems are designed using non- destructive techniques that often have the ability to adapt to changing conditions over time. Materials can usually be found locally or even onsite, reducing cost and incorporating native resources. In many cases riprap and tree revetments provide a comparable, and in some cases, better habitat for fish and invertebrates than natural streambanks. A table with sites, potential BMPs, and costs is in Appendix 2A.

In a number of cases in the Watershed, the stream is eroding the streambank as the watercourse is trying to reestablish meanders. This can be addressed by **natural channel design**, or **two-stage channel design** where natural channel design is not feasible. Natural channel design restores meanders to the system while considering the drainage needs of the area. A two-stage channel system incorporates benches that function as floodways. The low flow is contained in the deeper channel and higher flows are conveyed in the floodway bench. The width of the benches is often small due to the confining geometry of the constructed channel. Measurement and analysis procedures are used to size two-stage channel systems that are more self-sustaining than conventional one-stage constructed channels. Two-stage systems will have improved conveyance capacity, will be more self-sustaining, will create and maintain better habitat, and will improve water quality. Over time, these systems can also develop natural meanders in the lower channel without impacting bank stability. Substantial planning work will need to take place to understand the potential for work within existing easements or where additional property or easement acquisition will need to occur. Space constraints will inform which practice can be used. Cost estimation and preliminary design will be needed before pursuing funding for the implementation of this work. AUID 040500030702-05 immediately downstream of Gun Lake is the only reach with an impairment due to hydrology and should be prioritized. Significant straightening of the channel has occurred downstream to 112th St. and should also be evaluated for remediation.

Wetland restoration should be undertaken to restore floodplain capacity and moderate flows following storm events. The determination of wetland restoration sites depends considerably on the presence of hydric soils. Areas where hydric soils are present were historically wet, and the soils are more likely to have suitable chemical and physical properties for wetlands than upland soils. Studies have shown that wetlands constructed in historically upland areas are not as successful and do not have the functional capacity of restored wetlands, therefore, hydric soils should be sought when possible. The most amenable areas are usually agricultural fields that remain wet during the spring planting season or frequently flood during the growing season. Other idle fields or pasture areas are also good possibilities.

Programs are available to landowners wishing to restore wetlands on their property. The most common programs for agricultural land are the Wetland Reserve Program (WRP) and the Conservation Reserve Program (CRP). Each of these programs provides technical assistance and other resources toward wetland restoration. Varying soil rental rates are paid to the landowner in each of these programs for taking their land out of production. The programs are implemented on a site-by-site basis and administered by the USDA NRCS and/or the FSA.

The Michigan Wildlife Conservancy and United States Fish and Wildlife Service (USFWS) are also active in restoring wetlands for wildlife throughout the state. Generally, the landowner bears no cost, and the land does not have to be in agriculture to be eligible.

Wetlands do not have to be historically located in an area to have land use benefits. Constructed wetlands can be used to filter water from urban runoff, storm sewers, or combined sewer overflows. Wetland plants extract excess nutrients and heavy metals out of the water, and though it is not always necessary, harvesting these plants, especially in more polluted waters, can be a way to remove the nutrients and metals from the system. Two well-known success stories of this process are the Tollgate Wetlands in Lansing and the Inkster Wetlands near Detroit.

Wetland mitigation may be an option. EGLE may issue a permit in special circumstances to allow a wetland to be destroyed under the stipulation that for every acre of wetland destroyed, two acres of wetland must be constructed or restored. The new wetlands are called mitigated wetlands, and contractors normally pay landowners well for the construction of these wetlands. Mitigated wetlands may also be banked. These wetlands are constructed or restored in advance of losses through the EGLE regulatory program and sold or used as needed.

5.2.4 Residential Areas

Residential areas contribute numerous pollutants including microplastics, trash and debris, hydrocarbons, nutrients, pathogens, and salt; impervious surfaces in residential areas increase the volume, velocity, and temperature of runoff; shoreline development affects both terrestrial and aquatic species by reducing habitat and land-water connectivity; septic systems can be significant sources of pathogens and nutrients if not properly maintained. These impacts can be mitigated through the use of low-impact design principles and local policy.

Green stormwater infrastructure practices are numerous and site specific. They utilize various engineered techniques to promote stormwater infiltration rather than simply conveying it to the nearest waterbody as quickly as possible. Rain gardens, bioswales, and permeable concrete are a few examples of these practices. As with agricultural BMPs, a suite of practices should be adopted to create resiliency and capture as much runoff as possible.

Natural shoreline design is a landscaping technique incorporating bioengineered features and native plantings to prevent shoreline erosion while maintaining aquatic habitat and recreational uses. These designs vary greatly based on site conditions but provide similar benefits when well designed. In addition to habitat benefits, natural vegetation slows runoff and captures sediment similar to filter strips. This directly reduces sediment load, and also reduces pathogen and nutrient loading from animal waste or fertilizer found on lawns. Natural buffers have the added benefit of dissuading geese from loitering in the area.

Local policy is necessary to enhance oversight of septic systems through the implementation of a **septic testing ordinance**. The only sewer system in the watershed is run by the Gun Lake Area Sewer and Water Authority. All structures with wastewater discharge within 200 ft. of a sewer main are required to connect to this system. This includes the riparian areas of Barlow, Cobb, Payne, Little Payne, Gun, and Fawn Lakes in addition to some nearby developments. A map is available at www.gunlakesewer.org. The remainder of the watershed uses septic systems. Septic maintenance is a critical and often overlooked responsibility of homeowners—an estimated 10% of septic systems in Michigan are failing. This not only contributes to impairments in surface water quality; it impacts drinking water since most households rely on private groundwater wells. Increasing the frequency of septic testing will help to ensure that homeowners are aware of when action is needed. Additionally, funding for low-income households to maintain or replace their septic system should be made available.

Because this area is near a major traffic corridor between Kalamazoo and Grand Rapids, development pressure has been increasing as these cities grow. Local **stormwater policy** should ensure that new developments have their stormwater plans reviewed and approved by local officials. Allegan and Barry Counties both apply standards developed by the Municipal Separate Storm Sewer System (MS4) program when reviewing stormwater management strategies. However, no local units in the watershed require a post construction stormwater review for all new developments. Townships and municipalities should consider a post construction stormwater review ordinance that requires approval of stormwater systems by township or county personnel or contracted engineers on their behalf. This review should apply the criteria outlined by the MS4 program in the Post-Construction Storm Water Runoff Controls Program Compliance Assistance Document available at:

https://www.michigan.gov/egle/about/organization/water-resources/municipal-storm-water. Specifically, channel protection standards require that post-development project site runoff volume and peak flow rate be maintained at or below pre-development levels for all storms up to the 2-year, 24-hour event, and water quality protection standards ensure that stormwater BMPs adequately capture and treat first flush stormwater.

5.3 BMPS FOR NONPOINT SOURCE POLLUTION CATEGORIES BY WATERBODY

Appendix 2A (Tables 5.1A through 5.8A) presents the nonpoint source pollution sites sorted by pollution category and waterbodies, illustrating the predominant pollutant in the lakes, rivers, and streams. Appendix 2B includes the full list of nonpoint source sites sorted by waterbody and nonpoint source pollution categories. Sites should be revisited before seeking remediation funding to confirm that conditions have not changed and that these recommendations are still appropriate at that time.

5.4 OTHER RECOMMENDATIONS

Other recommendations for boaters and riparian landowners:

- Remove all signs of vegetation from boats and trailers before leaving access areas.
- Thoroughly wash boats and trailers before moving to another water body or leave boats dry docked for 7 to 10 days.
- Do not feed geese or other waterfowl.
- Remove pet or waterfowl waste from lawns.
- Be knowledgeable and aware of exotic species transport to prevent further spread throughout the watershed.

The following management goals were set forth in the MDNR study in 1991. Enhancing the sport fishery in Gun Lake could be accomplished by implementing the following recommendations:

- Conduct full fisheries surveys every 10 years.
- Muskellunge stocking should not be resumed.
- Continue the cooperative rearing agreement for walleyes with the Gun Lake Protection Association (GLPA).
- Evaluate the possible natural reproduction of walleye.
- Encourage GLPA to pursue boating regulations for the lake, such as slow or no-wake periods for early evening to early morning.

5.5 PERMITTING

The recommended BMPs in this chapter may need permits depending on their location and scale. These BMPs generally fit into three permitting categories: Soil Erosion and Sedimentation Control, Land and Water Interface, and Wetlands.

Soil Erosion and Sedimentation Control (SESC) Permits may be required for:

- Disturbing soils over an area of one (1) or more acres

- Projects within 500 feet of a lake, stream, river, storm drain, wetland, or other water body
- Building an agricultural/accessory building
- Construction projects for permanent dwelling and/or large scale additions

Permits can be submitted online or printed and mailed. For more information about SESC permits, contact the Allegan County Health Department Environmental Health Division or the Barry County Planning and Zoning Department.

Allegan County Health Department Environmental Health Division:
3255 122nd Avenue, Suite 200, Allegan, MI 49010
AlleganEH@allegancounty.org
(269)673-5415

Barry County Planning and Zoning Department
220 W. State St, Hastings, MI 49058
jmcmanus@barrycounty.org
(269)945-1290

Land and Water Interface Joint Permits may be needed for projects around the waterfront. This can include but is not limited to:

- Moving soil, grading, excavating, and dredging
- Building or repairing a dock, pier, or boardwalk
- Building or repairing a seawall, bulkhead, or riprap
- Creating, expanding, or drawing down an existing water body
- Laying utilities or intake/outlet pipes
- Constructing or expanding a marina

Land and Water Interface Permits are joint permits through Both EGLE and The United States Army Corps of Engineers. **Shoreline projects at or below the ordinary high water mark require a permit**. Permits can be submitted through the **MiEnviro Portal.** For more information, contact EGLE permitting staff.

Wetland Permits
The following activities may not be done in wetlands without a permit from EGLE:

- Deposit fill material
- Dredge or remove soil or minerals
- Construct, operate, or maintain any use or development
- Drain surface water

More information about wetland permits can be found on EGLE's website and by contacting permitting staff.

Table 5.1 - EGLE Land/Water Permitting Staff

EGLE Kalamazoo District Office: 7953 Adobe Road, Kalamazoo, MI 49009-5025 EGLE-DWEH-Kalamazoo@Michigan.gov (269)567-3500	**EGLE Grand Rapids District Office:** 350 Ottawa Ave NW, Grand Rapids, MI 49503 EGLE-DWEH-Grand-Rapids@Michigan.gov (616)356-0202
Allegan County Derek Haroldson HaroldsonD@michigan.gov (269)569-3609	Barry County Kelsey Krupp KruppK1@michigan.gov (616)401-1201

CHAPTER 6 – INFORMATION AND EDUCATION

6.0 GUN RIVER WATERSHED MANAGEMENT PLAN UPDATE

In 2020, the Allegan Conservation District received a grant from EGLE for a project to update the Gun River Watershed Management Plan. This update involved collecting data on erosion sites along the Gun River, analyzing ACPF results, recommending new BMP sites and critical areas, and more. This project did not include any social monitoring data or outreach efforts beyond meeting with a steering committee. Outreach and education efforts will be part of a 2024 implementation grant funded by EGLE which includes funding for a social survey to guide those efforts. The following chapter and Table 6.1 show possible outreach focuses and methods for the implementation work. This chapter will be updated with the results of the social survey.

The Community Outreach Plan (Outreach Plan) was developed to guide watershed activities and focus appropriate attention on issues formulated by the Steering Committee during the planning process. The strategies outlined in the Outreach Plan are designed to be the foundation of an outreach effort that can continue to be modified as issues and opportunities emerge.

6.1 KEY AUDIENCES

- Tribal, county, township, city, and village officials
- Agricultural producers
- Residents
- Recreational users

6.1.1 Outreach Goals and Objectives

1. Build awareness of how local policies, or lack thereof, affect water quality.
    a. Encourage local officials to proactively guide development through planning.
    b. Build consensus around septic and stormwater policies that provide local control without hampering desirable development.
2. Build and retain stakeholder awareness and involvement in implementation work.
    a. Encourage the implementation of BMPs that protect and improve water quality.
    b. Provide individuals with the knowledge necessary to sustain BMP implementation.
    c. Support community discussions about BMP implementation.
    d. Raise awareness of wetland benefits and regulations.
3. Form durable partnerships between stakeholder groups.
    a. Identify new partners for implementation work.
    b. Develop structures that facilitate continued communication between groups.

6.2 OUTREACH TOOL BOX

The tool box contains communications materials that are essential to the success of the community outreach efforts.

Gun River Watershed Project Logo - A Gun River Project logo has been created to connect communications about watershed activities to the project and to increase awareness.

General Information Brochure - A simple brochure containing general information about the Watershed (definition, goals, practices) and restoration goals will be developed. The brochure will include the logo, contact information, and relevant graphics. The brochure should be easy to read and be eye-catching.

Website - The Allegan Conservation District will maintain information on their website about Gun River and implementation progress. New information will be shared on social media outlets directing the audience to this website.

6.3 ACTIVITIES BY AUDIENCE GROUP

It should be noted that the Outreach Plan outlines a dynamic process that will require adjustments as implementation moves forward. The Outreach Plan is a starting point that provides a guide for outreach actions. More effective techniques are constantly being developed for pollution prevention, and materials will need to be kept up-to-date. Other water quality projects are occurring in the Kalamazoo River Watershed and provide opportunities to develop new partnerships and host joint workshops/events. The stakeholders in the Watershed will have the flexibility to suggest adjustments in the Outreach Plan and take advantage of future opportunities.

6.3.1 Tribal, County, Township, City, and Village Officials

Local officials need to be aware of this management plan in general, and specifically aware of the policy recommendations. Conversations with these officials need to be ongoing in order to develop an understanding of their role in protecting water quality.

Adopt protective ordinances - Develop resources in a usable format (maps, reports, electronic media) to support water quality protective ordinances and land-use planning strategies. Model ordinances can serve as a starting point for conversations around septic, stormwater, and purchase of development rights ordinances. Local units need to define what good development looks like in order to ensure the preservation of water quality and local character.

Promote Awareness of the Watershed Management Plan - Local officials need to have an understanding of the implementation plan and how they can contribute. Partnership with local government is critical in gathering support for implementation work, and sustaining it to achieve the long-term outcomes.

6.3.2 Agricultural Producers

Because of the prevalence of agriculture, producers are a critical audience. The majority of recommendations contained in this plan are relevant to producers, and a firm understanding of what practices to implement and how to do so effectively will be necessary for the success of this work. Broad awareness of the agricultural recommendations will serve to create networks of support where producers can help one another troubleshoot specific issues when implementing a practice.

Increased use of cover crops and reducing tillage - These practices are a significant paradigm shift for many producers, and implementation can look different from operation to operation. Educational programs need to focus on hand-on experience through workshops and events where producers can network and learn from each other. This will further serve to normalize the use of these practices so that, for example, a field full of residue isn’t thought of as messy.

Awareness of field infrastructure practices - tile control structures, contour buffer strips, and other structural practices can provide significant water quality benefits. Producers need to be aware of the benefits of these practices as well as what maintenance and use looks like. A tile control structure does no good if it isn’t used properly, but effective use can relieve problems due to seasonal water fluctuations.

Proper manure and waste storage - Operations with noted issues should be addressed on an individual basis. The Michigan Agriculture Environmental Assurance Program (MAEAP) can serve as an opener for these conversations because it is not regulatory, provides a comprehensive assessment of risks, and connects participants with funding. These producers need to be made aware of the impacts of poor waste storage and the steps that can be taken to address the issue.

6.3.3 Residents

Ultimately, it will be necessary to focus on education of riparian populations to promote good stewardship of private properties and infrastructure. Previous studies done by the Michigan Department of Natural Resources (MDNR) and a private water quality consultant have identified several practices for riparian landowners that will enhance the Gun Lake recreation potential:

- Compost leaves in an area away from the lake or rake them away from the lake and bag for removal.
- Use lake-safe fertilizers on lawns—phosphorus fertilizers are already restricted by State and County policies.
- Use lake water to water lawn and gardens.
- Preserve natural vegetation along the shoreline.
- Use phosphate free detergents in and around the house.

- Protect wetlands adjacent to the lake.

Increased use of natural shorelines and riparian plantings - Natural shorelines and plantings are the most comprehensive way to reduce the impact of residential properties. This practice is broadly beneficial and cost-effective, but needs to be normalized in order to become widespread. Demonstration riparian buffer sites and wetland restorations were completed as part of Gun River Project 2008-0025. The current condition of these sites should be evaluated, and high quality sites should be used in future outreach and education events.

Water quality monitoring and data collection - The creation of a local volunteer program is an entry point for broader local participation in water quality initiatives. This is also a low-cost way to keep an eye on water quality between more comprehensive monitoring efforts. Many landowners are not aware of this opportunity and that it can be easy and enjoyable. The Cooperative Lakes Monitoring Program is a volunteer opportunity for lake residents to get involved with by collecting water quality data on their lakes. More information can be found on their website: https://micorps.net/lake-monitoring/.

Protecting existing green space and natural land - Landowners need to be aware of opportunities for preserving their land in accordance with their wishes. A number of programs are currently available including the Qualified Forest Program, Farmland and Open Space Preservation Program, and easements through a land conservancy. Other programs like Forests for Fish have created materials describing the benefits of preservation efforts.

Permit requirements and enforcement - residents need to be aware of the existing regulations that protect water quality, when a permit is required, who to contact for help, and how to report illegal activity. It can be difficult for local officials to enforce these measures, and community awareness can both increase compliance and aid in enforcement. Some activities, like dumping sand to create a beach, happen quickly and are unlikely to be caught by local officials. The impact from these activities can be significant, and awareness of regulations is critical to preventing them. Environmental emergencies can be reported to the Pollution Emergency Alerting System hotline at 800-292-4706.

6.3.4 Residential Users

Stop the spread of invasive species - “Clean boats, clean waters” and “clean, drain, dry” initiatives are widespread and have readily developed materials. Educational signage should be posted at public launches to provide information on best practices for reducing aquatic invasive species spread.

Table 6.1 - Possible Education and Information focuses

Focus	Pollutant	Target Audience	Message	Delivery Mechanism	Potential Partners	Timeline	Milestones	Estimated Costs	Evaluation Criteria
Adoption of protective ordinances	Sediment, nutrients, pathogens	Local officials	Be proactive about defining what good development looks like, and enforce that vision with appropriate ordinances	Attend planning meetings, model ordinances	MDARD, local officials, CDs	2026 - 2028	Model ordinances created and distributed	$2000 per ordinance	Passage of septic, stormwater, and/or purchase of development rights ordinances
Awareness of the watershed management plan	Sediment, nutrients, pathogens	Local officials	The watershed management plan provides guidance and access to funding for protecting water quality and local character.	Distribute watershed management plan, informational meeting	CDs	2024 - 2025	Informational meeting(s) with public officials to review the plan		Informational meeting(s) with public officials to review the plan
Increased use of cover crops and reducing tillage	Sediment, nutrients	Agriculture	Cover crops and tillage reduction can reduce sediment loss, improve soil health, and reduce input costs leading to better profitability.	Agricultural brochure, Articles in specialty publications, workshops and field days	NRCS, MDARD, SWCS, NCR SARE, CDs	2024 - 2026	Yearly Agriculture BMP workshop	$450 brochure $100 per article $4000 per event	Number of farmers that received information, and number of new fields using cover crops and conservation tillage practices
Awareness of field infrastructure practices	Sediment, nutrients	Agriculture	Engineered solutions can provide significant water quality benefits while improving yields.	Agricultural brochure, workshops and field days, articles in specialty publications	NRCS, MDARD, SWCS, NCR SARE, CDs	2024 - 2026	Yearly Agriculture BMP workshop	$450 brochure $100 per article $4000 per event	Number of farmers that received information, and number of BMPs implemented

Focus	Pollutant	Target Audience	Message	Delivery Mechanism	Potential Partners	Timeline	Milestones	Estimated Costs	Evaluation Criteria
Proper manure and waste storage	Pathogens, nutrients	Agriculture	Improper manure storage can lead to waste entering the Gun River and high E. coli counts, limiting full and partial body contact in the watershed.	One-on-one meetings	NRCS, EGLE, MDARD, CDs	2026 - 2028	Yearly review of AFO conditions, MAEAP verifications		Number of AFO owners that received information, number of MAEAP verifications
Increased use of natural shorelines and riparian plantings	Sediment, nutrients	Residents	The way homeowners manage their lawn and landscape can have an impact on water quality. Limiting fertilizer use and growing native plant buffers near water can reduce harmful runoff.	Social media, website, newsletters, natural shoreline demonstration, Shoreline Living magazine	Native landscape companies, Michigan Shoreland Stewards, Michigan Natural Shoreline Partnership	2026 - 2028		$450 Lawn care brochure $1000 Shoreline demonstration	Number of homeowners reached, implementation of shoreline landscaping on Gun Lake and Gun River
Water quality monitoring and data collection	Pathogens, sediment, nutrients	Residents	Volunteer to monitor water quality to show improvement and quickly identify emerging issues.	Social media, website, newsletters	MiCorps and CLMP, VSMP, CDs, Lake Associations , MLSA,	2025	Gun Lake and other lakes in the watershed enrolled in CLMP monitoring	$200 Adopt A Stream $300 Lake monitoring $200 Friends of the Gun River	Volunteer programs implemented, Gun Lake enrolled in CLMP monitoring

Focus	Pollutant	Target Audience	Message	Delivery Mechanism	Potential Partners	Timeline	Milestones	Estimated Costs	Evaluation Criteria
Protecting existing green space and natural land	Pathogens, sediment, nutrients	Residents	Forests and wetlands naturally protect water quality and support healthy fisheries.	Social media, website, newsletters	SWMLC, LCWM, EGLE, ACHD, MDNR, CDs	2026 - 2028	1 easement in the Gun River corridor	Variable	Number of residents that received information, number of easements implemented in the Gun River Watershed
Prevent the spread of invasive species		Recreational users	Clean, drain, dry	Social media, website, newsletters, signage, promotional items	Lake associations	2026 - 2028	Signage at all public boat launches	$500 per sign $250 promotional items	Signage and boat cleaning stations at all public boat launches
Permit requirements and enforcement	Pathogens, sediment, nutrients	Farmers, Residents, Businesses	Knowing and following permit requirements for construction, wetland management, etc., protects water quality.	Local permit guide	EGLE, ACHD, local officials	2025	Development and distribution of permit guide	$1000 permit guide	Development and distribution of permit guide

NRCS - Natural Resources Conservation Service

MDARD - Michigan Department of Agriculture and Rural Development

SWCS - Soil and Water Conservation Society

NCR SARE - North Central Region Sustainable Agriculture Research and Education

MACD - Michigan Association of Conservation Districts

NACD - National Association of Conservation Districts

EGLE - Michigan Department of Environment, Great Lakes, and Energy

MDNR - Michigan Department of Natural Resources

CDs - Conservation Districts

CLMP - Cooperative Lake Monitoring Program

VSMP - Volunteer Stream Monitoring Program

ACHD - Allegan County Health Department

SWMLC - Southwest Michigan Land Conservancy

LCWM - Land Conservancy of West Michigan

MLSA - Michigan Lake and Stream Association

CHAPTER 7 – MILESTONES AND EVALUATION

Evaluation of the implementation of the Watershed Management Plan (WMP) will provide the Steering Committee an opportunity to assess the effectiveness of the activities that have been implemented to achieve the goals set forth in the plan. This chapter will describe the set of criteria and milestones that will be used to determine if pollutant reductions are being achieved over time and if substantial progress is being made toward attaining water quality standards. If implementation work does not result in the expected water quality improvements, this WMP should be revised to address any shortfalls. Table 7.1 outlines the monitoring plan and identifies the criteria for complete success. Quality Assurance Project Plans (QAPP) referenced will be developed as these monitoring plans are implemented.

This chapter will also discuss interim milestones that will demonstrate progress towards success. While attainment of water quality standards is the measure of complete success, the milestones are indicators of progress that don't require significant data collection. Progress towards milestones can easily and cheaply be reported to stakeholders. If milestones are not being met in a timely manner, stakeholders should meet to identify and address the barriers to progress.

7.0 EVALUATION CRITERIA AND MONITORING

The monitoring plan and success criteria are derived from the water quality standards relevant to the listed impairments or suspected impairments.

Other Indigenous Aquatic Life and Wildlife - A biological survey of the macroinvertebrate community is used to assess this designated use. Sites should receive a rating of "Acceptable" indicating a score of -4 to +4 for the macroinvertebrate community. Because sites in the lower Gun River currently have acceptable or higher ratings, these sites should show an increase in their score.

Total and Partial Body Contact Recreation - *E. coli* samples are used to assess this designated use. Five summer sampling events in a 30-day period, each event consisting of three samples, are used to calculate a geometric mean. The geometric mean should be less than 130 *E. coli* per 100 milliliters for the 30-day period or 300 *E. coli* per 100 milliliters on a single day for total body contact, and 1000 *E. coli* per 100 milliliters on a single day for partial body contact. The standard for total body contact applies from May 1st through October 1st, while the standard for partial body contact applies to the whole year.

Other Indigenous Aquatic Life and Wildlife (Lake Allegan) - The phosphorus TMDL for Lake Allegan targets a 50% reduction in nonpoint source pollutant loads, using 1998 levels as a starting point. Based on the report "Loading Assessments of Phosphorus Inputs to Lake Allegan, 1998" used in establishing the TMDL, this sets a target of 1,761 lbs of phosphorus from nonpoint sources in the Gun River Watershed during the 6 month growing season of April through September. This is a 50% reduction from the 1998 estimated loading of 3,522 lbs for the same 6 month growing season. Because this is not a concentration-based standard, loading needs to be calculated using flow and phosphorus concentration data. There are significant differences between computer-based modeling and monitoring-based estimation of pollutant loads. Because the TMDL uses monitoring, computer-based models should not be relied upon to measure progress towards TMDL goals.

Table 7.1 - Monitoring Plan

Monitoring Site Location	Parameter	Type of Analysis	Protocol	Frequency	Responsible Party	Success Criteria
Gun River near Patterson Rd	Macroinvertebrate	Biological survey	EGLE Procedure 51	5 yr interval	EGLE	"Acceptable" score
	E. coli	Bacterial monitoring	Grab samples	Determined by EGLE	EGLE	30 day mean < 130 cfu/100mL daily maximum < 300 cfu/100mL
Gun River near 116th Ave	*E. coli*	Bacterial monitoring	Grab samples	Determined by EGLE	EGLE	30 day mean < 130 cfu/100mL daily maximum < 300 cfu/100mL
Gun River near 10th St	*E. coli*	Bacterial monitoring	Grab samples	Determined by EGLE	EGLE	30 day mean < 130 cfu/100mL daily maximum < 300 cfu/100mL
	Phosphorus	Total phosphorus Apr - Sept	QAPP*	2 yr interval	ACD	Total load of 1790 lbs or less Apr - Sept.
	Flow	Monthly flow Apr - Sept	QAPP*	2 yr interval	ACD	
	Temperature	Average monthly temperature	QAPP*	5 yr interval	ACD	See table 7.2
Entire Watershed	Agriculture BMPs	Tillage, Residue, and AFO Survey	QAPP*	5 yr interval	ACD	Cover crops on 50% of fields, no till on 25% of fields, no unrestricted livestock access, no manure storage issues
	BMP Attitudes	Social Survey	QAPP*	After each project	ACD	Increased awareness and acceptance of BMPs
	Macroinvertebrate	Biological survey	EGLE Procedure 51	5 yr interval	EGLE	"Acceptable" score

*Quality Assurance Project Plan (QAPP), not yet developed.

Table 7.2 - Maximum monthly average temperature for fisheries

Month	J	F	M	A	M	J	J	A	S	O	N	D
Warmwater Fishery	41	40	50	63	76	84	85	85	79	68	55	43
Coldwater Fishery	38	38	41	56	70	80	83	81	74	64	49	39

Cold and Warmwater Fisheries - Impairment to the Gun River's fisheries is suspected due to high water temperature. Monitoring with an in-stream temperature logger should be used to assess and monitor attainment of this standard. Monthly average temperatures in degrees Fahrenheit can be found in table 7.2.

Other Success Criteria - Implementation success will also be defined by the prevalence of the recommended agricultural practices. Cover crops and no-till should become commonplace. Livestock access and manure storage issues should be eliminated completely. This will be directly observed through an agricultural survey, and public perceptions and understanding of these practices should be evaluated through a social survey.

7.1 INTERIM MILESTONES

Table 7.3 shows the milestones used to assess implementation progress. Progress will depend on resource availability and therefore some flexibility is built into this model. In order to find estimated pollutant reductions per interim period, reductions per acre for each practice were averaged and then applied to the desired acreage total for each period.

7.2 PROGRESS REPORTING

The Allegan Conservation District should compile an annual report of implementation progress to share with stakeholders. This report should include information from other relevant organizations regarding work done in the watershed. This may include:

- EGLE monitoring results
- New preservation projects from SWMLC
- Drain maintenance work
- Farm bill program statistics from NRCS

These supplemental reports may provide additional evidence that milestones are or are not being met. This report will serve as an annual touch point to maintain communication between stakeholders and ensure this plan continues to be executed.

Table 7.3 - Interim Milestones

	Short term (2024 - 2026)	**Mid term (2027 - 2029)**	**Long term (2030 - 2034)**
Field practices: Cover crops, no-till, and nutrient management	Implement practices on 1500 acres Estimated Reductions: 1045 lbs/year of Nitrogen 408 lbs/year of Phosphorus 169 Tons/year of sediment	Implement practices on 3000 acres Estimated Reductions: 2091 lbs/year of Nitrogen 816 lbs/year of Phosphorus 339 Tons/year of sediment	Implement practices on 7000 acres Estimated Reductions: 4,879 lbs/year of Nitrogen 1,904 lbs/year of Phosphorus 791 Tons/year of sediment
Buffer practices: Grassed waterways, filter strips, windbreaks, WASCOBs, and contour buffers	All landowners with potential fields contacted	Implement 50% of recommended practices	Implement remaining practices
Tile practices: Drainage water management, saturated buffers, and denitrifying bioreactors	All landowners with potential fields contacted	Implement 50% of recommended practices	Implement remaining practices
AFO practices: Waste storage, access control, grazing, etc.	All landowners contacted through MAEAP	Implement high priority manure storage and stabilization practices	Implement remaining practices
Hydrology practices: Wetland restoration, natural channel design, two stage ditch	Complete feasibility study	Affected landowners contacted, preliminary engineering	Final design and construction complete
Residential practices: Green stormwater infrastructure, natural shoreline design	Public education on best residential practices	Priority sites identified	Construction of demonstration sites at critical locations
Local planning: Stormwater policy, septic policy	Model ordinances drafted	Passage of ordinances	