THE MIDDLE HURON RIVER WATERSHED MANAGEMENT PLAN, SECTION 1.

WASHTENAW COUNTY, MICHIGAN

INCLUDING:
THE HURON RIVER FROM FLOOK DAM AT PORTAGE LAKE TO BEGINNING OF BARTON POND

BOYDEN CREEKSHED

HONEY CREEKSHED

MILL CREEKSHED

PREPARED BY
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Huron River Watershed Council

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WATERSHED MANAGEMENT PLAN FOR THE MIDDLE HURON RIVER, SECTION 1.

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LIST OF ACRONYMS

BANCS: Bank Assessment for Non-point source Consequences of Sediment

BEHI: Bank Erosion Hazard Index

DO: Dissolved Oxygen

EGLE: Michigan's Department of Environment, Great Lakes, and Energy

EPA: U.S. Environmental Protection Agency

EPT: Ephemeroptera, Plecoptera, and Trichoptera

GIS: Geographic Information Systems

HRWC: Huron River Watershed Council

MDEQ: Michigan Department of Environmental Quality (former name of EGLE)

MDNR or DNR: Michigan's Department of Natural Resources

NBS: Near bank stress

NPDES: National Pollutant Discharge Elimination System

NPS: Nonpoint source pollution

TMDL: Total Maximum Daily Load

TDS: Total Dissolved Solids

TSS: Total Suspended Solids

RCA: Reach contributing area (aka watershed)

SSC: Suspended Sediment Concentration

SEMCOG: Southeast Michigan Council of Governments

WMP: Watershed Management Plan

WWTP: Wastewater treatment plant

WCWRC: Washtenaw County Water Resources Commissioner

UNITS OF MEASURE:

CFU: Colony-forming Unit (bacteria)

cfs: Cubic feet per second (discharge/flow)

MPN: Most probable number (bacteria)

mg/L: milligram per liter (concentration of constituents in water), also equivalent to ppm: parts per million

µS/cm: microsiemens per centimeter (conductivity)

Chapter 1: Introduction

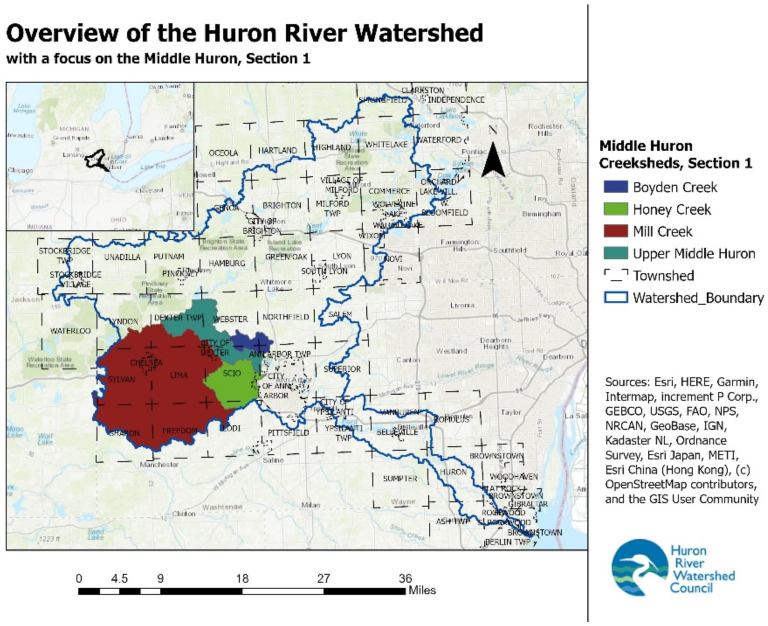
1.1 The Middle Huron River Watershed Management Plan: Section 1

The Middle Huron River Watershed Management Plan (WMP): Section 1 is part of an effort led by communities in this area seeking to plan activities to address water quality issues highlighted in the State of Michigan's Clean Water Act §303(d) report on impaired waters. The original WMP was completed in 1994, updated in 2000, 2008, and 2011, but was written for a larger area, covering the entire Middle Huron Watershed which covers the confluence of Mill Creek down to the end of Belleville Lake, and all tributaries draining to the Huron through that length. This 2022 version is the fourth update of that WMP, but it is narrower in scope as it only covers the upper geographic portion of that earlier WMP. A separate WMP was written for the middle (Section 2 approved by EGLE October 2020)[1] and will be written for the lower (Section 3) geographic portions.

For the purposes of this plan, Section 1 of the Middle Huron Watershed (Figure 1.1) will be referred to as the Watershed.

It is composed of the Huron River from Flook Dam (Portage Lake) to the start of Barton Pond, the watersheds of the direct drainage in this area, as well as the Mill, Boyden, and Honey subwatersheds (also called creeksheds throughout this document).

Figure 1.1. The Huron River Watershed is located in southeast Michigan. The focus of this report is on the subwatersheds highlighted in this map.



The Watershed is part of the larger Huron River Watershed, one of Michigan's natural treasures. The Huron River supplies drinking water to approximately 150,000 people, supports one of Michigan's finest smallmouth bass fisheries, and is the State's only designated Scenic River in southeast Michigan. The Huron River Watershed is a unique and valuable resource in southeast Michigan that contains ten Metroparks, two-thirds of all southeast Michigan's public recreational lands, and abundant county and city parks. In recognition of its value, the State Department of Natural Resources has officially designated 27 miles of the Huron River and three of its tributaries as "Country-Scenic" River under the State's Natural Rivers Act (Act 231, PA 1970). The Huron is home to 670,000 people, numerous threatened and endangered species and habitats, abundant bogs, wet meadows, and remnant prairies of statewide significance.

The Huron River Watershed encompasses approximately 900 square miles (576,000 acres) of Ingham, Jackson, Livingston, Monroe, Oakland, Washtenaw, and Wayne counties. The main stem of the Huron River is approximately 136 miles long, originating at Big Lake and the Huron Swamp in Springfield Township, Oakland County. The main stem of the river meanders from the headwaters through a complex series of wetlands and lakes in a southwesterly direction to the area of Portage Lake. Here, the river begins to flow south until reaching the City of Dexter in Washtenaw County, where it turns southeasterly and flows to its final destination of Lake Erie. The Huron is not a free-flowing river. At least 98 dams segment the river system, of which 17 are located on the main stem.

The drainage area to the Watershed is 204 square miles (130,302 acres), representing approximately 23% of the total Huron River Watershed. All or portions of 16 municipalities (not counting Federal or State) are situated in the Watershed (Table 1.1). Communities with more than 10% of their municipality in the Watershed are called "Core Communities" throughout this document. There are 12 of these.

The Watershed lies entirely in Washtenaw County except for a sliver of land in the headwaters of Mill Creek, which lies in Jackson County (1 sq mi, 0.5% of the watershed).

Table 1.1. Breakdown of Municipalities in the Watershed

Municipality	Size of Watershed in Municipality (sq mi)	% of Watershed in Municipality	% of Municipality in Watershed
Lima	36	18	100
Scio	33	16	100
Sylvan	31	15	91
Freedom	24	12	68
Sharon	21	10	56
Dexter Twp	21	10	63
Webster	14	7	38
Lodi	8	4	22
Lyndon	7	3	20
City of Chelsea	2	1	100
Northfield	2	1	4
City of Dexter	1	1	100
Ann Arbor Township	1	1	8

City of Ann Arbor	1	1	4
Washtenaw County	203	99.5	28
Jackson County	1	0.5	0.1

The Huron River in the Watershed begins with the Flook Dam (Portage Lake) and ends at the upstream end of Barton Pond (North Maple Road) The mainstem of the Huron River in the Watershed is 16.7 miles long. The elevation drops 48 feet over this distance for an average gradient of 2.9 ft/mi for the Huron River. For comparison, the entire Huron River has an average gradient of 3.3 ft/mi. The three major tributaries and 10 smaller creeks that feed the Huron River in this section are formed of 200 miles of open perennial and intermittent streams.

The entire Huron River in this Watershed area lies within a State of Michigan designated “Natural River District.” The Natural River District extends 400 feet landward from the river’s edge. Within this distance, most development activities require a permit, including building houses, decks, stairs, and other structures, cutting vegetation, and splitting the property into smaller parcels. New buildings must be set back 125 feet from the river and a 50-foot natural vegetation strip must be maintained along the river’s edge. Because of this protected designation, this Natural River District area has an “up north” feel while playing a vital role in keeping water clean. In southeast Michigan, the Huron River is the only river with this designation.

The Watershed contains several other protected natural areas, most prominently the Huron-Clinton Metroparks which surround the Huron River: Hudson Mills, Dexter-Huron, and Delhi. The upper northwest headwaters of Mill Creek are in the Waterloo State Recreation and Pinckney Recreation areas. There are numerous other public and private local parks as well.

As of 2020 data, the watershed’s land use is dominated by agriculture (44% of Watershed), forest (20%), wetland (19%) and developed land (10% of Watershed).[2] The City of Dexter and Chelsea contain denser urban and commercial centers, but these cities are small (2% of Watershed). The Watershed area contains 50 lakes, ponds, and impoundments, of which 27 are greater than 5 acres.

Outside of the EGLE funded planning project, in January 2021 the WMP stakeholder Washtenaw County Conservation District conducted a non-scientific survey of their constituency to see what water concerns they had. While the survey didn’t conform to EGLE protocols and the results are not statistically significant, the respondents expressed concerns about the amount of urban and agricultural runoff, fluctuations in water levels, bank erosion, and loss of wildlife habitat. Many of the commenters directly linked their concerns with climate change and increasing amounts of precipitation. People expressed concerns on how popular the Huron River is now with boaters and tubers and how this could lead to overuse and littering. They expressed concerns about invasive plant growth.

In recent decades, the Watershed has experienced amplified development pressures from a growing economy and urban sprawl. According to the U.S. Census data and the Southeast Michigan Council of Governments (SEMCOG)[3], Washtenaw County is currently the fastest growing county in southeast Michigan. The Watershed has increased from a population of 33,511 in 1990 to a population of 66,265 in 2020, a 91% growth rate[4]. The fastest area of growth in this time frame in the Watershed area is the City of Dexter (200% change), Webster Township (103% change), and Scio Township (83% change) [See Chapter 2.2 for complete details].

The SEMCOG forecast to 2040 shows a 15% increase in population from 2020 levels, across the southeast Michigan region. This indicates that the speed of growth in the Watershed could greatly slow as compared to the rate of development that occurred in the recent past. Unfortunately, the pattern of land use laid out by local government zoning ordinances and master plans will allow large amounts of natural area fragmentation and conversion to occur to accommodate this relatively modest amount of growth. While the modest growth presents a good opportunity for fixing as many of the problems caused by the rapid expansion as possible; it will also be incumbent on local governments to adopt land use policies and ordinances that allow development while preserving the natural green infrastructure and ecosystem services provided by the Watershed's natural areas.

Growth on the scale seen in the past decades hastened the degradation of the hydrology and water quality of surface waters. Through the processes of development, the Watershed has undergone wetland draining, deforestation, straightening and dredging streams ("drains"), removal of riparian vegetation, installation of impervious surfaces and storm sewers, inadequate control of soil erosion, and poorly designed stream crossings. Such practices resulted in altered hydrology ("flashy" flows and flooding), soil erosion and sedimentation, elevated nutrients, nuisance algal blooms, dangerous levels of pathogens, degraded fisheries, and destruction of natural lands that provided wildlife habitat, recreation, air quality, filtering of polluted runoff, temperature regulation, flood control, groundwater storage, drinking water supply, carbon storage and sequestration, and a host of other ecosystem services.

The time is now to fix these issues wherever possible and prevent them from occurring again in the future.

1.2 Purpose of the Watershed Management Plan

The primary purpose of this plan is to address existing water quality impairments for the Watershed and prevent future impairments through protection, restoration, and mitigation. This plan outlines steps considered necessary to meet both quantitative and qualitative water quality goals for the Huron River and its watershed.

In order for the State of Michigan to approve a watershed plan, the plan must meet the following criteria as established in State Rule 324.8810:

> *A watershed management plan submitted to the EGLE for approval under this section shall contain current information, be detailed, and identify all of the following:*
>
> *(a) The geographic scope of the watershed.*
> *(b) The designated uses and desired uses of the watershed.*
> *(c) The water quality threats or impairments in the watershed.*
> *(d) The causes of the impairments or threats, including pollutants.*

(e) A clear statement of the water quality improvement or protection goals of the watershed management plan.
(f) The sources of the pollutants causing the impairments or threats and the sources that are critical to control in order to meet water quality standards or other water quality goals.
(g) The tasks that need to be completed to prevent or control the critical sources of pollution or address causes of impairment, including, as appropriate, all of the following:
(i) The best management practices needed.
(ii) Revisions needed or proposed to local zoning ordinances and other land use management tools.
(iii) Informational and educational activities.
(iv) Activities needed to institutionalize watershed protection.
(h) The estimated cost of implementing the best management practices needed.
(i) A summary of the public participation process, including the opportunity for public comment, during watershed management plan development and the partners that were involved in the development of the watershed management plan.
(j) The estimated periods of time needed to complete each task and the proposed sequence of task completion.

The above criteria are necessary for approval under the Clean Michigan Initiative guidelines. To be approved for funding under federal Clean Water Act section 319, a plan must also meet the "9 Minimum Elements:"

1. *An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan). Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed.*
2. *An estimate of the load reductions expected for the management measures described under paragraph (c) below. Estimates should be provided at the same level as in item (a) above.*
3. *A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.*
4. *An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan.*
5. *An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.*
6. *A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.*

7. *A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.*
8. *A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised.*
9. *A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.*

1.2.1 Designated and Desired Uses

According to Michigan's Department of Environment, Great Lakes, and Energy (EGLE), the primary criterion for water quality is whether or not the water body meets its designated uses. Designated uses are recognized uses of water established by state and federal water quality programs. In Michigan, the goal is to have all waters of the state meet all designated uses. It is important to note that not all of the uses listed below may be attainable, but they may serve as goals toward which the watershed can move.

All surface waters of the state of Michigan are designated for and shall be protected for all of the following uses.[5] The designated uses that apply to the Watershed are in boldface:

- **Agriculture**
- **Industrial water supply**
- **Public water supply**
- **Navigation**
- **Warmwater fishery**
- **Fish Consumption**
- **Other indigenous aquatic life and wildlife**
- **Partial body contact recreation**
- **Total body contact recreation between May 1 and October 31**
- Coldwater fishery

Due to human impacts and the impairments they cause throughout the Watershed, not all of the designated uses are fulfilled.

In addition to state-designated uses, the residents of the Watershed wish to use its surface waters in ways that are not yet achievable. The following desired uses have been identified by the communities in the watershed over the course of the development and updating of the WMP:

Coordinated development
Promote a balance of environmental and economic considerations through intentional community planning and coordinated development within and among the Watershed communities.

Hydrologic functions of natural features

Protect and enhance natural features related to water quantity and quality, including wetlands, floodplains, riparian buffer zones, and stream channels that regulate the flow of stormwater runoff, protect against flooding, and reduce soil erosion and sedimentation.

Open space, recreation and urban amenities
Protect priority natural habitat, recreational areas and trails, agricultural lands, and urban open spaces from development in order to maintain their natural functions, preserve rural character, and enhance recreational opportunities for present and future generations.

Coldwater Fishery
No waters in the Watershed are designated as a coldwater fishery. Mill Creek is a Warm Transitional stream, with enough cold springs to keep the creek marginal for brown trout. Brown trout survive in Mill Creek through stocking and some unknown amount of natural reproduction. However, there are citizens in Mill Creek led by Trout Unlimited Ann Arbor who work toward keeping the temperature in Mill Creek as low as possible; a coldwater fishery is a desired use of Mill Creek even though it is not officially designated as such.

1.2.2 Total Maximum Daily Load Program

A Total Maximum Daily Load (TMDL) is the maximum amount of a particular pollutant a waterbody can assimilate without violating state water quality standards. Water quality standards identify the applicable “designated uses” for each waterbody, such as swimming, agricultural or industrial use, public drinking water, fishing, and aquatic life. EGLE establishes scientific criteria for protecting these uses in the form of a number or a description of conditions necessary to ensure that a waterbody is safe for all of its applicable designated uses.

The state also monitors water quality to determine the adequacy of pollution controls from point source discharges. If a waterbody cannot meet the state’s water quality criteria with point-source controls alone, the Clean Water Act requires that a TMDL must be established. TMDLs provide a basis for determining the pollutant reductions necessary from both point *and nonpoint* sources to restore and maintain the water quality standards. Point sources is the term used to describe direct discharges to a waterway, such as industrial facilities or wastewater treatment plants. Nonpoint sources are those that enter the waterways in a variety of semi- or non-traceable ways such as stormwater runoff.

In Michigan, the responsibility to establish TMDLs rests with EGLE. Once a TMDL has been established by EGLE, affected stakeholders must develop and implement a plan to meet the TMDL, which will bring the waterbody into compliance with state water quality standards.

There are three relevant TMDL’s for this WMP, and as they will be referenced throughout the plan, they are first presented here. The first is the Total Phosphorus TMDL for Ford and Belleville Lake (Appendix A). While Ford and Belleville Lake itself are not in this Watershed of interest, the TMDL does include the Huron River and all associated tributaries starting at Flook Dam on Portage Lake, which is in this Watershed, thus the TMDL applies to this Watershed plan.

The second and third TMDLs for this Watershed are the *E.Coli* TMDL *for* Honey Creek (Appendix B), and the statewide *E.Coli* TMDL (Appendix C), as portions of Mill Creek are impaired for *E.Coli* and fall under this plan.

1.2.3 Assessment Unit Identifiers

Assessment Unit Identifiers (AUIDs) are specific bodies of water upon which EGLE applies assessments. AUIDs are given a numeric code that is used as an identifier. As of the 2020 EGLE Integrated Report[6], six AUIDs in the Watershed are listed for water quality problems that can be addressed by this plan (Figure 1.2, Table 1.2).

Multiple waters throughout the Huron River watershed are listed as impaired for fish consumption due to PCB and mercury. The impairments are addressed by statewide TMDLs[7,8]. The AUIDs listed for these are included in Table 1.3, but because the problems associated with PCB and mercury pollution are linked to broadly diffuse air-deposition originating outside of the Huron River Watershed, actions designed to address this TMDL are not emphasized in this plan, which focuses on locally-sourced impairments.

Figure 1.2: Stream reaches with Impaired Designated Uses

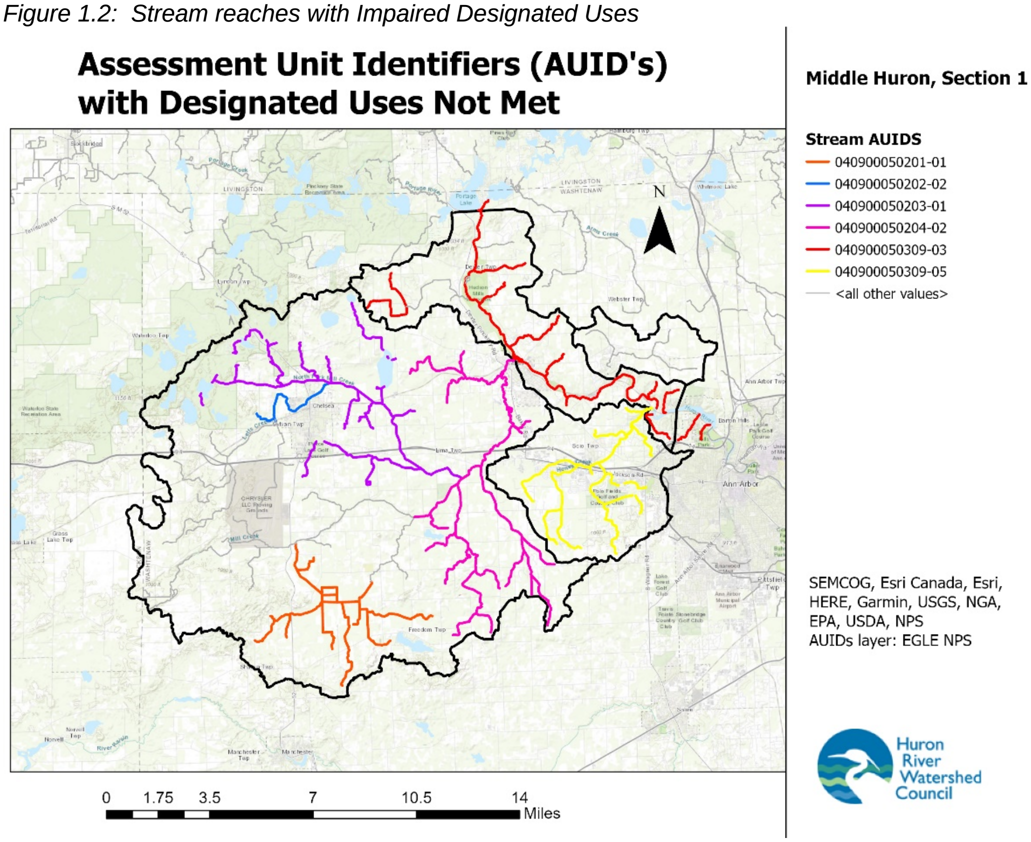


Table 1.2: Stream reaches with Impaired Designated Uses and established TMDLs (not including Fish Consumption: PCB and Mercury)

AUID	AUID Name	Designated Use Not Met	Pollutant/Cause	Stream length (miles)
MI-04090005201-01	Pleasant Lake tributaries	Other Indigenous Aquatic Life and Wildlife	Habitat Alterations Flow Regime Modification	23.4
MI-04090005202-02	Letts Creek Downstream of Cavanaugh Lake Road	Other Indigenous Aquatic Life and Wildlife	Cause Unknown	4.2
MI-04090005203-01	Mill Creek, North Fork	Total Body Contact Recreation Partial Body Contact Recreation	*E. Coli*	33.0
MI-04090005204-02	Mill Creek	Total Body Contact Recreation Partial Body Contact Recreation	*E. Coli*	40.5
MI040900050309-03	Huron River and Unnamed Tributaries	Fish Consumption	Perfluorooctane Sulfonate (PFOS)	16.6
MI040900050309-05	Honey Creek including all tributaries	Total Body Contact Recreation Partial Body Contact Recreation	*E. Coli*	25.3

Table 1.3: Stream reaches with Fish Consumption impaired use due to PCB or Mercury.

AUID	AUID Name	Designated Use Not Met	Pollutant/Cause	Stream length (miles)
MI-04090005201-01	Pleasant Lake	Fish Consumption	PCB	23.4
MI-04090005202-01	Wilkinson Drain at Old US-12	Fish Consumption	PCB	5.1
MI-04090005202-02	Letts Creek Downstream of Cavanugh Lake Road	Fish Consumption	PCB	4.2
MI-04090005202-03	Letts Creek Upstream of Cavanaugh Lake Road	Fish Consumption	PCB	15.4
MI-04090005203-01	Mill Creek, North Fork	Fish Consumption	PCB	33.0
MI-04090005203-03	Four Mile Lake	Fish Consumption	Mercury	Lake: 251 acres
MI-04090005204-01	Mill Creek and Unnamed Tributaries to Mill Creek	Fish Consumption	PCB	27.4
MI-04090005204-02	Mill Creek	Fish Consumption	PCB	40.5
MI040900050309-03	Huron River and Unnamed Tributaries	Fish Consumption	PCB	16.6
MI040900050309-04	Boyden Creek	Fish Consumption	PCB	7.0

MI040900050309-05	Honey Creek including all tributaries	Fish Consumption	PCB	25.3
MI040900050309-06	Huron Creek (listed as Unnamed)	Fish Consumption	PCB	3.8

1.3 The Watershed Management Plan Community Input

The first task involved in developing the original 1994 Watershed Management Plan was the formation of a Policy Advisory Committee, with members representing each of the communities in the project area. In January 1993, an initial meeting of this group was convened to discuss issues related to nonpoint source pollution in the planning area and individual community concerns. Following this introductory meeting, goals and objectives for controlling water quality were developed and submitted to committee members for review and approval. Since that time the Committee has continued to meet on a regular basis to assist in watershed planning activities throughout the Middle Huron basin. Currently, the Middle Huron Partnership Initiative coordinates the meeting of these communities with the expressed intent to plan and implement activities to address the Ford and Belleville Lakes TMDL for phosphorus.

The Huron River Watershed Council (HRWC) was the primary author of the WMP starting in 1994 and continues this role for the 2022 update.

For the 2008 update, an Advisory Committee was established, with representation from each of the communities in the Middle Huron Watershed. Project staff held bi-monthly meetings with the Advisory Committee to get feedback on different sections of the WMP. Materials were also distributed to Committee members and other interested parties for review, comment, and input. All communities were given draft copies of the WMP for review prior to finalizing. Small updates to the plan were made in 2011.

Several Technical Advisory Committees were established to provide input to individual components of this plan. A Committee was established to assist in revising the Drain Commissioner's standards governing the design of stormwater management systems in new developments. Members included staff from local planning, engineering, building inspection and utilities departments. Private engineering and planning consultants were also represented, as well as the HRWC, the County Soil Conservation District and the MDNR. Committee members were provided with working drafts of the Drain Commissioner's standards (including explanations about how revisions work to improve water quality and quantity control) and asked to provide feedback on their practicality for implementation within Washtenaw County. Revised standards were adopted in 1994. Public involvement and review also guided the 2000 update and the 2008 update.

For the 2020 era updates, HRWC broke the Middle Huron into 3 sections. This report covers Section 1. HRWC assembled a stakeholder committee which consisted of the Core Communities in the Watershed (all those with >10% of their municipality in the Watershed, Table 1-1.) Other organizations with knowledge or interests in the area were invited as well: Huron-Clinton Metroparks Authority; Washtenaw County Conservation District, Ann Arbor Trout Unlimited, and Legacy Land Conservancy. Not all these invitees elected to join the stakeholder committee, but all were welcomed. Stakeholders were given an overview of HRWC's data collection and monitoring efforts over the past 10 years, and gave input as to what projects their municipalities had accomplished since the 2008 WMP and what projects they would like to see implemented. All stakeholders were given draft copies of the WMP for review and comment prior to final changes and approval by EGLE.

Additionally, the Middle Huron Partnership was formed to address the Ford and Belleville Lakes TMDL. The Partnership originally formed in 1999 following development of the TMDL, and an updated Cooperative Agreement was signed in 2005 (Appendix D) and was effective through 2009. The group still continues to meet and work in 2022, and is still facilitated by HRWC. While the agreement has expired, the Agreement still serves as a voluntary guide for the partners to address the phosphorus reduction targets described in the TMDL. The Partnership now meets multiple times a year to report on progress, and were also given this plan for opportunity to review and comment prior to its finalization.

1.4 Other Subwatershed Management Plans

This Plan was developed with the intention of fulfilling the watershed management planning criteria for the U.S. EPA's Clean Water Act §319 Program and EGLE's Clean Michigan Initiative Program. It is a revision from the previous plan approved in 2008.

The "Bacteria Reduction Implementation Plan for the Honey Creek Watershed" Honey creek bacteria plan was approved by EGLE in May 2014 and is dated for use from 2014 to 2024[9] (Appendix E). This plan addresses Honey Creek bacteria reduction more specifically than the broader WMP you are currently reading.

It should also be noted that HRWC developed the 319-approved Mill Creek Watershed Plan in 2006[10]. As this current Middle Huron Section 1 plan incorporates Mill Creek, it should now be considered the most up to date examination of Mill Creek and the older Mill Creek plan can be considered retired or archived.

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[1] Huron River Watershed Council. 2020. https://www.hrwc.org/what-we-do/programs/watershed-management-planning/middle-huron-WMP-section-2/. Accessed May 2022.
[2] SEMCOG, Southeast Michigan Council of Government. 2021. https://semcog.org/gis. Accessed May 2021.
[3] SEMCOG, the Southeast Michigan Council of Governments. November 2018. Population and Household Estimate for Southeast Michigan. www.semcog.org. Accessed October 2021.
[4] U.S Dept of Commerce, Michigan: 2010. 2010 Census of Population and Housing. https://www.census.gov/prod/cen2010/cph-2-24.pdf. Accessed 2021.
[5] Brown, E., A. Peterson, R. Kline-Roback, K. Smith, and L. Wolfson. February 2000. Developing a Watershed Management Plan for Water Quality; and Introductory Guide, Institute for Water Research, Michigan State University Extension, Michigan Department of Environmental Quality, P.10.45 R323.1100 of Part 4, Part 31 of PA 451, 1994, revised 4/2/99.
[6] EGLE, 2020. Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report, Appendix B2. https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-12711--,00.html. Accessed June 2021.
[7] EGLE 2020. Final 2020 Statewide PCB TMDL. https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-292645--,00.html. Accessed June 2021
[8] EGLE 2020. Final 2020 Statewide Mercury TMDL. https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-301290--,00.html. Accessed June 2021

[9] Huron River Watershed Council. 2014. “Bacteria Reduction Implementation Plan for the Honey Creek Watershed”. https://www.hrwc.org/wp-content/uploads/Honey_Creek_WMP.pdf. Accessed May 2022.

[10] HRWC, 2006. Mill Creek Subwatershed Management Plan. https://www.hrwc.org/wp-content/uploads/Mill20Creek20Management20Plan.pdf. Accessed June 2021.

Chapter 2: Current Conditions

An effort has been made to collect all readily available information to establish a baseline of current conditions of the Watershed. The information collection effort included requests to Advisory Committee members and researchers in the area. Numerous studies and datasets of relevance were obtained in this process. In addition, spatial data was gathered and analyzed in various Geographic Information System's projects. It is difficult to explain the full breadth of what the GIS provides in text and static picture alone, so the projects and maps shown in this chapter are available from HRWC for any future project that could benefit from zooming up on specific locations.

2.1 Landscape and Natural Features

2.1.1 Climate

The rapidly changing climate in Southeast Michigan merits special consideration and for this watershed management plan was given a separate chapter (Chapter 3).

2.1.2 Geology, Soils, and Groundwater

The primary underlying glacial geology in the Watershed are moraines of fine or medium-textured till (Figure 2.1). End moraines are areas where glacial processes deposited huge quantities of rock and soil material of various sizes in one place. The mixture of varying sized soil particles increases the soils' ability to hold moisture and nutrients, which is conducive to agriculture and can also create large areas of groundwater storage (Figure 2.2).

The other primary geology underlying the Watershed is glacial outwash sand and gravel (Figure 2.1). Glacial outwash plains were created by melting glaciers whose runoff sorted soils into layers of similarly sized particles. These well-sorted soils include sand and gravel that allow rapid infiltration of surface water to groundwater aquifers and stream systems. These soils are primarily found in along the Huron River and are areas of high groundwater recharge rates. (Figure 2.2)

Depth to groundwater (Figure 2.3) and soil permeability (Figure 2.4) are important factors to consider in where to preserve or protect natural areas that may provide groundwater recharge to the watershed's aquifers and streams. To maintain safe drinking well water it is very important to protect areas where fast infiltration and low distance to the groundwater table rapidly brings water to the groundwater.

Speed of water infiltration can also control the applicability of certain stormwater control structures (i.e., best management practices), especially infiltration-based, and the appropriateness of certain development proposals that may require added water quality precautions within the watershed (i.e., gas stations, chemical storage facilities, etc.).

Figure 2.1. The Watershed's Glacial Geology.

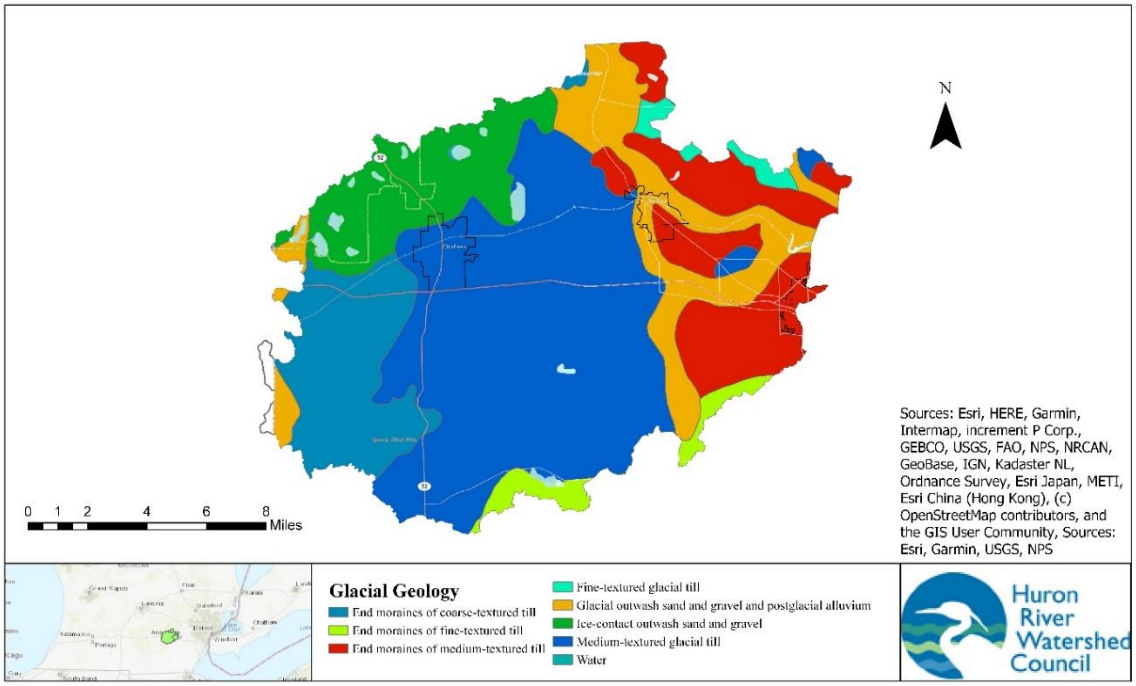


Figure 2.2. General groundwater recharge rates across the Watershed.

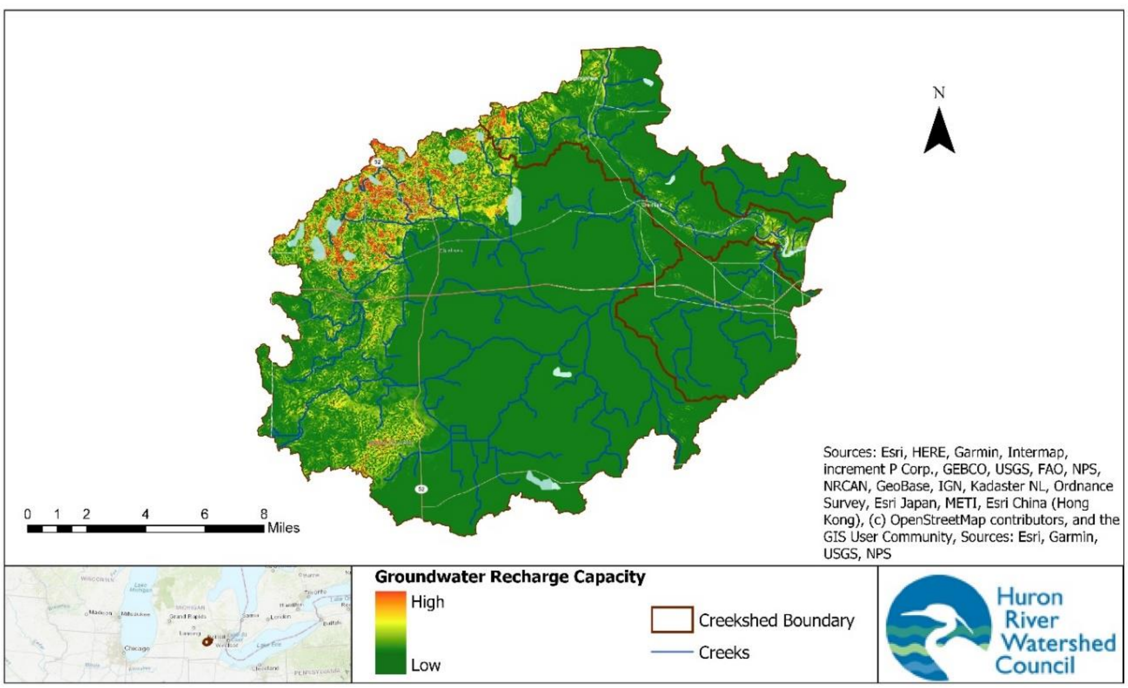


Figure 2.3. Depth to groundwater in the Watershed.

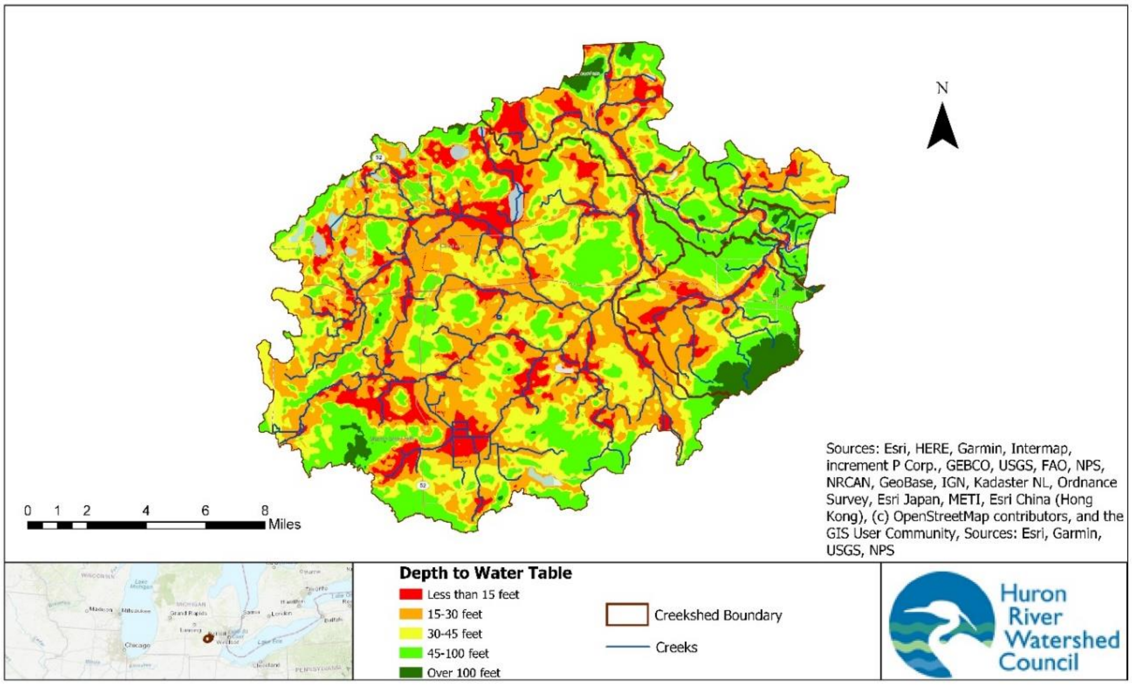
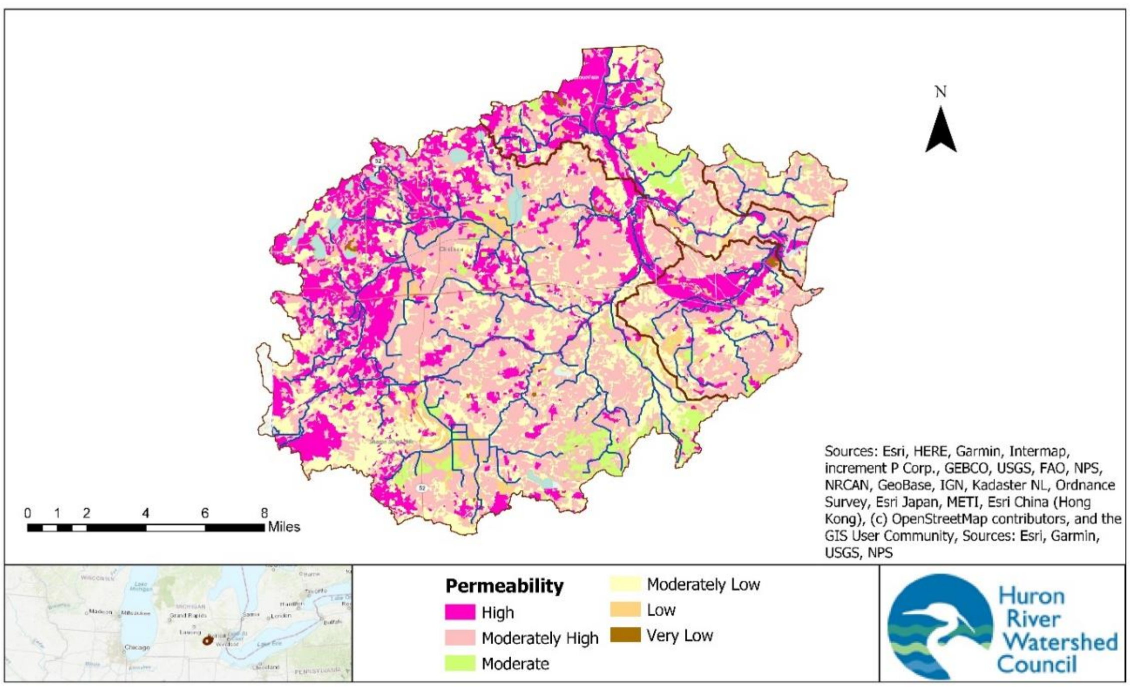


Figure 2.4. Relative soil permeability characteristics for the Watershed.



2.1.3 Hydrology

Hydrology refers to the study of water quantity and flow characteristics in a river system. How much and at what rate water flows through a river system, and how these factors compare to the system's historic or "pristine" state, are critical in determining the long-term health of the waterway. In a natural river system, precipitation in the form of rain or snow is intercepted by the leaves of plants, absorbed by plant roots, infiltrated into groundwater, soaked up by wetlands, and is slowly released into the surface water system. Very little rainwater and snowmelt flows directly into waterways via surface runoff because there are so many natural barriers in between.

When vegetated areas are replaced by roads, rooftops, sidewalks, and lawns, a larger proportion of rainwater and snowmelt falls onto impervious (hard) surfaces. In less developed areas, this stormwater runoff flows either into roadside ditches that drain to the nearest creek, or, in the more densely developed areas, it flows into a system of storm drainpipes that eventually outlet to the creek. During a rain event, this increased runoff causes the flow rate of the creek to increase dramatically over a short period of time, resulting in what is referred to as "flashy flows." In addition to rapidly increasing flows during storm events, the increase in impervious surface also decreases base flows during non-storm conditions because less water infiltrates into the ground to be slowly released into the creek via groundwater seeps.

Extreme flashiness can lead to rapid erosion of streambanks (especially in areas where the streambank vegetation has been removed or altered) and sedimentation. These impacts create unstable conditions for the macroinvertebrates and fish. Directly connected impervious landscapes pose a significant problem to hydrology. An example of a directly connected impervious surface is a rooftop connected to a driveway via a downspout that is then connected to the street where stormwater ultimately flows into the storm drain and into local creeks and streams.

The Huron River and its tributaries in the Watershed have been altered substantially by wetlands drainage, stream channelization, dam construction, deforestation, and urbanization. These activities have affected the hydrology of the Huron River and its tributaries: flow volume and flow stability have changed substantially, along with channel morphological features, such as gradient and shape. The extensive network of dams and lake control structures, developed areas, engineered drains, farm-field tile drains, and construction sites all play a role in producing flashy, sediment-laden flows.

The Huron River begins at an elevation of 1016 feet in the headwaters and descends 444 feet to an elevation of 572 feet at its confluence with Lake Erie, for an average gradient of 3.3 feet per mile (0.06%). The Huron River flowing through our Watershed region is just a little less steep than average at 2.9 feet per mile (0.05%), and less than half as steep as the next section of the river as it flows through Ann Arbor (7.6 feet per mile (0.14%)). The river channel gradient has a controlling influence on river habitat such as flow rates, depth, width, channel meandering, and sediment transport.

Stream flow data for the Upper Middle Huron Watershed has been collected at the U.S. Geological Survey (USGS) gage stations on the Huron River near Hamburg (#04172000, slightly upstream of the Watershed) since 1952 and on Mill Creek near Dexter (#04173500) since 1953. In 2020, the mean annual flow at the Hamburg station was 343.2 cubic feet per second (cfs), representing a drainage area of 308 square miles, or 1.11 cfs per square mile. The mean annual flow at the Mill Creek station was 129.6 cfs in 2020, with a drainage area of 128 square miles, or 1.01 cfs per square mile. Across the whole historical data record, an average year would flow at 232 cfs and 87 cfs for the Huron River near Hamburg and Mill Creek near Dexter, respectively. Examining the average years over time, the data record illustrates that flow has, on average, increased in both the Huron River and Mill Creek since 1953 (Figures 2.5 and 2.6).

Fig 2.5. Average Annual Discharge of the Huron River near Hamburg, from water year 1952-2020. The red line indicates that annual discharge has been, on average, increasing throughout the historical record.

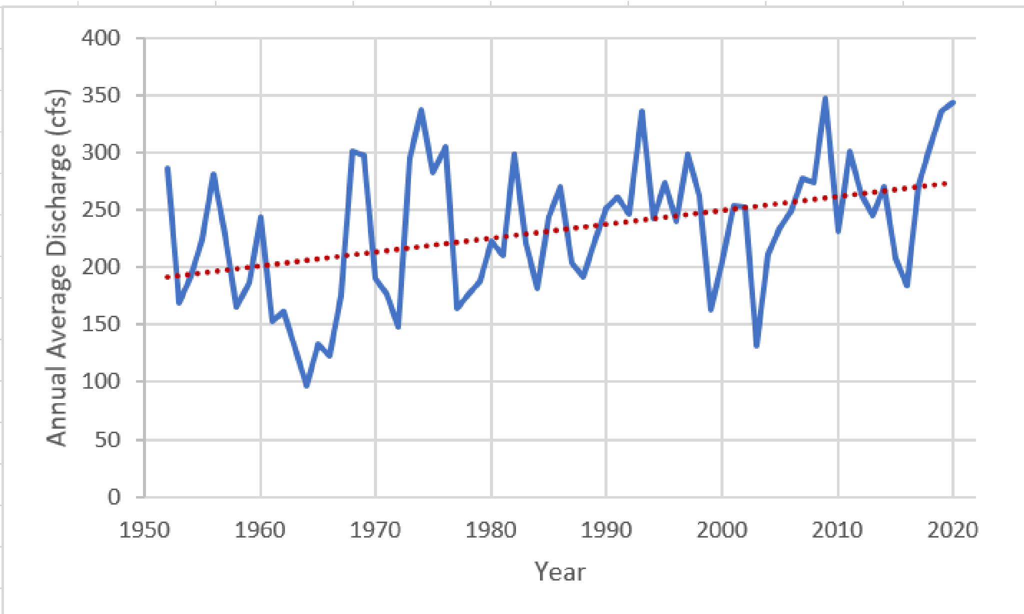
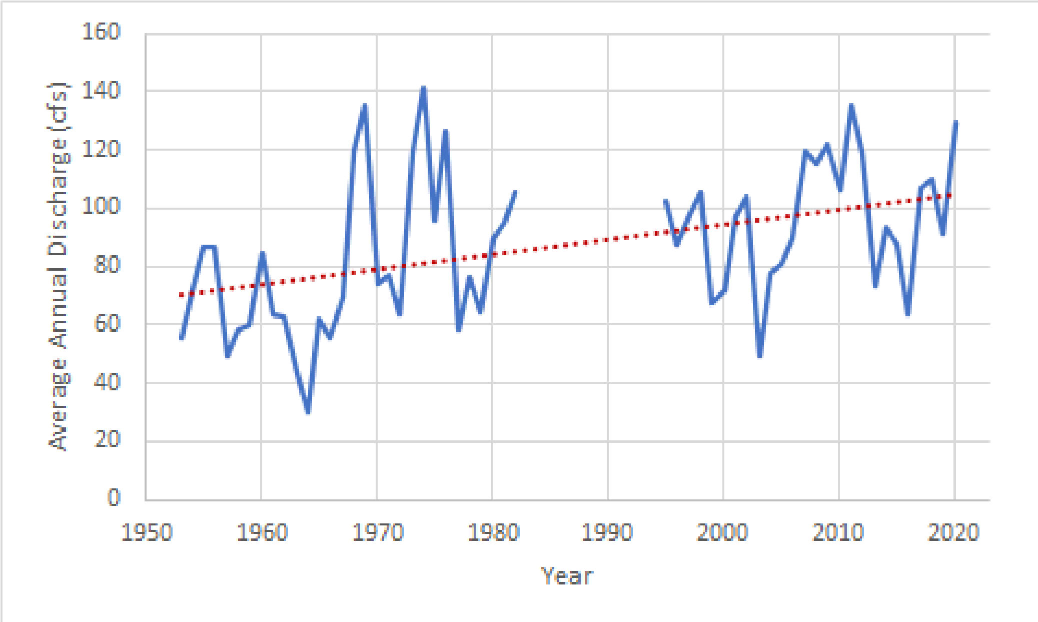


Figure 2.6. Average Annual Discharge of Mill Creek near Dexter, from water year 1953-2020. The red line indicates that annual discharge has been, on average, increasing throughout the historical record.



Development and resulting changes to the hydrology and hydraulics are a significant threat to the Watershed. Human impacts and development have generally increased daily fluctuations in the Huron's streamflow. Land drainage for urban or agricultural use has degraded the original, more stable flow regime. Draining wetlands, channelizing streams, and creating new drainage channels have decreased flow stability by increasing peak flows and diminishing recharge in groundwater tables.

Tributaries to the Huron River suffer from comprehensive channelization, lack of cover, and large flow fluctuations because of efforts to accelerate drainage through these streams. Tributaries in the watershed section for this plan show evidence of this altered hydrology in a number of ways. Table 2.2 provides some hydrological statistics and measures to help evaluate the health and stability of flow in the Huron River and tributaries. Most of these statistics are related to peak flows following a "bankfull event," which is a rainstorm that causes streams to rise to or just over the tops of their banks and enter the floodplain. Each year such a storm has a 50% chance of occurring, or about once in about every 1.5 to 2 years in southeast Michigan, and includes 2.25-2.5" of rain.[1] A reference bankfull flow can be determined using a creekshed's drainage area, that is based on an evaluation natural streams in southern Michigan.[2] Estimates of bankfull flows for watershed tributaries are much closer to reference flows than tributaries in more urbanized sections of the watershed. The river itself at the upstream extent of the watershed may be very close to reference flow. However, stream flows are still quite flashy in tributaries in this watershed. All 3 tributaries are well above the median flashiness rating[3] for Michigan streams of similar drainage area, though they are closer to the median than their urban counterparts.

Table 2.2 Estimated Bankfull Flows for Watershed Tributaries

Tributary Creek	Drainage Area (mi^2)	Reference Flow (cfs)	Measured Flow (cfs)	Storm precipitation (in)	Flashiness Index	R-B Index Rating (4=worst 1=best)
Mill	129	496	964	2.72	0.18	4*
Boyden	7.53	72	154	1.69	0.94	4

Tributary Creek	Drainage Area (mi²)	Reference Flow (cfs)	Measured Flow (cfs)	Storm precipitation (in)	Flashiness Index	R-B Index Rating (4=worst 1=best)
Honey	20.5	142	407	2.61	0.30	3
Huron @ N Territorial	538	1,308	1,160	1.53	NA	NA

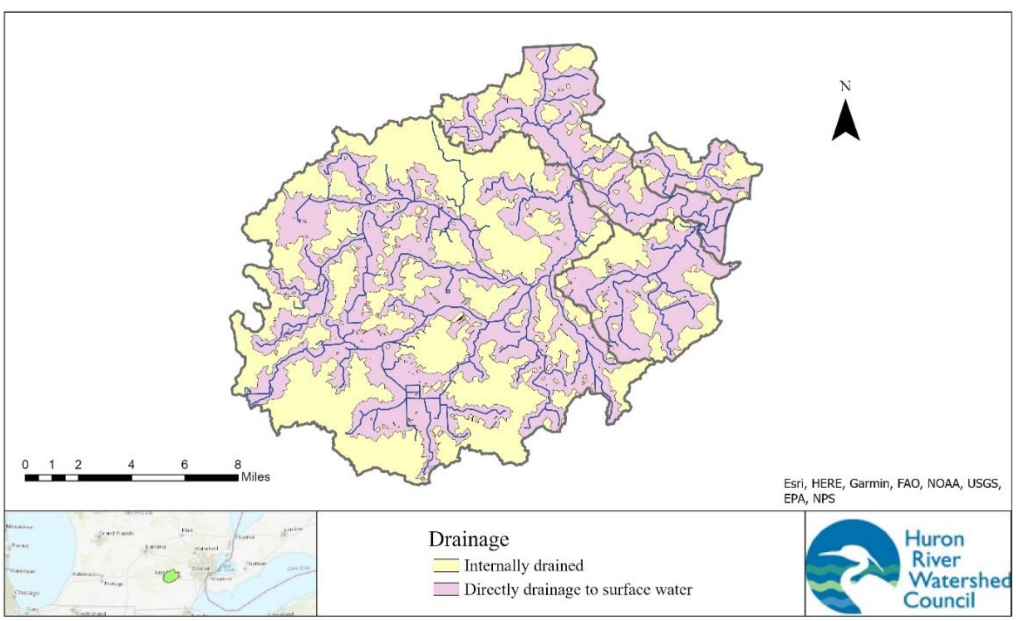
Reference Flow is based on regional reference curves for southern Michigan.
Measured flow is the peak flow measured by HRWC or USGS for a rain event similar in size to a 50% (2-year return), 24-hour event (2.35"). Precipitation provides the actual size of the storm.
*Flashiness Index (R-B Index) and ratings are based on the Richards-Baker Flashiness methodology and analysis of Michigan streams. * Mill Creek's rating is in the highest quartile in Michigan, but the lowest across 6 Midwestern states.*

Summer water temperatures have become warmer and more variable due to lower base flows, channel widening and clearing of shading stream-side vegetation. Landscape alterations and increased peak flows have accelerated erosion within the basin and increased the sediment load to the river.[4]

Additional factors important in reviewing and understanding the hydrology of the watershed are direct drainage, depth to groundwater, soil permeability, and groundwater recharge that indicate the infiltration potential of groundwater.

Direct drainage areas (Figure 2.7) are areas that have significant spatial and temporal influence on the quantity and quality of water entering the river system via groundwater or surface water flows (all pink areas on map). Much of this flow may come from direct flow from impervious surfaces. Excluded from direct drainage are portions of the landscape that form depressions where the dominant flow of water reaches the groundwater slowly through infiltration (yellow areas on map). The map presented in Figure 2.7 is derived from a model that calculates flow accumulation based, in part, on the amount of imperviousness in each area.

Figure 2.7. Direct and indirect drainage in the Watershed. Land mapped as pink drains rapidly to surface water via throughflow or overland flow while land mapped as yellow drains slowly to groundwater.



2.1.3.1 Dams and Impoundments

Another component contributing to the hydrology of the Middle Huron Watershed is the presence of dams and impoundments. According to the National Inventory of Dams, nine dams are located in the Watershed (Figure 2.8 and Table 2.3).[5] Dams may be constructed for uses such as hydropower, recreation, or stormwater and flood control. Most of the dams in the Watershed were developed for recreational purposes via water impoundment. Dams that were previously useful can outlive their intended purposes and become hazards and ecological detriments to the river. Dams can create hazards by collecting debris or simply by requiring recreationalists to circumnavigate them. They act as ecological detriments by holding back silt and nutrients, altering river flows, decreasing oxygen levels in impounded waters, blocking fish migration and eliminating spawning habitat, increasing nuisance plant growth in impoundments, altering water temperatures, and injuring or killing fish.

One of the major success stories in the entire Huron River Watershed was the removal of Dexter Dam from Mill Creek in 2008 as eloquently recorded in this video: https://www.youtube.com/watch?v=kLmnPIZxtgE

The removal of the dam improved water quality and spurred on new park and economic development in the City of Dexter.

Flook dam, at the output of Portage Lake and the upstream start of the Watershed, is the only large dam in the Watershed. The other eight are smaller and on tributary streams. Notable among these are the dams that create Green Oak Lake and Bridgeway Lake on Boyden Creek in the Loch Alpine residential neighborhood, and the water control structure on Four Mile Lake in the Mill Creek watershed.

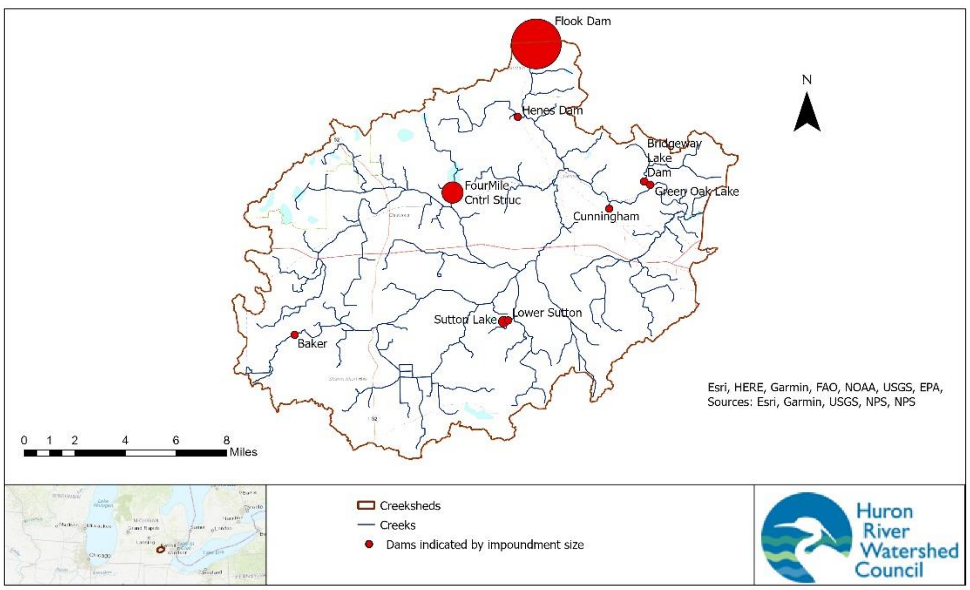
Table 2.3. Inventoried Dams in the Watershed

Dam Name	**Waterway**	**Ownership**	**Downstream Hazard Potential**[t]	**Purpose**	**Date Built**	**Dam Height** (Feet)	**Impound ment Area** (acres)
Flook Dam	Huron River	Washtenaw County Water Resources Commissioner	Significant	Lake level control	1965	13	769
Four Mile Control Structure	Mill Creek Trib	Michigan DNR	Low	Recreation	1990	5	256
Sutton Lake Dam	Mill Creek Trib	Privately Owned	Low	Recreation	1959	12	64
Bridgeway Lake Dam	Boyden Creek	Loch Alpine Improvement	Low	Recreation	1928	19	15
Green Oak Lake Dam	Boyden Creek	Loch Alpine Improvement	Significant	Recreation	1928	22	11
Baker Dam	Mill Creek	Privately owned	Low	Mill originally, current purpose likely is Recreation al	1826; rebuilt 2000	6	10

Dam Name	Waterway	Ownership	Downstream Hazard Potential[t]	Purpose	Date Built	Dam Height (Feet)	Impoundment Area (acres)
Lower Sutton Dam	Mill Creek Trib	Privately Owned	Low	Recreation	Unknown	6	8
Cunningham Dam	Huron River Trib	Privately Owned	Low	Unknown	Unknown	6	3
Henes Dam	Huron Creek	Privately Owned	Low	Recreation	1948	6	1

[t]Dam Hazard Potential:
Three hazard potential categories:
High- expected loss of life, severe impacts
Significant- possible loss of life, significant impacts
Low- no loss of life, minor impacts

Figure 2.8. Nine dams are located in the Watershed. Locations are shown with the size of the dot indicating size of the dam as reflected by the amount of water impounded behind it.



2.1.4 Significant Natural Features and Biota

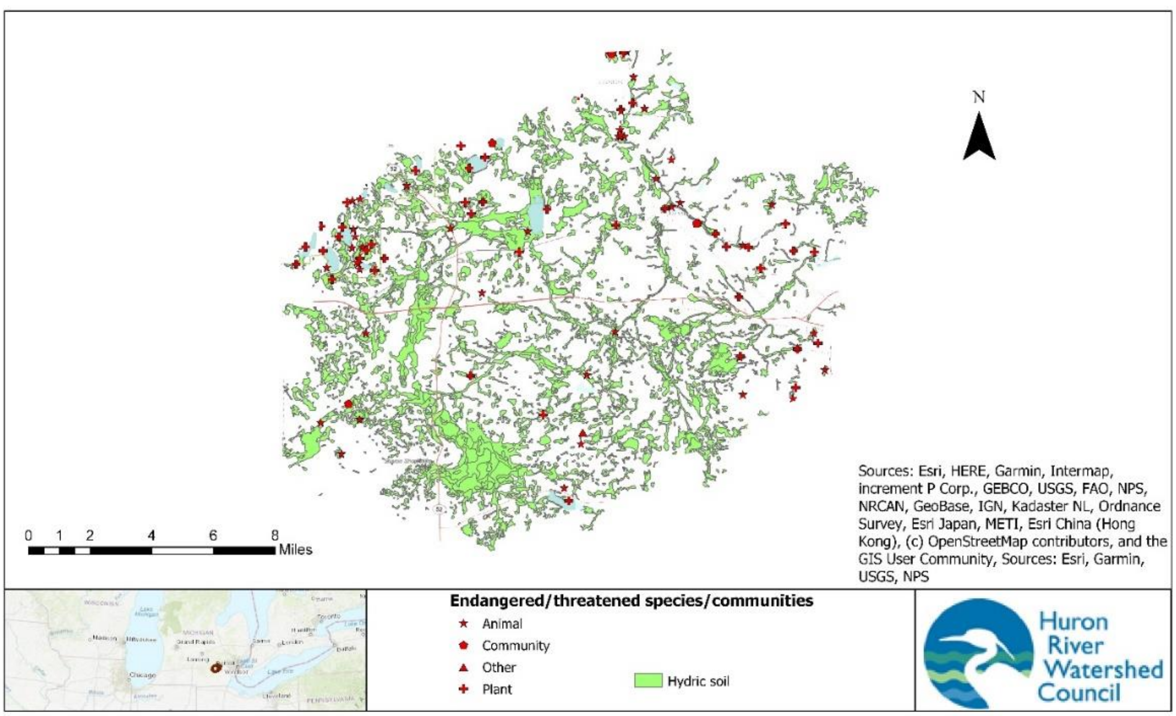
2.1.4.1 Threatened, Endangered, and Special Concern Biota

With the fast growth of Washtenaw County, significant building pressure has caused the Watershed to become altered and degraded. Still, pockets of high-quality habitat and diverse species persist due to conscientious planning and policy-making efforts that seek to preserve wildlife habitat. The expansiveness and ecological quality of the remaining open spaces and native habitats directly impact the quality of life and quality of water in the Watershed. Researchers have recognized plant and animal species and plant community types as integral parts of the Watershed that deserve protecting. Among those conservation targets are the threatened and endangered species that have been observed in the Watershed (Appendix F)[6]. Many of the plant and animal occurrences in the table are partially or entirely dependent on aquatic ecosystems for survival.

2.1.4.2 Critical Habitat and Ecosystem Services

Recovering these species requires protecting the ecosystems on which they depend. Key conservation areas of the Watershed system include critical habitat for plant and animal communities (including habitat for rare, threatened or endangered species), such as wetlands; large forest tracts; springs; spawning areas; the aquatic corridor, including floodplains, stream channels, springs and seeps; steep slopes; and riparian forests (Figure 2.9). Priority areas are those with intact, native ecosystems due to floral and faunal integrity.

Figure 2.9. Location of Endangered/threatened species or communities and regions of hydric soils.



Natural areas close to and draining directly to tributaries and lakes are highly important to water quality, creeks rely on those areas to filter pollution and hold floodwaters after our ever-increasingly intense storms. Areas that encompass headwater streams provide a host of services to the river system – their close connection to groundwater, wetlands and subsurface water flows provides base flow to streams, controls flooding downstream, and spawning areas for fish.

In addition to their importance as wildlife habitat, undeveloped areas, such as forest, meadow, prairie, wetlands, ponds and lakes, and groundwater recharge areas, provide a host of ecosystem services to the watershed otherwise unobtainable by human invention, including the following:

- Groundwater. Natural systems allow rainwater and snowmelt to infiltrate into groundwater aquifers. About 50% of Michigan residents rely on groundwater for drinking water. Groundwater also provides irrigation water for agriculture and cooling water for industry.
- Surface water. By intercepting runoff and keeping surface waters supplied with a constant flow of clean, cool groundwater, natural systems keep streams, rivers and lakes clean.
- Drinking water: Residents of Ann Arbor rely on the Huron River for drinking water, while residents of the rest of the Huron River Watershed rely on private or municipally controlled drinking water wells that pull groundwater from aquifers replenished through natural areas.
- Pollutant removal. As water infiltrates into the ground or passes through wetlands, soil filters out many pollutants. Vegetation also takes up nutrients and other pollutants, including phosphorus, nitrogen, bacteria, and even some toxic metals.
- Erosion control. Vegetation intercepts water and soil absorbs it, keeping it from eroding streambanks and hillsides. River- and lakeside wetlands are especially important for erosion control along riverbanks and lakeshores.
- Air purification. Vegetation purifies the air we breathe.
- Flood and drought control. Vegetation and soil intercept runoff water, moderating floods and droughts.
- Wildlife habitat and biodiversity. Natural systems are vital to the survival of aquatic and terrestrial wildlife. In addition to its aesthetic value, maintaining the biodiversity of species is vital to our economy and health.
- Recreation. Natural areas provide recreation such as hiking, bird-watching, canoeing, hunting, and fishing that generate revenues for the local community.
- Cooling. Tracts of undeveloped land soak up solar heat and prevent heat islands from forming. Heat islands warm water runoff, which leads warm water to flow into streams and disrupts the aquatic climate.
- Carbon storage and sequestration. Plants take up carbon as a major nutrient and store it as they grow; when they die, the soil stores the degraded plants as carbon.
- Property values. Natural areas enhance the value of neighboring properties.

The remaining undeveloped, natural areas in the Watershed were mapped and prioritized in 2002, and updated in 2007 and 2018 through the Natural Areas Assessment and Protection (NAAP) project of the Huron River Watershed Council

(Figure 2.10) [7] In order to prioritize protection and conservation efforts, the mapped sites were ranked based on the following ecological and hydrological factors: size; core size, presence of water; presence of wetlands; groundwater recharge potential; potential for rare remnant plant community; topographical diversity; glacial diversity, how connected they were or could be to other natural areas, vegetation quality, potential for restoration, and biodiversity.

201 sites (45,406 acres) in the Watershed were identified as priority natural areas, with 17 sites (14,674 acres) ranked as highest priority for protection, 54 sites (15,756 acres) ranked as medium-high priority for protection, 111 sites (13,988 acres) ranked as medium-low priority for protection and 19 sites (987 acres) ranked as lower priority for protection.

Of the 37,000 acres of natural areas mapped, only 8000 acres are protected as parks and other public ownership, preserves owned by conservancies and other nonprofits, and lands with conservation easements. This includes many of the highest priority areas, such as the Waterloo and Pinckney Recreation areas as well as the Metroparks right along the Huron River's riparian zone. The parcels outlined in red in Figure 2.11 are the NAAP sites that do not have a protected land status and that would be good candidates for HRWC field assessments to determine priority for protection. Protection options for municipalities, state and federal agencies, and nonprofit conservation groups include programs such as the Regional Conservation Partnership Program, property-tax funded land protection millages, grants through foundations, carbon sequestration and storage funding, the Clean Water Act State Revolving Fund, Clean Water Action Section 319 Funding, among others.

Figure 2.10. Priority ranking of Natural Areas in the Watershed.

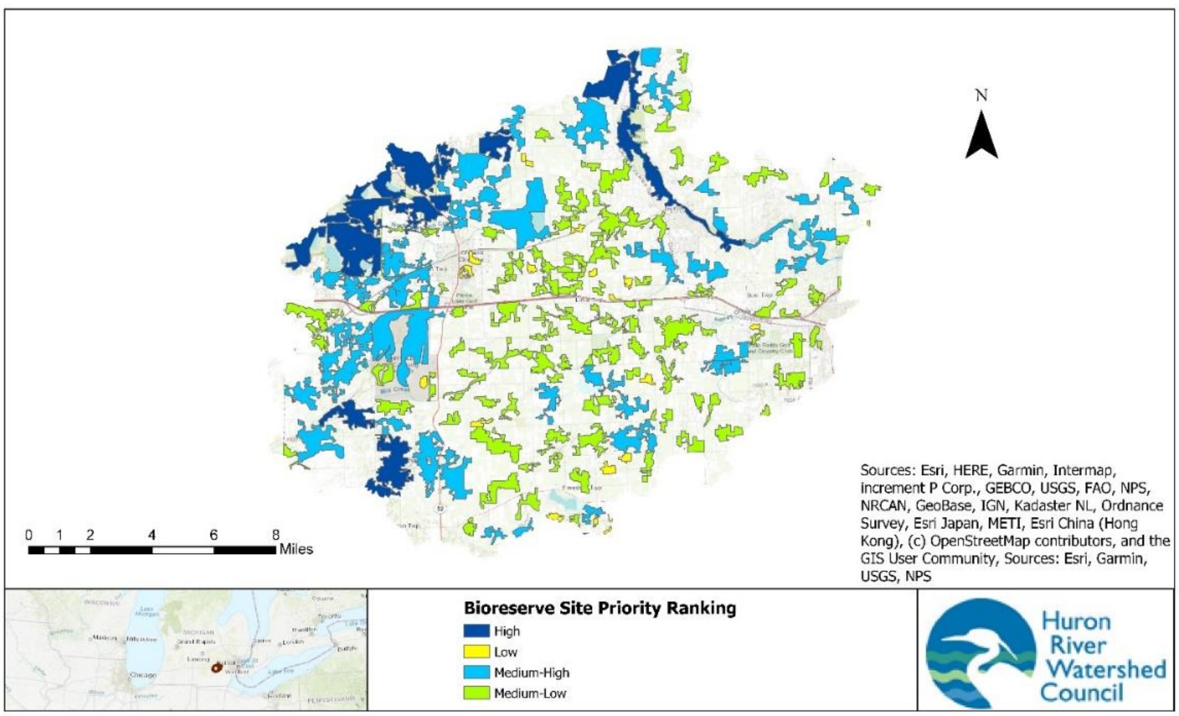
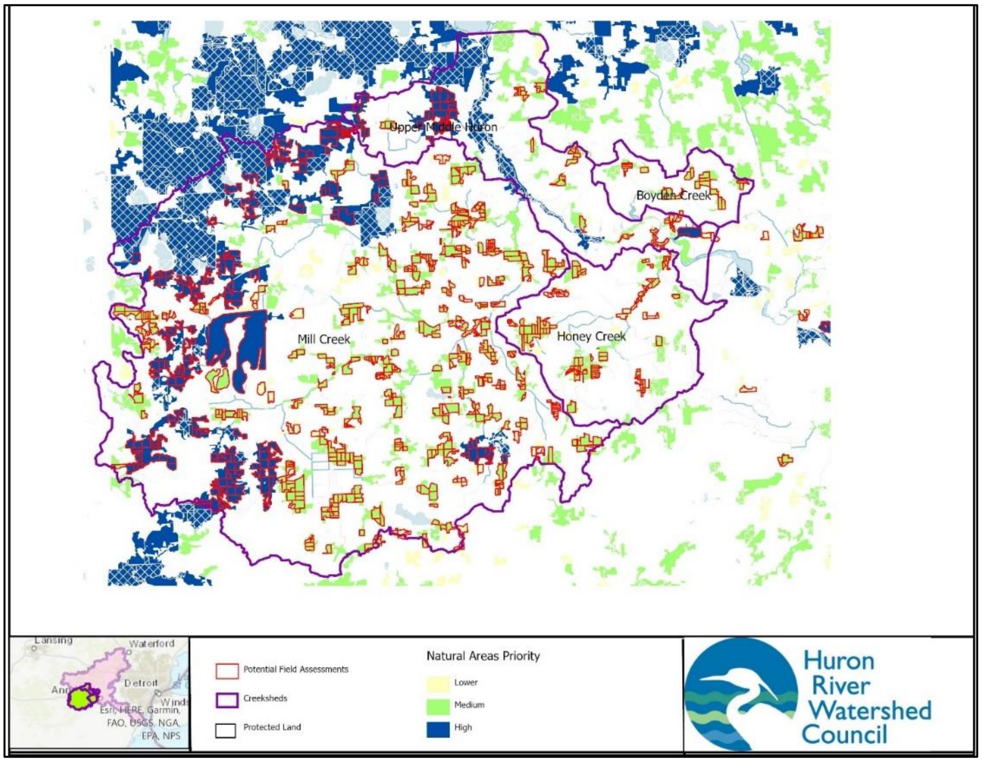


Figure 2.11. HRWC's NAAP priority natural areas overlaid with protected lands. Credit: Conservation and Recreation Lands-"CARL"[8]



[1] National Oceanic and Atmospheric Administration. 2013. Atlas 14, Volume 8. Precipitation-Frequency Atlas of the United States, Midwestern States.

[2] Stantec Consulting, Ltd. 2015, Revised Bankfull Discharge for Selected Michigan Rivers and Regional Hydraulic Geometry Curves for Estimating Bankfull Characteristics in Southern Michigan Rivers Study. Project Number: 2011-0100.

[3] Fongers, D., et al, Michigan Department of Environmental Quality. 2007. Application of the Richards-Baker Flashiness Index to Gaged Michigan Rivers and Streams.

[4] Michigan Department of Natural Resources. 1995. Huron River Assessment. Fisheries Special Report No. 16

[5] Michigan Department of Natural Resources. 2000. National Inventory of Dams database. Lansing, MI: MDNR.

[6] Michigan Features Natural Inventory, 2019. https://mnfi.anr.msu.edu/species/explorer

[7] Appel, Michael D, and Rome, Clea D. 2002 Identifying and Ranking Natural Areas in the Huron River Watershed. https://www.hrwc.org/wp-content/uploads/IdentifyingAndRankingNaturalAreasintheHuronRiverWatershed.pdf. Accessed June 2022.

[8] DEQ MiWaters. Conservation and Recreation Lands. http://gisp.mcgi.state.mi.us/arcgis/rest/services/DEQ/MiWaters/MapServer/49. Accessed June 2022.

2.2 Communities and Current Land Use

2.2.1. Political Structure

With an area of 204 square miles, the Watershed encompasses portions of 14 communities, 11 townships and three cities, Ann Arbor, Dexter, and Chelsea. One hundred percent of the cities of Dexter and Chelsea fall within the Watershed while only 4% of Ann Arbor is in the Watershed. Of the 11 townships, 2 of them have less than 10% of their area in the Watershed (Northfield and Ann Arbor Townships), while Lyndon is 20% and this ranges up to 100% for Lima and Sylvan. See Table 1.1 for the full breakdown.

99.5% of the Watershed is in Washtenaw County and the remainder is in Jackson County.

Political jurisdictions regarding the Huron River and its tributaries, riparian zones, and land are controlled by federal and state laws, county and local ordinances, and town by-laws. Regulatory and enforcement responsibility for water quantity and quality regulation often lies with the EPA and EGLE. Major activities regulated by the state, through EGLE, are the alteration/loss of wetlands, pollutant discharges (NPDES permits), control of stormwater, and dredging/filling of surface waters.

The State of Michigan maintains that:

> "'Surface waters of the state' means all of the following, but does not include drainage ways and ponds used solely for wastewater conveyance, treatment, or control:
>
> (i) The Great Lakes and their connecting waters.
>
> (ii) All inland lakes.
>
> (iii) Rivers.
>
> (iv) Streams.
>
> (v) Impoundments.
>
> (vi) Open drains.
>
> (vii) Wetlands.
>
> (viii) Other surface bodies of water within the confines of the state."[8]

The Huron River and its tributaries are public and subject to public trust protection. The Michigan Natural Rivers Act (PA 231, 1970) designated a 27.5-mile stretch of the Huron River from Kent Lake Dam in Oakland County to Barton Pond in Washtenaw County as a "country-scenic river." Therefore, the entire Huron River in this section of the Watershed falls in these bounds.

The Natural Rivers District includes 400 feet on either side of the ordinary high watermark where development is severely limited. On private lands, zoning requires 125 foot building setbacks on the mainstem and 50 foot setbacks on tributaries. Minimum lot width for new construction is 150 feet, with a 125 foot septic setback, and 50 feet of natural vegetation along the river. All restrictions apply to public lands as well, and the natural vegetation requirement increases to 100 feet for public lands. Within the District, no new commercial, industrial or extractive development is permitted within 300 feet of the river or tributaries.

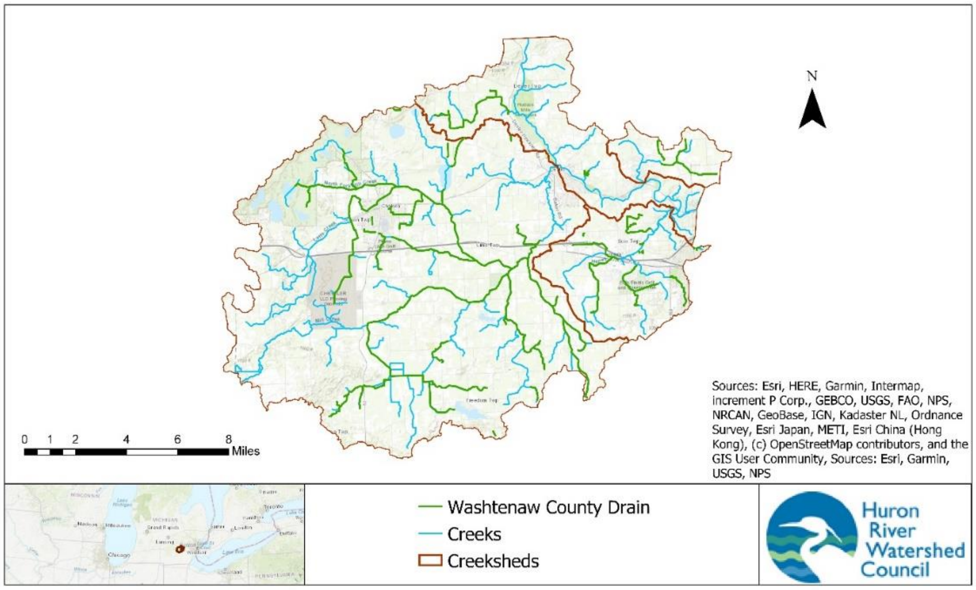
County government assumes responsibility for carrying out certain state policies. In most cases, county governments enforce the state erosion control policy, under the Michigan Soil Erosion and Sedimentation Control Act 347 of 1972 and Part 91 of Act 504 of 2000. 2. Some cities, villages, charter townships, and some general law townships have elected to enforce Part 91 through adoption of a soil erosion and sedimentation control ordinance. These agencies are called Municipal Enforcing Agencies (MEAs). MEAs will review soil erosion and sedimentation control plans, issue permits, and take enforcement actions when necessary to ensure compliance with Part 91 within their jurisdiction. In the Watershed many of the townships are MEAs[9]: Chelsea, Dexter, Freedom, Lima Township, Lyndon, Sharon, and Sylvan.

Designated county drains are maintained by the Washtenaw County Office of the Water Resources Commissioner. Figure 2.12 indicates the stream channels that are designated county drains in the watershed which may be open ditches, streams or underground pipes, retention ponds or swales that convey stormwater. These systems are designed to provide storm water management, drainage, flood prevention, and stream protection for urban and agricultural lands. The Drain Code gives the Water Resource Commissioner authority for construction or maintenance of designated county drains for flood control and water management.

In addition to oversight of these drains, in Washtenaw County the Water Resource Commissioner is required to maintain established lake levels throughout the county. Through the Inland Lake Level Act (Act 146, P.A. of 1961), a board of commissioners may file a petition in circuit court to establish a special assessment district to pay the costs of establishing and maintaining a lake level. The Water Resource Commissioner must determine the apportionment of costs incurred and assess for maintenance of the lake level. Section 24 of the Inland Lake Level Act requires inspection of all lake level control structures on all inland lakes that have normal levels established under this Act to be completed once every three years by a licensed professional engineer.

Drains including roadside ditches, pipes, bridges, and culverts under state highways and county roads that are not designated county drains are maintained by the Washtenaw County Road Commission.

Figure 2.12. Designated County Drains within the Watershed area (Marked as green and thicker lines).



Each local government in the watershed has a zoning code and holds regularly scheduled meetings where rulings are made on policy additions and changes, budgets, land use issues, and other important local business. Working with the guidance of statewide procedures, townships and other local governments have power to formulate land use and development policy, among other important activities. The cities of Dexter and Chelsea also have jurisdiction over and management responsibility for sewers and stormwater infrastructure, such as gutters, catch basins, pipes and outlets.

While state and county governments take an active role in many relevant watershed or water quality regulations and policies, local governments assume much leadership in land and water management by passing and enforcing safeguards. These local ordinances can be more protective than state laws, though state regulations set minimum protections that cannot be violated. Working under numerous established procedures, local governments may enact ordinances to control stormwater runoff and soil erosion and sedimentation; protect sensitive habitats such as woodlands, wetlands and riparian zones; and establish watershed-friendly development standards and lawn care and landscaping practices, among other options. Local governments oversee enforcement of their policies.

2.2.2. Growth Trends

Prior to European settlement, the region around the watershed was home to Chippewa and Potawatomi Native American tribes who had long used the land for farming, hunting, and gathering. Despite an unfavorable report by the U.S. Surveyor-General in 1815 that characterized the soils in the area as being unsuitable for farming, European settlers soon began to recognize the area's agricultural potential, which subsequently became an important area for livestock and grain in the 19th century. The settlers moved in, forcibly displacing the original inhabitants and massively altering the ecological landscape. This agricultural trend thrived until, in the wake of World War II, growth in southeast Michigan was catalyzed by the baby boom, increased automobile ownership, and establishment of better road systems. As a result, the influence of agriculture began to diminish as land was transferred to suburban uses in a trend that continues today.

A discussion of growth trends in the Watershed is challenged by the fact that readily available demographic data is based on political, rather than hydrologic boundaries. Furthermore, for several of the Watershed's 14 communities, only small portions of their areas are located in the watershed. As such, growth trends in these peripheral communities are not necessarily indicative of growth trends in the Watershed as a whole. Therefore, this section focuses on the 11 core communities which have 10% or more of their area in the Watershed: Townships of Lima, Scio, Sylvan, Freedom, Sharon, Dexter, Webster, Lodi, Lyndon, and the Cities of Dexter and Chelsea.

Federal decennial census data shows the historical rate of growth in the Watershed area, and then a SEMCOG model predicts future growth (Table 2.4).[10,11] From 1990 through 2020, the core communities' population nearly doubled (91% change). The largest contributor to this was Scio Township, whose population increased by 7,974 (83% change), though the City of Dexter tripled in size (200% increase) and Webster Township doubled (103% increase). Freedom Township was the only to area to have a population decrease.

With the exception of Freedom and Sharon Township, all of the areas are expected to grow by some positive rate in population by 2030 and 2040, but SEMCOG notes that the recession in the circa-2010 timeframe contributed to a slowing growth period and that in general the rate of growth is predicted to be slower from 2020-2040 than it was from 1990-2010.

Changes in total housing also reflect the rapidly changing population throughout the Watershed. Building of housing closely reflects population growth. [12]

Table 2.4. 1990-2040 Population Changes for Core Communities in the Watershed[13]

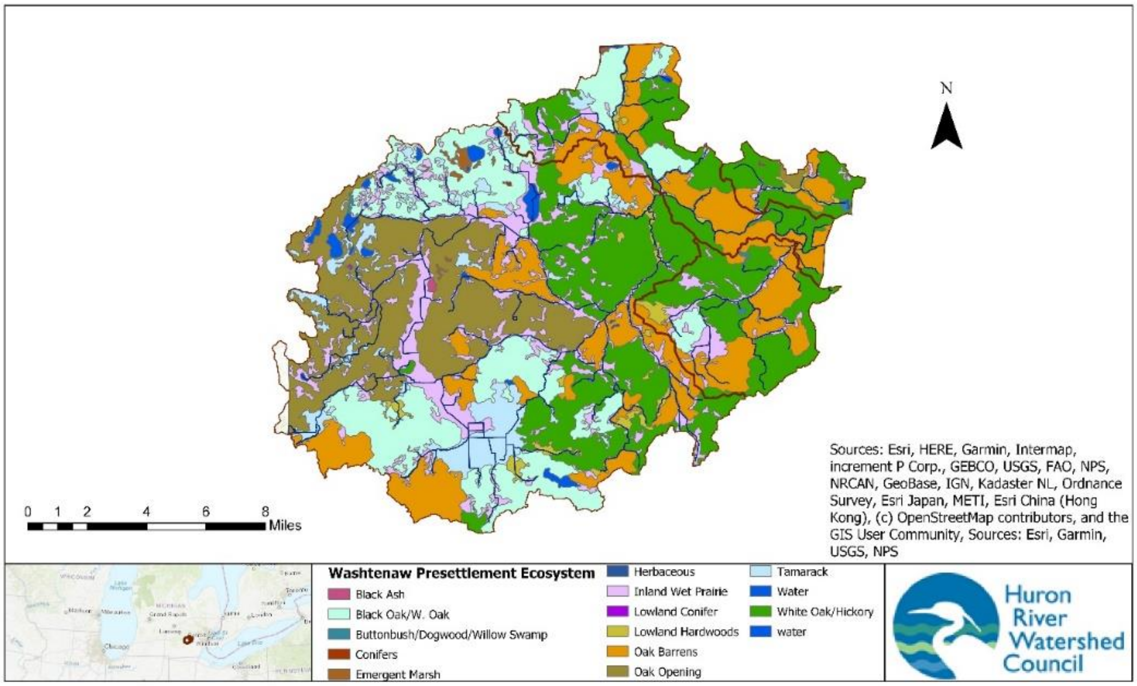
	1990 Census	**2000 Census**	**2010 Census**	**2020 Census**	**% change 1990-2020**	**2030 SEMCOG forecast**	**2040 SEMCOG forecast**
Freedom	1486	1562	1428	1332	-10%	1315	1241
City of Chelsea	3772	4398	4944	5467	45%	6676	6757
City of Dexter	1497	2338	4067	4500	200%	4594	4715
Dexter Township	4407	5248	6042	6696	52%	6795	7140
Lima	2132	2517	3307	4024	89%	4034	4607
Lodi	3902	5710	6058	6417	64%	6277	7196
Lyndon	2228	2728	2720	2656	19%	2842	2950
Sharon	1366	1678	1737	1817	33%	1696	1716
Scio	9578	13421	16470	17552	83%	23650	25572
Sylvan	2508	2734	2833	3311	32%	1791	4658
Webster	3235	5198	6328	6575	103%	6595	7078
TOTAL	33,511	46533	54821	63946	91%	66265	73,630

2.2.3. Land Use and Development

As the Watershed's communities develop, the potential increases for negative environmental impacts, including water quality impacts from erosion, sedimentation, and increased inputs of stormwater pollutants. Potential impacts on water quantity also increase as wetlands, woodlands, floodplains and other natural features that regulate water quantity are altered or replaced with impervious surfaces.

Prior to permanent European settlement, grasslands of oak barrens and forests of several species of oak and hickory dominated the landscape of the Watershed. This dominant landscape was interspersed with patches of wetlands, such as lowland hardwood and many acres of wet prairie (Figure 2.13).

Figure 2.13. Watershed's Ecosystems, circa 1830's.



Upon permanent settlement, the land began to be used for human benefit. Initial activities on the land centered on the clearing of grasslands for agricultural production and the use of forested areas for wood and wood by-products.

The most recent land use data, indicates the significant changes to the landscape that have occurred since settlement. (Figure 2.14)[14]. A very simple breakdown is that the Watershed is 44% agriculture/rural residential, 44% natural lands including wetlands, fields, and forests, and 10% urban/developed. Two percent are other uses that don't fit neatly into these categories like cemeteries, utilities, golf courses, and mining (Tables 2.5).

While 44% of the land is still natural, much of that is heavily affected by development impacts, and there is considerable potential for the reduction of water quality through agricultural practices and stormwater runoff. In addition, the vast majority of those natural lands are designated for some kind of residential, agricultural, or commercial land use (based on local government master plans and zoning ordinances), so their status can easily change when development proceeds forward.

The Watershed does not exist in isolation, and is called the Middle Huron for a reason. It receives substantial water from upstream, which comes into the Watershed with some water quality problems of its own. This upstream area is almost 500 square miles, is 9% impervious, and made up of landcover and landuse with the following breakdown: 24% forest, 19% agriculture, 5% open water, 1% grassland, 18% wetland, and 33% urban and residential. The Chain of Lakes Watershed Management Plan[15], while getting dated at this point, is still the best source of explanation for the section of the Huron River immediately upstream of the Watershed.

Figure 2.14. Current Land Use in 2020.

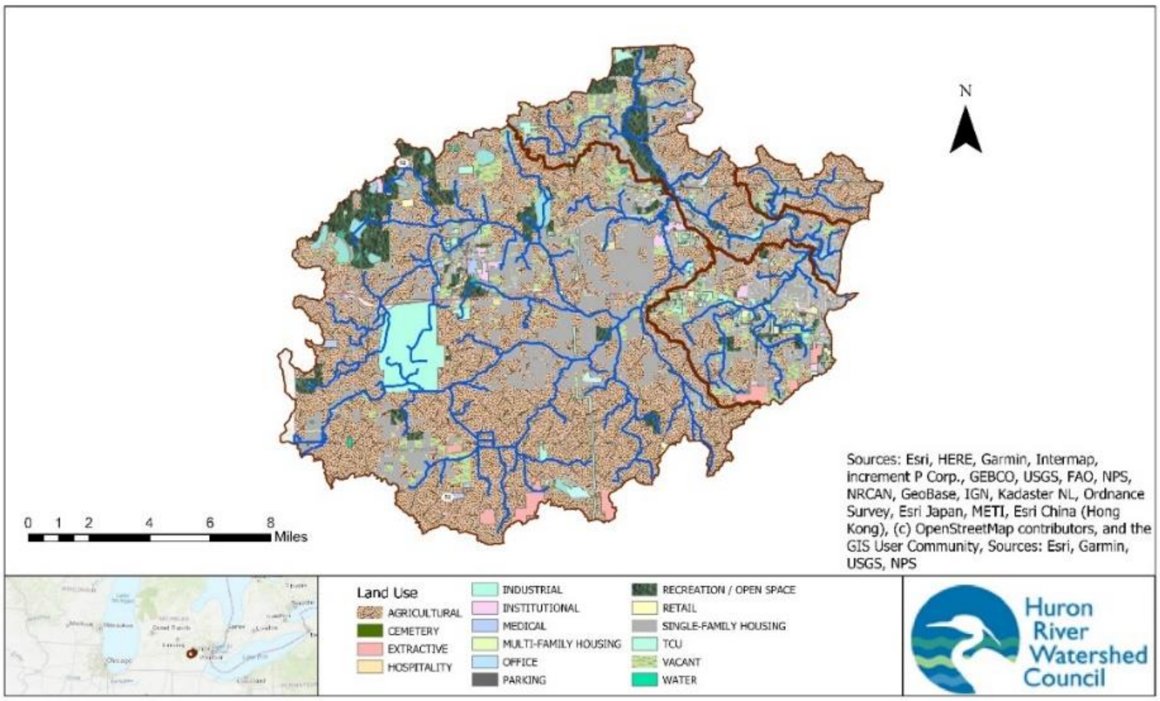


Table 2.5. 2020 Land use and Land cover in the Watershed, broken into the sub-watersheds.

Landuse/ Landcover	Breakout	Mill		Boyden		Honey		Upper Huron		The Watershed (all)	
		Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Watershed
Total		86357	100	4540	100	13038	100	17038	100	120973	100
Agricultural / Rural Residential		41340	48	2566	57	3662	28	5198	31	52767	44
Cemetery		50	0	1	0	4	0	2	0	56	0
Extractive		577	1	0	0	498	4	0	0	1075	1
Developed	**Total Developed**	5925	7	439	10	3586	28	2455	14	12405	10
	Hospitality	58	0	0	0	23	0	0	0	81	0
	Industrial	1537	2	0	0	346	3	57	0	1940	2
	Institutional	486	1	2	0	173	1	67	0	728	1
	Medical	136	0	0	0	23	0	4	0	163	0
	Mixed Use	87	0	0	0	6	0	3	0	96	0
	Office	69	0	0	0	161	1	10	0	240	0
	Parking	21	0	0	0	16	0	0	0	37	0
	Utilities	150	0	92	2	66	1	150	1	457	0
	Retail	166	0	0	0	333	3	17	0	516	0
	Attached Condo Housing	11	0	1	0	17	0	1	0	30	0
	Mobile Home	76	0	0	0	161	1	0	0	237	0
	Multi-family housing	78	0	0	0	90	1	2	0	170	0
	Single-family Housing	3048	4	345	8	2170	17	2146	13	7709	6

Landuse/ Landcover	Breakout	Mill		Boyden		Honey		Upper Huron		The Watershed (all)	
		Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Watershed
Forest	**Total Forest**	15885	18	660	15	2306	18	5371	32	24222	20
	Beech Maple	24	0	7	0	15	0	10	0	56	0
	Central Hardwood/Oak	1562	2	84	2	291	2	508	3	2446	2
	Dry-Mesic Oak Forest	1051	1	14	0	17	0	290	2	1371	1
	Dry Oak Forest	4534	5	111	2	317	2	1060	6	6021	5
	Maple Basswood	8352	10	443	10	1615	12	3060	18	13470	11
	Northern Hardwoods	1	0	0	0	0	0	0	0	1	0
	Northern Pine-Oak	20	0	0	0	1	0	8	0	29	0
	Pine	342	0	1	0	51	0	436	3	829	1
Golf Course		145	0	119	3	134	1	145	1	543	0
Grassland	**Total Grassland**	3452	4	108	2	1117	9	988	6	5664	5
	Grass and shrub land	3287	4	107	2	1114	9	947	6	5455	5
	Pine-Oak Barrens	165	0	0	0	2	0	41	0	209	0
Recreation/ Open Space		523	1	38	1	288	2	392	2	1241	1

Landuse/ Land cover	Breakout	Mill		Boyden		Honey		Upper Huron		The Watershed (all)	
		Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Creekshed	Acres	% of Watershed
Wetlands	**Total Wetland**	18461	21	609	13	1442	11	2488	15	23001	19
	Aquatic Bed Wetland	21	0	0	0	0	0	5	0	25	0
	Emergent Wetland	488	1	0	0	0	0	110	1	598	0
	Floodplain	6752	8	184	4	703	5	1163	7	8802	7
	Lowland Conifer	4	0	0	0	0	0	4	0	8	0
	Lowland Hardwoods	635	1	54	1	161	1	261	2	1112	1
	Mixed Wooded Wetland	59	0	0	0	0	0	0	0	59	0
	Rich Swamp	6986	8	299	7	192	1	630	4	8107	7
	Shrub-Herbaceous Wetland	1022	1	17	0	46	0	154	1	1239	1
	Shrub/Scrub Wetland	2496	3	54	1	339	3	160	1	3049	3
	Swamp	0	0	0	0	0	0	1	0	2	0

2.2.4. Point Sources and Permitting

Due to the nutrient TMDLs in Ford and Belleville Lakes, waste load allocations for phosphorus contributions from permitted point sources have been established in all upstream contributing portions of the Huron River watershed. These waste load allocations set goals on the maximum amount of phosphorus that should be discharged into waters flowing to these TMDL areas. These limits are considered when determining the amount of phosphorus that may be discharged by existing National Pollutant Discharge Elimination Systen (NPDES) permittees. The TMDL may also factor into determining whether additional phosphorus-discharging facilities may be permitted to locate in a TMDL area, and what their discharge limits may be.

There are several point source facilities in the watershed that hold NPDES permits issued by the State of Michigan (Figure 2.15). The number of permitted point sources is not static due to expiring old permits and activation of new permits.

As of June 2022 according to EGLE's MiWaters mapping tool[9], 122 permits were in issuance. Receiving waters for the discharges include direct drainage to the Huron River, all major tributaries, numerous secondary streams or drains, and impoundments along these water bodies.

Individual Permits are written to reflect site-specific conditions of a single discharger and is unique to that discharger. There were 12 of these in the Watershed as of June 2022.

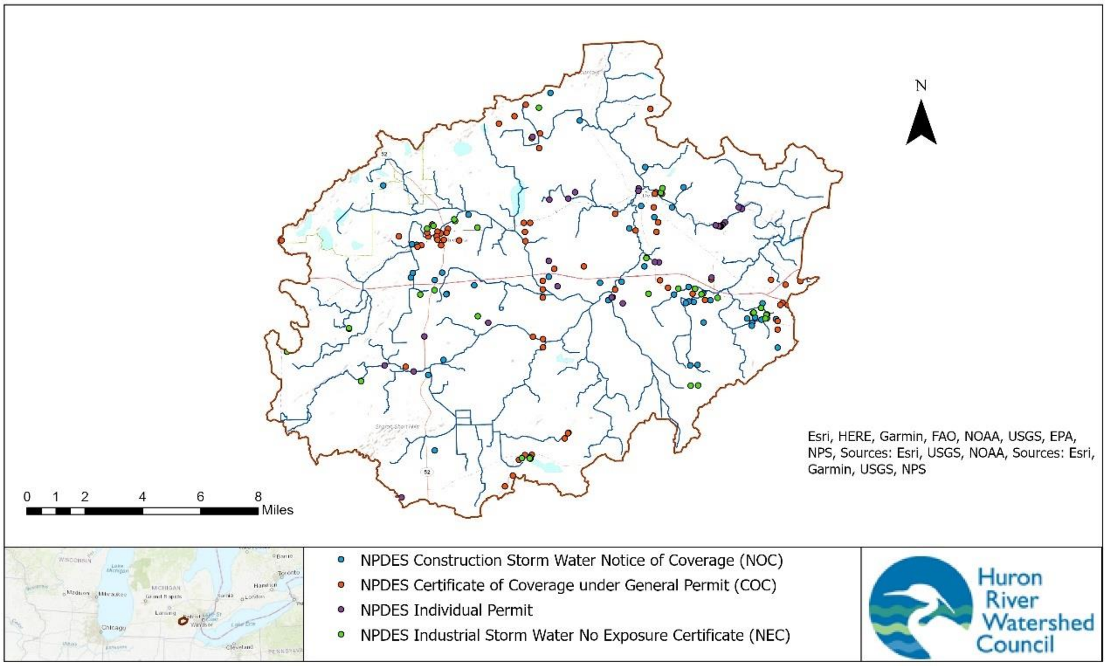
- Ann Arbor Waste Water Treatment Plant
- Chelsea Waste Water Treatment Plant
- Dexter Waste Water Treatment Plant
- Loch Alpine Waste Waster Treatment Plant
- Thornton Farms Waste Water Treatment Plant
- Thetford/Norcold-Dexter
- Sweepster-Harley Attachments
- Chrysler-Chelsea Proving Grounds
- Pall Life Sciences Inc
- Manchester Waste Water Treatment Plant
- Washtenaw County MS4 Facility
- Edward Brothers Inc.

Fifty-one of the permits were for NPDES Certificate of Coverage under General Permit (COC). General permits contain effluent limitations protective of most surface waters statewide but are not tailored to a specific permittee.

Forty-six of the permits were issued to facilities that discharge stormwater associated with construction activities. (NPDES Construction Storm Water Notice of Coverage, NOC).

NPDES Industrial Storm Water No Exposure Certificate (NEC) permits for various types of industrial materials and activities where it is expected that the activities are protected from exposure to rain, snow, snowmelt, and runoff through storm-resistant shelters. There are 13 of these permits in the watershed.

Figure 2.15. NPDES permits in the Watershed, as of June 2022. Some permits have multiple locations, all of which are mapped here.



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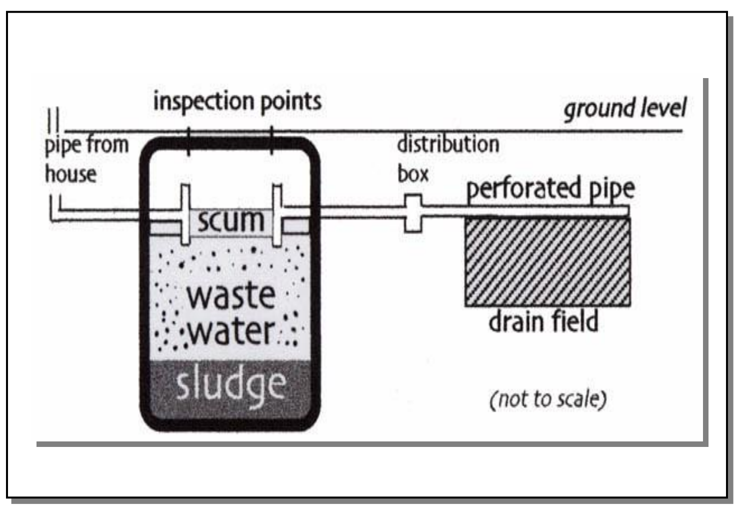
2.2.5. Sanitary Sewer Service Areas and Privately-Owned Septic Systems



The Watershed has a mix of households whose waste discharges are treated by publicly owned wastewater treatment plants (WWTP) or on-site decentralized wastewater systems (privately-owned septic systems). Sanitary sewers rely on the connection of pipes from residential, commercial, and industrial sites that ultimately are received at a wastewater treatment plant where treatments are applied before discharge. Privately owned on-site septic systems, or septic tanks, allow wastewater from a single (sometimes multiple) entity to be treated via biological and infiltration processes. Both technologies are effective methods of wastewater treatment if maintained and operated properly; however, impairments do occur. Households currently served by sanitary sewers are located in the urbanized areas of the watershed, while remaining areas are served by on-site septic systems (Figure 2.16).

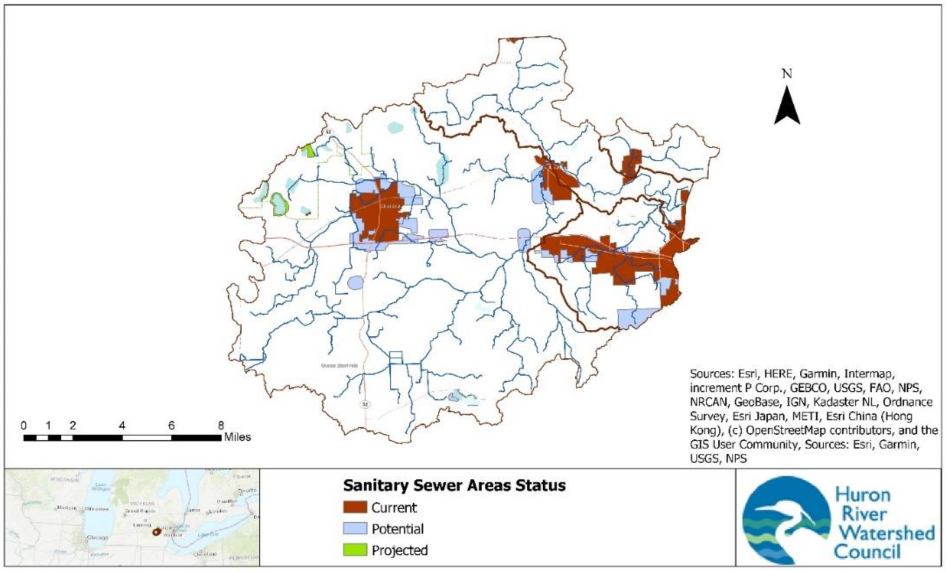
Improperly functioning sewer systems and privately-owned septic systems can have a profound impact on water quality. By carrying nutrients (phosphorus and nitrogen), bacteria, pharmaceutical agents, and other pollutants to waterbodies with little or no treatment, impaired systems can result in unhealthful conditions to humans (i.e., bacterial contamination) and to aquatic organisms (i.e., low dissolved oxygen from plant growth).

If either system is designed, constructed, or maintained improperly, it can be a significant source of water pollution and a threat to public health. The Washtenaw County Health Department regulates the design, installation, and repair of privately-owned septic systems. Washtenaw County currently requires regular maintenance and inspection to assure proper functioning of these systems, which occurs at the time the property is sold.

Sanitary sewer systems can suffer from improper installation and maintenance. For instance, in many older developments sanitary sewer pipes can be inadvertently connected to stormwater drainage systems, causing what is termed an “illicit discharge.” These discharges can have an even greater impact on water quality than impaired septic systems, depending on the type, volume, and frequency of the activity. Both county and local units of government covered by Phase II stormwater permits are required to identify and eliminate illicit discharges in their communities through an Illicit Discharge Elimination Program (IDEP).

Development projects can utilize community wastewater systems, also known as decentralized wastewater systems, which provide on-site wastewater treatment for multiple homes much like a giant septic system. Community wastewater systems are increasingly being used to build high density developments in un-sewered areas where soils are not suitable for individual septic systems. A drawback of these large septic systems is the potential discharge of large quantities of septic waste into a localized groundwater area. Conversely, community wastewater systems can also be a tool for mitigating the impacts of individual septic systems over a larger area; rather than locating several individual septic systems in close proximity to a lake or waterway where they could pose a greater risk to surface waters or groundwater, a community wastewater system could allow the homes to be built near the waterbody, while the community septic system would be located at a greater distance from the waterbody. Community systems can also allow houses to be grouped together on smaller lots, thus avoiding conversion of natural areas to accommodate each individual lots. Due to the potential impacts of community wastewater systems, communities should be aware of their complexities and plan accordingly for their location, construction, and operation.

Figure 2.16. Sanitary Sewer Areas in the Watershed



2.3 Water Quality Parameters

This section provides a synopsis of water constituents and how they make up and affect the aquatic ecosystems of the Watershed. Many of these parameters are also indicators for gauging water quality. A general discussion of basic limnology (lake behavior) is also presented. While these parameters are important and useful in evaluating overall water quality, data for all of them were not readily available for all creeks in the Watershed. For the data that is available, it has been broken down to the creekshed level and presented in Section 2.4.

2.3.1. Chemical and Physical Parameters

2.3.1.1 Stream Morphology and Substrate

Stream channels provide a diversity of habitats for aquatic life and each serves a different function for the stream ecosystem. Most natural stream channels alternate through a pattern of riffles (small rapids), runs, glides and pools. The specific shape and pattern is controlled by the underlying geology (bedrock, rocks and soils) and hydrology (pattern and size of stream flow). Natural streams can take on a variety of forms along the journey from headwaters to confluences, and these forms are generally dynamic – changing somewhat following each major storm. If the stream has a good connection to its floodplain, it might meander from one channel to another and back again over the years. As this movement occurs, the stream lifts, transports and deposits sediment into its channels or floodplains, creating new aquatic and upland habitat. As hydrology is altered (e.g. through artificial channelization or upland urbanization and disconnection to groundwater), storm flows increase, and the erosion rates of stream banks and beds increase as well. This can result in homogenization of channel type, habitat destruction, and loss of important sediment and chemical processing functions. Phosphorus can be exported with higher erosion, and stagnant, low oxygen pools can form that promote bacterial growth. Highly altered streams of this type produce biological communities with very low diversity.

Stream bottoms or substrate can be composed of a number of different materials, depending on the geology of the stream bed and surrounding drainage area. This substrate can vary from a predominance of large particles such as gravel, cobble or even bedrock to moderately sized sands to fine organic particles in silt and clay. Silt, which is the fine-grained particulate matter that results from eroded soil, can be deposited in streams over substrate composed of larger particles. Silt in riffles can limit the number of creatures living in a creek because it fills the spaces between surfaces and reduces oxygen in the substrate. Eroded silt also degrades water quality because soil binds pollutants, like phosphorus, which helps to create nuisance algae blooms. Many streambeds in the Huron River system are naturally sand or gravel bottoms. When fine sediments build up too fast, the natural aquatic ecology cannot rapidly adapt and the biotic diversity may be degraded. Erosion is a natural process, but dramatic increases in fine sediment suggest unnaturally high erosion rates upstream. Evaluation of stream banks can help determine the need for bank and channel restoration.

One method HRWC uses to assess stream habitat is through a procedure called "Measuring and Mapping"[10], which itself is a volunteer friendly version of EGLE's Procedure 51 Habitat Assessment.[11] In this assessment, volunteers conduct a pebble count/substrate size analysis across ten cross sections of the creek, assessing at a minimum 100 pieces of substrate and then computing overall substrate size percentages (% boulder, cobble, rock, gravel, sand, fines/muck). Volunteer also answer qualitative questions regarding amount and quality of riffles, runs, pools, riparian habitat, woody debris, and so on. HRWC use these answers to calculate a stream habitat score with the same metrics used in the P51 assessment.

In recent years, HRWC began using a method called BANCS (Bank Assessment for Non-point source Consequences of Sediment, Appendix G) to evaluate the stability of representative stream reaches (i.e. segments) throughout the Huron River Watershed. In summary, the rapid evaluation method assesses the erodibility of a stream reach's banks and the hydraulic forces impacting those banks to estimate erosion rates for each bank. These bank assessments can then be compiled into an overall erosion rate for the stream reach or average rates for all evaluated streams within a creekshed. The erosion estimates should only be used to get a general sense of the scale of erosion relative to other streams in the system (rather than taken as precise estimates of sediment load), as the techniques are designed for a rapid and broad assessment.

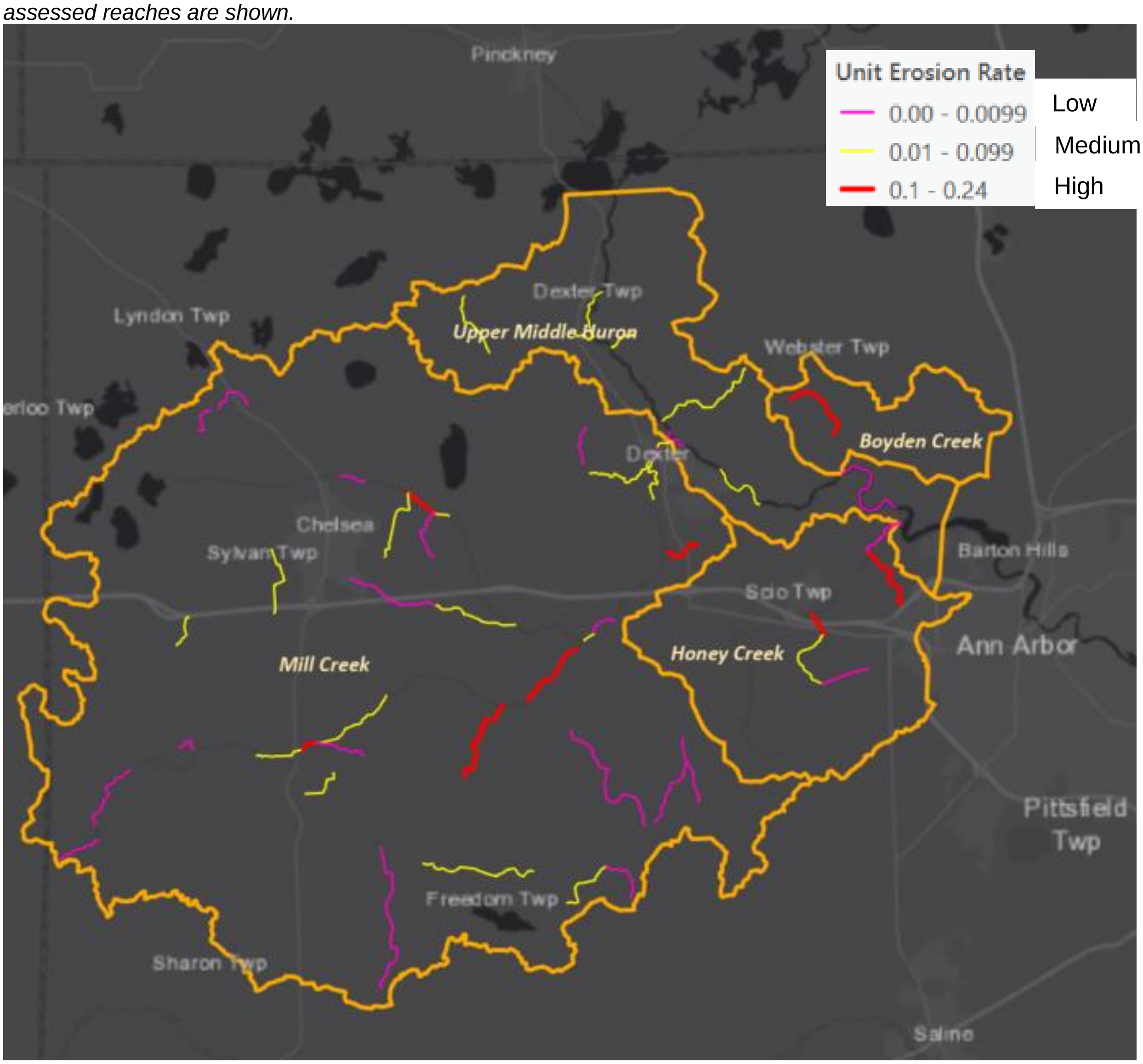
Given the size of the Watershed and total length of streams, HRWC needed to assess a sample of reaches rather than attempt a full census. To get a representative sample of different types of streams, HRWC segmented reaches by drainage area. For this Watershed, teams of HRWC field assessors were able to evaluate 36 miles of stream/river to estimate erosion rates for 62 miles of stream reaches.

Results for each creekshed are presented in section 2.4, but Figure 2.17 shows the evaluated stream reaches and their erosion rates. Within the Watershed, there are a small number of stream reaches with high erosion rates (Table 2.5). The rest of the reaches are split almost evenly between those with a moderate erosion rate and those with a low erosion rate, or stable banks. Reaches with high erosion rates tended to be in the mid-range of drainage area size class, as none of the river sites had high rates, and few of the smallest headwater streams did as well.

Table 2.6. Summary of BANCs results for the Watershed.

Erosion Rate	# of Reaches	% of Assessed	Assessed Reach Length (mi)	% of Total Length	Mean Drainage Area (mi^2)	Median Drainage Area (mi^2)
High	9	14%	8.9	14%	15.8	5.5
Moderate	21	42%	26.3	42%	84.5	6.7
Low	30	43%	26.8	43%	82.6	3.8
Total	60	100%	62.0	100%		

Figure 2.17 Estimated Unit Erosion Rates (in tons/yr/ft of stream) for Evaluated Stream Reaches. Note: only assessed reaches are shown.



2.3.1.2 Phosphorus

Phosphorus and nitrogen are nutrients essential for the growth of aquatic plants. Phosphorus is needed for plant growth and is required for many metabolic reactions in plants and animals. Generally, phosphorus is the limiting nutrient in freshwater aquatic systems. That is, if all phosphorus is used up, then plant growth will cease no matter how much nitrogen is available. Phosphorus is the main parameter of concern that causes excessive plant and algae growth (eutrophication) in lakes and impoundments. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient-poor or low plant productivity), mesotrophic (moderate nutrient levels and moderate plant productivity), eutrophic (nutrient-rich, high plant productivity) and hypereutrophic (excessive plant productivity and excessive nutrients). Eutrophic and hypereutrophic conditions are characterized by depletion of dissolved oxygen in the water. Low levels of dissolved oxygen adversely affect aquatic animal populations and can cause fish kills. High nutrient concentrations interfere with recreation and aesthetic enjoyment of waterbodies by causing reduced water clarity, unpleasant swimming conditions, foul odors, blooms of toxic and nontoxic organisms, and interference with boating.

Phosphorus enters surface waters from point and nonpoint sources, with nonpoint sources accounting for the vast majority of phosphorus loading in the Watershed. Wastewater treatment plants are the primary point sources of the nutrient. Additional phosphorus originates from the use of industrial products, such as toothpaste, detergents, pharmaceuticals and food-treating compounds. Tertiary treatment of wastewater, through biological removal or chemical precipitation, is necessary to remove more than 30% of phosphorus.

Nonpoint sources of phosphorus include human, natural, and animal sources. Because phosphorus has a strong affinity for soil, stormwater runoff from activities that dislodge soil or introduce excess phosphorus (such as conversion of land to urban uses and over-fertilization of lawns) is frequently considered the major nonpoint source of phosphorus contribution to waterbodies. Eroded sediments from agricultural areas carry phosphorus-containing soil to surface waters. Septic system failures and illicit connections also are routes for phosphorus introduction. Domesticated animal and pet wastes that enter surface waters comprise another nonpoint source of phosphorus. Natural sources include phosphate deposits and phosphate-rich rocks that release phosphorus during weathering, erosion and leaching; and sediments in lakes and reservoirs that release phosphorus during seasonal overturns. EGLE considers total phosphorus concentrations higher than 0.03 mg/L (parts per million) to have the potential to cause eutrophic conditions.

Due to the persistent and systemic presence of high concentrations of phosphorus in Ford and Belleville Lakes, as well as the Huron River and tributaries upstream in the watershed, high nutrient loading is the top challenge identified in this Plan. A TMDL for excessive phosphorus loading from point and nonpoint sources has been established for Ford and Belleville Lakes and their contributing waters. While the flowing Huron River and its tributaries do not generally show signs of excessive phosphorus concentrations, the impoundments along these waterways tend to act as sinks for phosphorus loading, which can lead to eutrophic conditions.

2.3.1.3 Nitrogen

Nitrogen is also considered essential in determining algae growth in lakes and is found in a number of forms, including molecular nitrogen, ammonia, nitrates, and nitrites. Nitrogen is often found in waterbodies at higher concentrations than phosphorus. Consequently, nitrogen is often not considered the limiting nutrient to detrimental growth. Additionally, unlike phosphorus loading, nitrogen loading is often difficult to reduce due to the high water solubility of nitrogen. Therefore, concerns regarding nitrogen and its role in eutrophication often are considered secondary to phosphorus in southeast Michigan. However, studies have shown that high nitrate concentrations, even without phosphorus limitations, can promote eutrophication. In addition, studies also reveal that dual control on nitrogen and phosphorus result in short term reductions in eutrophication. Typical sources of nitrogen in surface waters include human and animal wastes, decomposing organic matter, and runoff from fertilizers. Improperly operated wastewater treatment plants and septic systems, as well as sewer pipeline leaks also can act as additional sources of nitrogen to waterbodies. EGLE considers total nitrogen levels greater than 1 to 2 mg/L to have the potential to cause eutrophic conditions. Nitrate levels above 10 mg/L are considered unsafe for drinking water[12].

2.3.1.4 Salts, Conductivity, and Total Dissolved Solids

Salts typically enter waterways from road salting (de-icing) operations or from water softener backwash discharge into the environment. De-icing products, primarily sodium chloride, are used locally by MDOT, county road commissions, homeowners, and business/commercial establishments. Salts are highly soluble in water and easily wash off pavement into surface waters and leach into soil and groundwater. High concentrations of salt can damage and kill vegetation, disrupt fish spawning in streams, reduce oxygen solubility in surface water, interfere with the chemical and physical characteristics of a lake, and pollute groundwater making well water undrinkable.

A study by the USGS in Oakland County on the effects of urban land use change on streamflow and water quality showed a strong positive correlation between salt ions (sodium, potassium, and chloride) and residential and commercial landcovers, as well as overall percentage of the watershed built, and population density.[13] These ions were negatively correlated with agriculture, open space, forest, and wetland land covers. While it may be reasonably stated that the rapid urbanization in the Watershed has led to increased salt concentrations in the water, the extent to which this is occurring and the impacts of these salt concentrations requires additional monitoring data and studies. Michigan has a relatively new water quality standard for chloride concentration. Chloride is the most persistent and harmful component of most salts. Based on this standard, the chronic and acute impacts on aquatic wildlife occur at relatively high chloride concentrations – approaching sea water concentrations.

Best management practices to reduce salt inputs may include the use of alternative road de-icers such as calcium carbonate, magnesium chloride or calcium acetate that are not as detrimental to water quality. In addition to salt alternatives, proper calibration of salt dispensing equipment and optimizing the timing of de-icing applications can reduce over-use of salt and alternative de-icers.

Conductivity, a broad indicator of general water quality, increases with the amount of dissolved ions, such as salts or metals. There is some evidence that average conductivity measured at a site over 800 microsiemens (µS) can be correlated with lower stream biodiversity.[14] Conductivity over 800 µS may indicate the presence of toxic substances, but it can also be high due to naturally occurring ions. Many toxins are also not detected by conductivity measures. A high conductivity measurement signals a need for further investigation to better determine the cause and potential sources.

Since 2002, conductivity has been recorded at sites in the Watershed through the Chemistry and Flow Monitoring Program. Monitoring data is collected twice monthly from April through September. In addition, conductivity is monitored by HRWC's River Roundup program when the volunteer teams sample for macroinvertebrates.

Conductivity is also highly correlated with Total Dissolved Solids (TDS), which include anything dissolved in water including minerals, salts, metal, cations, anions and organic molecules. Though a more accurate measurement for expressing the chemical constituents of water, TDS is a more expensive and complicated measurement to make, and thus Conductivity is often used in lieu of TDS.

2.3.1.5 Organic Compounds and Heavy Metals

Organic compounds (PCBs, PFAS, PAHs, DDT, etc.) and heavy metals (lead, copper, mercury, zinc, chromium, cadmium, etc.) can potentially cause adverse impacts on river ecosystems. These chemicals and metals can disrupt the physiology of aquatic organisms and can accumulate in their fatty tissues. Organic chemicals such as PCBs are by-products of manufacturing processes and the combustion of fossil fuels. They are also present in automobile fluids such as gasoline and oils. Other organic chemicals are found in pesticides and herbicides. Heavy metals are also a common by-product of manufacturing, but these contaminants are also common in agricultural and road runoff.

In the Watershed, potential sources of organic compounds and heavy metals include urban areas, roads, permitted industries, existing in-stream contamination from historic activities, chemicals from lawns, and runoff from agricultural operations.

Coal tar sealcoats are incredibly high in polycyclic aromatic hydrocarbons (PAHs). PAHs are of concern because many of these compounds have been identified as toxic, mutagenic, teratogenic (causing birth defects) and/or probable human carcinogens. Coal tar sealants contain 1000 times more PAHs than asphalt-based sealants (a readily available alternative) and are the number one source of PAHs in lake sediments.[15] PAHs from coal tar sealcoat are released into the environment in several ways. When applied, these compounds volatilize into the air, affecting air quality. As the sealcoat weathers, dust from the pavement makes its way into homes on shoes and clothing. When it rains, loose particles move into soils, stormwater catch basins, lakes, and rivers.

HRWC has done significant work on PAHs in the last decade. HRWC conducted PAH sampling in several detention ponds in Fleming, Mallets, and Traver Creeksheds (results shown in the Middle Huron River Section 2 Watershed Management Plan[16]). Results show that the Watershed has elevated PAH levels; and since studies indicate that 50-75% of PAHs found in sediments in the Great Lakes Region come from coal tar sealants.[17] HRWC has worked with municipalities to pass ordinances restricting use. Within the Watershed, Scio Township and the City of Dexter have now adopted ordinances that make it illegal to sell or apply high PAH pavement sealers.

Polyfluoroalkyl substances (PFOS) are a family of manmade organic molecules that were revealed to be a problem in the Huron River Watershed in August 2018, after EGLE reported high levels in the tissues of fish from Kent Lake. In 2018, the Michigan Department of Health and Human Services has issued a "Do Not Eat Fish" advisory for most of the Huron River from the crossing at North Wixom Road in Milford all the way to Lake Erie. This includes the Huron River section contained in the Watershed of this Management Plan. The Huron is now listed for failure to meet the Fish Consumption designated use in the 2020 EGLE Integrated Report[18]. This is a critical area that needs further addressing. See more details in section 2.5.2.4- Fish Consumption Advisory on the Huron River: Perflurooctane Sulfonate (PFOS) Impairment.

A number of international, national and regional studies over the past two decades have documented the presence of pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) in surface waters. PPCPs include substances such as drugs and cosmetics. EDCs are any chemicals that have been shown to interfere with the normal function of the human endocrine system. Both types of compounds have potential human health and wildlife impacts. Researchers are currently working to evaluate the effects of environmental exposure to PPCPs and EDCs.

These substances can enter the environment through a number of routes including: wastewater treatment discharge, industrial discharge, runoff from confined animal feeding operations, and land application of animal waste. The U.S. Geological Survey conducted a national study of 139 streams in 30 states and found that 80% of those streams contained at least one of the 95 compounds they targeted.[19]

In 2004, a targeted study conducted for the City of Ann Arbor assessed city waters for 22 compounds of concern. [20] The researchers in that study found that ten of the 22 compounds were present in the source water in Barton Pond, with four remaining in finished drinking water; and 17 of the 22 compounds were found in wastewater influent, with 15 compounds making their way into the effluent discharged to the Huron River. The existing treatment processes for both drinking water and wastewater reduced the concentrations for most, but not all the target compounds.

2.3.1.6 Acidity (pH)

Measuring pH provides information about the H+ concentration in the water. pH is measured on a logarithmic scale that ranges from 0-14, so river water with a pH value of 6 is 10 times more acidic than water with a pH value of 7. Organisms that live in rivers and streams can survive only in a limited range of pH values. In Michigan surface waters, most pH values range between 7.6 and 8.0. Michigan Water Quality Standards require pH values to be within the range of 6.5 to 9.0 for all waters of the state. The pH of rivers and streams may fluctuate due to natural events, but humans also can cause unnatural fluctuations in pH. For example, chemical contamination from spills can cause short-term pH changes.

2.3.1.7 Turbidity and Suspended Sediments

While some sedimentation in a river system is natural, when streambanks in one area erode and the soil is deposited downstream, the Watershed experiences heavy sedimentation on the Huron River, its tributaries, and lakes and impoundments. Impacts of soil erosion and sedimentation on downstream water resources include decreased aesthetic quality with increased turbidity, decreased light penetration and decreased plant growth, and decreased aquatic habitat quality with sediment covering and clogging gills of fish and aquatic insects. In addition, nutrients and other pollutants often bond with soil particles, increasing the detrimental impacts of sedimentation on water resources.

Many streambeds in the Huron River system are naturally composed of sand, gravel, and cobble. However, a problem arises when there are rapid shifts from these coarse materials to more fine sediments. Excessive deposits of fine sediment are known to impair macroinvertebrate communities.

Increased stormwater flows result in increased sediment loadings for a variety of reasons. Soil particles are picked up by stormwater as it flows over roads, through ditches, and off of bridges into surface waters. Increased flows from stormwater runoff or dam discharge have enough energy to scour soils and destabilize stream banks, carrying bank sediments downstream. In addition, runoff from some construction sites can be sources of sediment if proper soil erosion and sedimentation controls are not in place on bare soil that has been exposed during the construction process. Sediment enters the water at bridges as a result of inadequate construction and maintenance practices, and via road ditches, which convey sediment from unpaved roads into the stream. Other sources of sediment include wash-off from paved streets and parking lots. Active agricultural land may be a source of concern in the rural areas of the Watershed since traditional farming practices leave soil bare and tilled at certain times of the year, which results in soil vulnerable to wind and water erosion.

Turbidity is the measure of the relative clarity of water and is a measure of the suspended solids in the water that reduce the transmission of light. This relationship depends on several factors including the size and shape of the suspended particles along with their density in the water, as well as the degree of turbulence at the sample site. Turbidity should not be confused with color since darkly colored water can still have low turbidity or high relative clarity. Total suspended solids (TSS) include all particles suspended in water that will not pass through a filter of a specified size. Suspended solids are any particles/substances that are neither dissolved nor settled in the water. A third measure, suspended sediment concentration (SSC) is now being promoted by EGLE, USGS and EPA as a more accurate measure for open channel monitoring. SSC differs from TSS in the methods of calculation. Both express the amount of sediments suspended in a sample of water.

High turbidity and TSS/SSC result from soil erosion, stormwater runoff, algal blooms and bottom sediment disturbances. Turbid water absorbs heat from the sun. Warmer water holds less oxygen than cooler water, resulting in less oxygenated water. Water with high turbidity loses its ability to support diverse aquatic biology. Suspended solids can be diverse in composition, including clay, silt and plankton as well as industrial wastes and sewage or other components. High amounts of suspended solids can clog fish gills, reduce growth rates and disease resistance in aquatic organisms, decrease photosynthesis efficiency, reduce dissolved oxygen (discussed in a later section) levels, and prevent egg and larval development. Settled particles can accumulate on the stream bottom and smother fish and amphibian eggs and aquatic insects including larvae of benthic macroinvertebrates.

Michigan Water Quality Standards set a narrative standard that waters of the state shall not have any of the following unnatural physical properties in quantities which are or may become injurious to any designated use: turbidity, color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits. Most observers consider water with a TSS concentration less than 20 mg/l to be relatively clear. Water with TSS levels between 40 and 80 mg/l tends to appear cloudy, while water with concentrations over 150 mg/l usually appears dirty. The nature of the particles that comprise the suspended solids may cause these numbers to vary.[21] Standards have not been established for turbidity, but levels for turbidity have been set for stream segments that have been listed for impairment of biota.

Stormwater carries sediment directly into the nearest waterway.
Photo: HRWC files

A simple, though somewhat subjective, method of measuring water clarity in lakes uses a Secchi disk, which is an 8-inch diameter plate with alternating quadrants painted black and white. The observer lowers the disk into water until it disappears from view and then raises it until it becomes just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. Nearly all Secchi disc measurements on Michigan inland lakes will be between one and forty feet, and this score is also an indicator of nutrient levels in the lake. EGLE classifies Secchi disk readings greater than 16 feet as indicative of oligotrophic (low nutrient) conditions. Secchi disk readings between 6.5 and 16 feet indicate mesotrophic conditions, and Secchi disk readings less than 6.5 feet indicate eutrophic (high nutrient) or hypereutrophic conditions.[22]

2.3.1.8 Temperature

Water temperature directly affects many physical, biological, and chemical characteristics of a river. Temperature affects the amount of oxygen that can be dissolved in the water, the rate of photosynthesis by algae and larger aquatic plants, the metabolic rates of aquatic organisms, and the sensitivity of organisms to toxic wastes, parasites, and diseases. These factors limit the type of macroinvertebrate and fish communities that can live in a stream.

An average summer temperature of about 72º F is the warmest water that will support coldwater fish, such as sculpin and trout. Fish that can survive in warmer waters up to 77º F include smallmouth bass, rock bass, sunfish, carp, catfish, suckers, and mudminnows. Average summer temperatures above 77º F exclude many fish and cool water insects[23]. Fluctuations in temperature also affect biodiversity. Extreme fluctuation in summer temperature, as defined by a difference of more than 18º F between the average maximum and average minimum stream temperature, have been found to decrease fish diversity at warm sites.[24]

Thermal pollution—the discharge of heated water from industrial operations, dams, or stormwater runoff from hot pavement and other impervious surfaces—often causes an increase in stream temperature. The Michigan Water Quality Standards specify that the Great Lakes and connecting waters and inland lakes shall not receive a heat load that increases the temperature of the receiving water more than 3º F above the existing natural water temperature (after mixing with the receiving water). Rivers, streams and impoundments shall not receive a heat load that increases the temperature of the receiving water more than 5º F for warmwater fisheries. These waters shall not receive a heat load that increases the temperature of the receiving water above monthly maximum temperatures (after mixing).[25]

All waters in the Watershed are warmwater fish streams. However, coldwater fish species are found occasionally in the Watershed, and the presence of EPT (Ephemeroptera-Plecoptera-Trichoptera) and sensitive aquatic insect families at many monitoring sites is an indication of adequately cool stream temperatures. Low flows below impoundments, removal of streambank vegetation, and inputs of stormwater runoff (which are typically substantially warmer than base stream flows) are all potential contributing factors to elevated water temperatures.

2.3.1.9 Dissolved Oxygen

Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water. DO is essential for fish and is an important component in the respiration of aerobic plants and animals, photosynthesis, oxidation-reduction processes, solubility of minerals, and decomposition of organic matter. Aquatic plants, algae and phytoplankton produce oxygen as a by-product of photosynthesis. Oxygen also dissolves rapidly into water from the atmosphere until the water is saturated. Dissolved oxygen diffuses very slowly and depends on the movement of aerated water. DO levels fluctuate on a diurnal basis. They rise from morning through late afternoon as a result of photosynthesis, reach a peak in late afternoon, then drop through the night as a result of photosynthesis stopping while plants and animals continue to respire and consume oxygen. DO levels fall to a low point just before dawn.

The amount of oxygen an organism requires varies according to species and stage of life. DO levels below 1-2 mg/L do not support fish. DO levels below 3 mg/L are stressful to most aquatic organisms. Minimal DO levels of 5-6 mg/L usually are required for growth and activity. Low DO levels encourage the growth of anaerobic organisms and nuisance algae. Cold water species like trout need between 9-12 mg/L, depending on the species. The accumulation of organic wastes and accompanying aerobic respiration by microorganisms as they consume the waste depletes DO in freshwater systems. High levels of bacteria from sewage pollution and high levels of organic matter can lead to low DO levels. Michigan Water Quality Standards states that surface waters protected for warmwater fish and aquatic life must meet a minimum dissolved oxygen standard of 5 mg/l.[26]

2.3.2 Biological Parameters

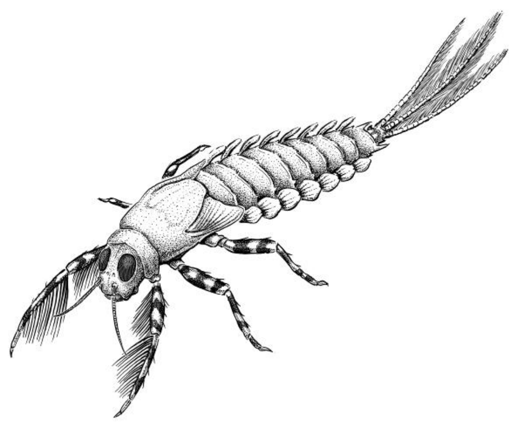
2.3.2.1 Bacteria

Bacteria are microorganisms that are found everywhere. Coliform is a group of bacteria that includes a smaller group known as fecal coliforms, which are found in the digestive tract of warm-blooded animals. Their presence in freshwater ecosystems indicates that pollution by sewage or wastewater may have occurred and that other harmful microorganisms may be present. A species of fecal coliform known as *Escherichia coli* or *E. coli* is analyzed to test for contamination. *E. coli* counts are used as a measure of possible drinking water contamination, as high concentrations can result in serious illness. The potential sources of *E. coli* in surface waters are varied and difficult to pinpoint. They include human sources such as failed septic fields, but also wildlife sources such as geese and raccoons and pet or feral sources as well.

Rule 62 of the Michigan Water Quality Standards (Part 4 of Act 451) limits the concentration of microorganisms in surface waters of the state and surface water discharges. Waters of the state that are protected for total body contact recreation must meet limits of 130 *Escherichia coli* (*E. coli*) per 100 milliliters (ml) water as a monthly geometric mean of five sampling events (3 samples per event) and 300 *E. coli* per 100 ml water for any single sampling event during the May 1 through October 31 period. The limit for waters of the state that are protected for partial body contact recreation is a geometric mean of 1000 *E. coli* per 100 ml water for any single sampling event at any time of the year.[27]

2.3.2.2 Macroinvertebrates

Insects living in the creek compose the benthic macroinvertebrate population, along with clams and other mollusks, crayfish, and other taxa. Typically, monitoring focuses on insects (in aquatic stages of development) as they are representative of a variety of trophic levels, are sensitive to local environmental conditions and are easy to collect. Since the macroinvertebrate population depends on the physical conditions of the stream as well as water quality, its composition indicates the overall stream quality. Insect diversity indicates good stream quality and is measured by the number of different insect families. 87 benthic insect families are found in the Huron River Watershed.[28]



*Brush-legged Mayfly (*Ephemeroptera isonychiidae*) drawing: Matt Wimsatt*

Macroinvertebrate data is collected through HRWC River Roundup event, formerly known as HRWC's Adopt-a-Stream, which relies on trained volunteers to monitor more than 80 sites in the Huron River watershed, including 15 in the Watershed of this management plan. Monitoring data has been gathered since as early as 1992 at some sites through annual spring and fall collection days, and a winter stonefly search each January. Four sites in the Watershed are considered primary sites, on the Huron main branch and at each of the mouths of the main creeks. Collections are taken at primary sites in every event unless the volunteer labor force is low enough to prevent that. Eleven sites in the Watershed are secondary sites and collected every other year. There are also 3 tertiary sites that are only sampled occasionally, and given the low frequency of sampling, the tertiary sites are not included in this WMP (Figure 2.18).

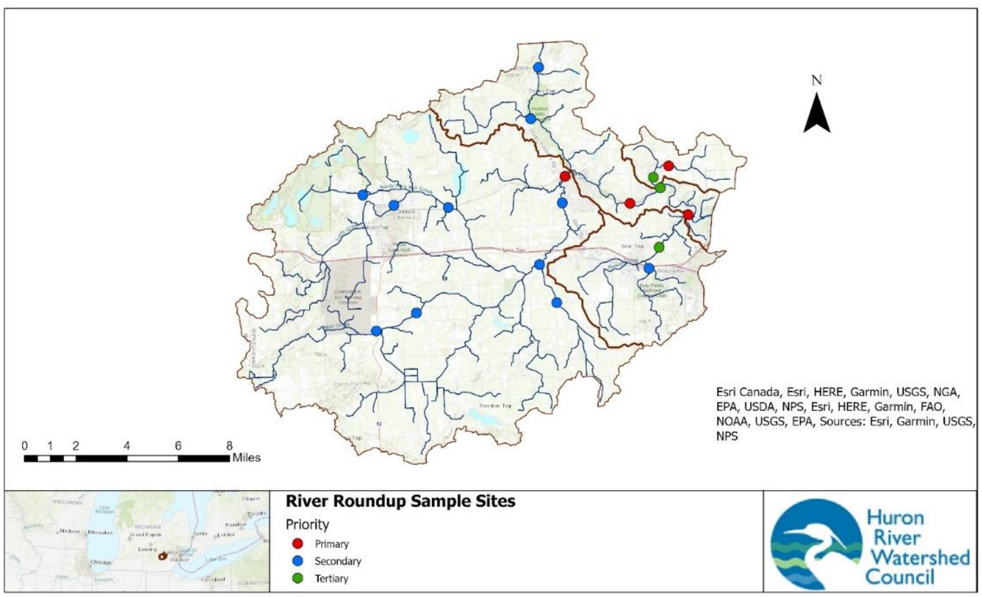
Insect families belonging to the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are known as the EPT families, which are indicators of alterations in stream flow, temperature, oxygen and other changes that raise metabolic rates.

HRWC also uses Hilsenhoff's Index of Biotic Integrity to understand the level of organic pollution tolerance in the insect community. Sensitive insect families, such as Perlidae

(Perlid stonefly) and Brachycentridae (log-cabin caddisfly), are highly sensitive to organic pollution. William Hilsenhoff's conducted a study that ranked macroinvertebrates on a scale of 0-10 in terms of pollution sensitivity. Organisms ranked 0, 1, or 2 are considered sensitive in HRWC's protocols.[29] 19 of the 87 benthic insect families living in the Huron River Watershed are sensitive.[30] HRWC looks at numbers of Sensitive families as well as computing an overall Hilsenhoff IBI which is essentially a weighted average of the Hilsenhoff ranking, with 0 being Excellent and 10 being Very Poor. It is possible that a site with a high total insect family count can still have a poor Hilsenhoff IBI if the insect community there has a high proportion of pollution tolerant taxa.

The presence of winter stoneflies, which are active in January and require high levels of oxygen, are indicators of good stream quality. Absence of winter stoneflies suggests that toxic pollutants may be present. Since there is usually little or no stormwater runoff in January, there is a greater likelihood that any pollutants in the stream are persistent toxic substances present in the bottom of the streambed. Conversely, at a site where insect diversity is lower than expected but winter stoneflies are present, pollutants connected or related to stormwater runoff (i.e. nutrients or sediment) are more likely to be the problem.

Figure 2.18. Sample sites for HRWC's River Roundup (Benthic Macroinvertebrates monitoring).



2.3.2.3 Fish

Fish depend upon aquatic insects for food, and they also need good quality stream habitats and free-flowing reaches for all life cycle phases. More than 90 species of fish are native to the Huron River Watershed, however at least 99 species now live in its waters due to human-induced changes to the river's fish communities. Many native species still are present and abundant, yet many have declined to the point of rarity and are considered threatened or endangered. Increased peak flows, reduced summer base flows, increased and more varied temperatures, and increased turbidity and sediment loads have negatively affected critical fish habitat requirements, particularly as they relate to spawning and survival of young fishes. Dams have also affected fish populations by altering temperature and flow patterns, as well as inundating more high-gradient reaches and blocking migrations among critical seasonal habitats within the river.[31]

No information is available on the pre-European settlement fish community in the Middle Huron system. The headwaters and most tributaries of the Huron River had fairly stable flows. Summer water temperatures remained cool due to substantial water volumes, shaded banks, and local inflow of additional groundwater. Diverse habitats existed, including extensive gravel and cobble riffles, deep pools with cover, channel-side marshes, and flood plain wetlands.

A 1938 survey of the headwaters and tributaries upstream of Ann Arbor found about 25 species.[32] Higher-gradient stretches with extensive gravel riffles and pools held mudminnow, hornyhead chub, silver shiner, rosyface shiner, common shiner, lake chubsucker, northern hog sucker, golden redhorse, black redhorse, yellow bullhead, stonecat, tadpole madtom, brindled madtom, longear sunfish, rock bass, smallmouth bass, rainbow darter, fantail darter, and greenside darter.

Vegetation-dependent mud pickerel, northern pike, blackstripe topminnow, and least darter were also present.

Most common in the faster flowing, low gradient stretches connecting natural lakes were white sucker, largemouth bass, bluegill, pumpkinseed, Johnny darter, logperch, and yellow perch.

Neither muskellunge nor walleye were found in the 1938 survey. These may have been originally present but extirpated during early settlement.

Today, the Huron River throughout most of the Watershed area is considered to be a prime smallmouth bass fishery. The Michigan Department of Natural Resources (MDNR) has established a catch-and-immediate-release only on bass from the Mast Road Bridge in Dexter downstream to the Delhi Road Bridge.[33]

The Huron River tributaries in the Watershed are considered mostly to be a “second quality warmwater fishery”. Second quality warmwater feeder streams are those that contain significant populations of warmwater fish, but game fish populations are appreciably limited by such factors as pollution, competition, or inadequate natural reproduction. Small streams are often difficult to fish because of their small size; typically less than 15 feet wide.[34]

In the last ten years, MDNR, working with Ann Arbor Trout Unlimited, has been stocking brown trout in the main branch of Mill Creek as it enters the City of Dexter. Trout Unlimited had collected many years of temperature data in order to show that trout would be able to survive in the creek year-round. The creek temperature is marginal for trout during the summer months, but they are regularly caught and survive there year-round, providing trout anglers an enjoyable “Up-North” fishery experience on what is technically a warm water stream. More details are included in section 2.4.2 Mill Creek.

2.3.3. Lake Behavior (Limnology)

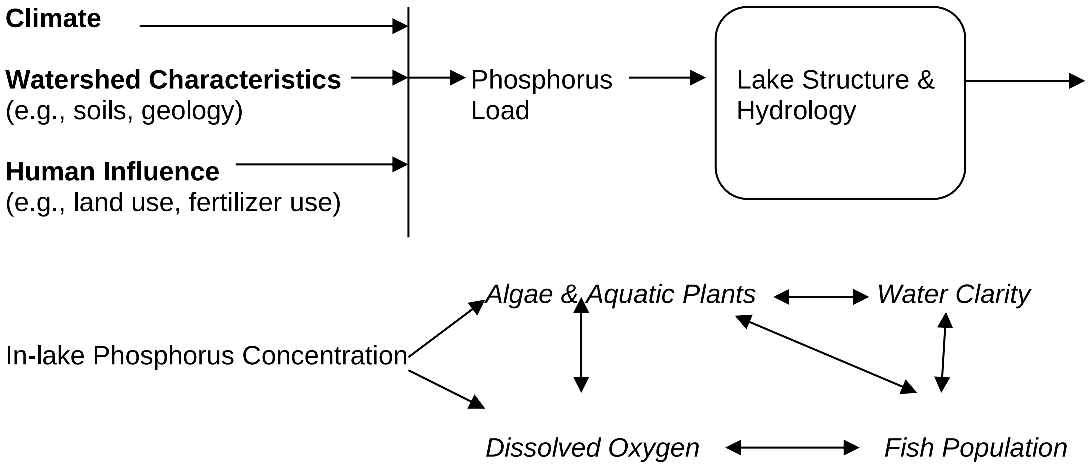
Limnology is the physical, chemical, and biological science of study of freshwater systems, including lakes. The Watershed includes several significant impoundments. A general review of lake behavior in response to nutrients is useful for understanding how lake and river system dynamics differ.

While numerous water quality parameters are studied to determine the trophic status and water quality status of lakes, in-lake phosphorus concentrations are often the determining factor. Trophic status is a useful means of describing the water quality of a lake since it defines the expected productivity and biotic composition of the system. While many factors influence the overall trophic status of a lake, the interaction of climate, watershed characteristics (e.g., soils), and human influences are the most dominant (Figure 2.19). [35]

Generally, a lake with concentrations of phosphorus less than 0.01 mg/L will be considered oligotrophic. A lake will be considered mesotrophic at concentrations of 0.01 mg/L to 0.02 mg/L and eutrophic to hypereutrophic at or greater than 0.02 mg/L or 0.03 mg/L.[36] Oligotrophic and mesotrophic lakes normally support cold- or cool- water fisheries (e.g., trout, some species of bass) and numerous recreational activities. The water in these lakes is also often suitable for drinking water supply. Eutrophic lakes often support warm water fisheries (e.g. bass, bluegill, catfish, carp, etc.) and have a more limited recreational value compared to oligotrophic or mesotrophic lakes because of periodic nuisance algal blooms and aquatic macrophyte growth. Hypereutrophic lakes, which experience frequent and intense nuisance algal blooms, do not ordinarily support cold or warm water fisheries and offer little or no recreational value. In addition, these lakes often exhibit decrease in open water surface areas because of layers of algal and aquatic plant masses.

Temperate zone lakes, like those in the watershed, experience changes in water chemistry and biology throughout the year. As winter ice thaws in the spring, winds and temperature changes in surface waters cause mixing within the water column. The result is water with temperature, dissolved oxygen, and other variables that are essentially equal at all depths This event is often referred to as a spring turnover. In the summer months, warm air temperatures interact with surface waters causing stratification or layering of lake water due to water temperature and density relationships. During this time of thermal stratification, little mixing of lake water occurs. Lakes that receive increased pollutant loading can exhibit quantifiable reductions in water quality at this time because of the lack of oxygen in the bottom water. As fall approaches, cooler air temperatures increase surface water density and mixing establishes uniformity within the water column in what is termed as fall turnover. During the winter months, the lake may stratify again.

Figure 2.19. Illustrative Schematic of Phosphorus Load Determinants and Lake Response.



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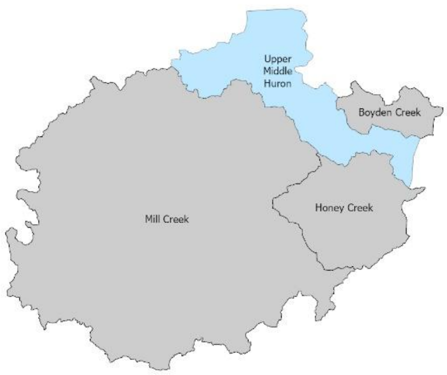
2.4. Creekshed Current Conditions

In order to gain a perspective on the past and present general water quality conditions in the Watershed, efforts were made to compile and summarize relevant and readily available existing water quality data. This effort included but was not limited to acquisition of studies conducted by state researchers, as well as requests to Advisory Committee members and researchers in the area.

Numerous studies and datasets of relevance were obtained in this process; however, spatial and temporal data may be somewhat limited in certain areas, especially for areas of the Watershed drained by minor tributaries. Due to these limitations, the following narrative should be considered a snapshot of water quality in the Watershed rather than a comprehensive review.

Four hydrologically distinct drainage areas, or creeksheds, were delineated and their water quality summaries are reviewed below.



2.4.1 Huron River and direct drainage tributaries

2.4.1.1 Creekshed Natural Areas

The watershed's forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from runoff, and provide wildlife habitat and beautiful places for us all to enjoy. The water flowing into the Upper Middle Huron

About 29% of this subwatershed remains as intact natural areas. About a third of these areas are protected from development. (including Hudson Mills, Dexter-Huron, and Delhi Metroparks). Without designated protection, the rest of the natural areas in this area face an uncertain future. It will be important to keep these lands natural, so they can continue to help keep the Huron healthy.

Based on HRWC's Natural Areas Assessment and Protection project of the Huron River Watershed Council (Figure 2.10) [1], the Huron Creek (the largest direct drainage into the Huron River in this area) watershed has 1200 acres of high and medium-high priority natural areas that are not protected, and much of the remaining land in that creekshed is agricultural.

Fish and insect communities are less diverse when impervious surface exceeds 8-12% of the total watershed area.[2,3] 6% (1.7 square miles) of this area is impervious. However, the river is impacted by the 9% impervious surfaces upstream of the Watershed as well, which are not considered in this number.

2.4.1.2 Hydrology

The hydrology of the Huron River through this section of the Watershed is discussed and evaluated in section 2.1.4, along with general conclusions about hydrology in all of the tributaries. The river flow through the watershed likely rises and falls at a generally natural rate above the confluence with Mill Creek. The observed peak flow is within range of a reference flow for a bankfull storm event, and the flow upstream of the watershed has been determined to be relatively stable. Once upstream and Mill Creek flows join together, the total flow nearly doubles.

The hydrology in the many, small direct drainages to the river has not been measured nor evaluated. Given the size of their drainage areas, direct drainage streams will have little impact on the overall river flow.

2.4.1.3 Morphology

Recent conditions:
HRWC evaluated stream morphology for four direct drainages to the Huron River, along with four sections of the river itself (Appendix G). The terrain along the Huron River can be quite diverse in these tiny tributary drainages. While there is some development along the river, most stretches have very good riparian cover with a well-connected floodplain. Slopes along this section of the river are comparatively gentle until the approach to Barton Pond. The stream reaches in the Watershed all have low to moderate erosion rates that reflect the good riparian cover and low slopes. All direct drainages showed moderate erosion rates and three of the four river reaches did as well. The Huron River itself has a unit erosion rate of 0.011 tons/year per linear foot of river assessed, which is somewhat lower than the average rate of 0.040 tons/yr/ft across all of the assessed reaches of the Watershed (Table 2.7). None of the river reaches had erosion rates in the highest priority category.

Combined, the direct drainages had an average unit erosion rate of 0.025 tons/yr/ft. Generally, the direct drainage tributaries are small streams with gentle slopes. Several of the streams run through Huron-Clinton Metroparks, which are comparatively undeveloped and have significant tree cover to help maintain streambank stability. Overall, the 3.25 miles of evaluated Huron River generates an estimated total of 195 tons/year in eroded soil, while the 3.72 miles of evaluated direct drainages erode a combined 481 tons/year. The Huron River and its direct drainages do not contribute substantially to the overall sediment load of this Watershed.

Table 2.7. General erosion rates for the assessed streams of 3 primary Creeksheds, the main Huron branch, and the smaller direct-to-Huron drainages.

Measurement	Huron River (3.72 miles assessed)	Direct-to-Huron Drainages (3.25 miles assessed)	Boyden Creekshed (0.70 miles assessed)	Honey Creekshed (4.96 miles assessed)	Mill Creekshed (23.13 miles assessed)
Erosion Rate (tons/yr/ft)	0.011	0.025	0.104	0.044	0.044
Tons per year	195	481	382	1152	5373

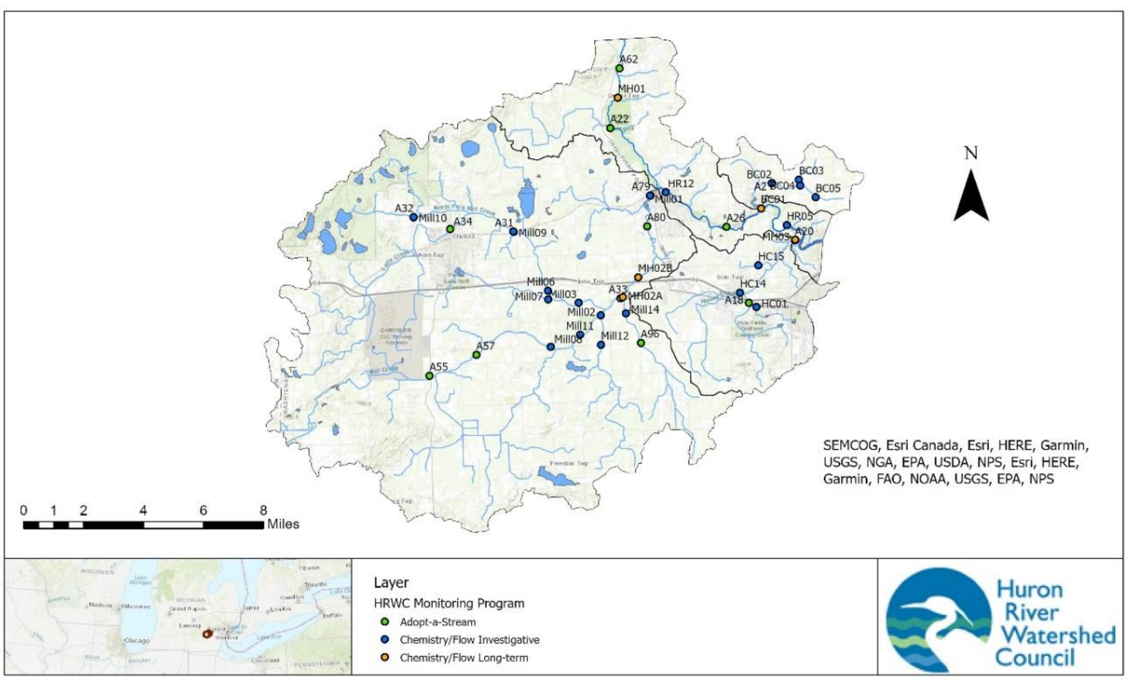
2.4.1.4 Stream Habitat

At a minimum of every five years and occasionally more frequently, HRWC conducts a habitat assessment at the monitoring sites (Figure 2.20). The assessment is composed of qualitative observations (riparian width, erosion sites, meandering, woody debris, counts of riffles/pools/runs, desktop observations through aerial photography and GIS) combined with quantitative measurements of stream substrate (substrate size analysis across ten cross section transects).

At both studied Huron River sites in this subwatershed (A26 and A62), the Huron River has substrate favorable for aquatic life; medium sizes rocks and gravel compose the majority of the river substrate, with an even mix of sand and large boulders and cobbles, and with muck or fine organic sediment only at the river edges or lodged along the bottom edges of large pieces of substrate. Fine sediments get more dominant as the river begins to slow down near Barton Pond. Most of this river section has thick forested riparian buffers, although irregularly spaced houses have grassy lawns on the stream banks. There is plentiful instream woody debris and a wide variety of water depths that provide cover and flow refugia.

Huron Creek (A22), a direct tributary to the Huron River in Hudson Mills Metropark, is a small and shallow creek with a substrate composed primarily of 70% gravel, rock, and cobbles, and 30% sand and silt. At the location where the creek is monitored, near its mouth, the riparian zone is a thick covering of forest and wetlands with plentiful woody debris providing macroinvertebrate habitat and cover for small fish. Outside of the Metropark, Huron Creek is heavily straightened, maintained for drainage, and surrounded by agriculture.

Figure 2.20. Location of HRWC monitoring sites in the Watershed.



2.4.1.5 Phosphorus

Recent conditions and historic data (>10 years old):
HRWC's Chemistry and Flow Monitoring Program has monitored the Huron River at North Territorial within Hudson Mills Metropark (MH01) twice monthly during the growing season since 2003. Over the entire sampling period between 2003 and 2020, total phosphorus concentrations in the Huron River at North Territorial have seen a statistically significant decline (p=0.04) (Table 2.8).

Over the past ten years of complete data from 2010 to 2019 (Table 2.9), phosphorus concentrations also saw a statistically significant decline (p=0.00003). Mean and median total phosphorus concentrations are at or below the TMDL target for Ford and Belleville Lakes of 0.03 mg/l. Mean total phosphorus from 2010 to 2019 was 0.03 mg.l (s=0.02) with a median of 0.024 mg/l and a range of concentrations from 0.13 mg/l to 0.0 mg/l

Table 2.8. Mean and Median Values for Chemistry Parameters Monitored by HRWC's Chemistry and Flow Monitoring Program, 2002-2020[a]

Parameter	Huron River: North Territorial (MH01)	Mill Creek: Parker Road	Boyden Creek at Huron River Drive[f] (BC01)	Honey Creek at Huron River Drive
TP[b] (mg/l)	0.03(0.025)	0.064(0.051)	0.04(0.034)	0.056(0.041)
TSS[b] (mg/l)	3.1(2.4)	14.0(8.3)	6.2(5.0)	11.1(4.8)
NO2[c] (mg/l)	0.006(0.005)	0.013(0.009)	0.012(0.010)	0.007(0.005)
NO3[c] (mg/l)	0.27(0.20)	0.88(0.70)	0.64(0.60)	0.50(0.50)
E. Coli[d] (cfu/100ml)	49(15)	876(493)	106(7)	491(227)
pH[e]	8.0(8.1)	7.9(8.0)	8.2(8.2)	8.0(8.1)
Conductivity[e] (µS)	690.2(690.0)	706.8(720.0)	606.9(632.0)	951.6(1000.0)
TDS[f] (mg/l)	498.2(494.0)	535.6(539.5)	487.3(422.5)	705.4(731.3)
DO[g] (mg/l)	8.8(8.9)	8.9(8.8)	8.8(8.3)	9.7(9.6)
Temperature[f] (°F)	70.3(73.2)	63.6(65.8)	69.7(71.8)	62.3(64.0)

[a] = Mean with median in parentheses; no data for 2007 across all parameters; 2020 data only from June to September due to COVID-19

[b] = Data from 2003 to 2020

[c] = Data from 2002 to 2019

[d] = Data from 2006 to 2019

[e] = Data from 2002-2011 and 2014-2020

[f] = Data from 2014-2020

[g] = Data from 2002-2009 and 2014-2020

Table 2.9. Mean and Median Values for Chemistry Parameters Monitored by HRWC's Chemistry and Flow Monitoring Program, 2010-2019[a]

Parameter	Huron River: North Territorial (MH01)	Mill Creek: Parker Road	Boyden Creek at Huron River Drive[3] (BC01)	Honey Creek at Huron River Drive
TP (mg/l)	0.03(0.024)	0.067(0.05)	0.041(0.033)	0.056(0.04)
TSS (mg/l)	3.5(2.2)	12.7(7.1)	6.1(4.6)	11.2(4.8)
NO2 (mg/l)	0.005(0.005)	0.013(0.009)	0.012(0.010)	0.006(0.004)
NO3 (mg/l)	0.27(0.20)	0.89(0.70)	0.64(0.60)	0.49(0.50)
E. coli (cfu/100 ml)	50(14)	911(473)	106(7)	506(201)
pH[2]	8.0(8.1)	7.9(8.1)	8.2(8.2)	8.0(8.1)
Conductivity[2] (µS)	686.1(674.0)	693.8(702.5)	598.8(625.5)	888.8(901.0)
TDS[3] (mg/l)	496.4(494.0)	533.0(539.5)	487.5(422.5)	699.5(724.8)
DO[3] (mg/l)	9.4(9.5)	9.5(9.4)	8.8(8.2)	9.9(9.7)
Temperature[3] (°F)	70.4(73.5)	63.7(66.3)	69.3(71.8)	62.2(63.9)

[1] = Mean with median in parentheses

[2] = Only data for 2010, 2011, and 2014-2019

[3] = Only data from 2014-2019

2.4.1.6 Suspended Solids

Recent conditions and historic data (>10 years old):
Since beginning collection of total suspended solids data in 2003, HRWC's Chemistry and Flow Monitoring Program has seen a statistically significant decline (p=0.0001) in concentrations at the North Territorial Huron River monitoring site (MH01). Over the past ten years of complete seasonal data (2010-2019), a statistically significant declining trend is also observed (p=0.001). During that period, mean and median total suspended solids concentrations of 3.5 mg/l (s=1.3) and 2.2 mg/l were far below the state stormwater threshold of 80 mg/l. Even the max total suspended solids concentration from 2010 to 2019 was 7.0 mg/l, indicating very low sediment loading at this location even during high precipitation events. (Tables 2.8, 2.9)

2.4.1.7 Nitrate and Nitrite

Recent conditions and historic data (>10 years):
From 2003 through the present, HRWC has monitored nitrate and nitrite twice monthly where the Huron River crosses North Territorial Road through its Chemistry and Flow Monitoring Program (MH01). Both nitrate and nitrite ranges at the North Territorial Road site remain below the EPA's Maximum Contaminant Levels, with a range of 0.0 to 0.6 mg/l for nitrate and 0.0 to 0.05 mg/l for nitrite from 2003 to 2019. Over that period, there has been a statistically significant decline in nitrite values (p=0.0001) while nitrate values illustrate no observable trend.

Recently, from 2010 to 2019, nitrite values have also seen a statistically significant decrease ($p=0.07$). Both short term (2010 to 2019) and long term (2003 to 2019) nitrate values averaged 0.27 mg/l ($s=0.13$) with a median of 0.20 mg/l. Nitrite values averaged 0.005 mg/l ($s=0.004$) from 2010 to 2019 and 0.006 mg/l ($s=0.01$) from 2002 to 2019. Both timescales had a median nitrite value of 0.005 mg/l. (Tables 2.8, 2.9)

2.4.1.8 Conductivity

Recent conditions and historic data (>10 years old):
From the mid-1990s to the present, HRWC tests conductivity at three sites in this subwatershed; Huron River: Zeeb Road (A26), Huron River: Bell Road (A62), and a smaller tributary, Huron Creek: Hudson Mills Metropark (A22). HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring. All three sample locations average less than 800 µS for the time period and no statistically significant changes have occurred over time.

In addition to the River Roundup Program, HRWC's Chemistry and Flow Monitoring Program also measures in-stream conductivity of the Huron River where it crosses North Territorial Road during its monitoring season from April to September. From 2010 to 2019, values at the North Territorial Site ranged from 456.1 to 1550.0 µS/cm. During that period, mean conductivity of the Huron River at North Territorial Road was 686.1 µS/cm ($s=137.7$) and median conductivity was 674.0 µS/cm. Mean and median conductivity values are both below the 800 µS/cm threshold used by HRWC, indicating lesser concern of salt and metal pollutants at the North Territorial Road monitoring site. There is no observable trend in conductivity values at the North Territorial Road site, as there is a high degree of seasonal variability in values. (Tables 2.8, 2.9).

It would be expected that road salt can cause spikes of conductivity during periods of snow melt, but snowmelt events have not been monitored.

2.4.1.9 pH

Recent conditions:
HRWC's Chemistry and Flow Monitoring program has monitored pH where the Huron River crosses North Territorial Road (MH01) since 2002. From 2002 to 2020, pH values at North Territorial Road generally fall within the prescribed range under the Michigan Water Quality Standards for surface waters, save for two measurements around 6.0. pH values at the Huron River at North Territorial Road from 2010 to 2019 ranged from 6.0 to 8.6, with an average of 8.0 (s=0.4) with a median of 8.1. (Tables 2.8, 2.9).

2.4.1.10 Temperature

Recent conditions:
In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. During the May-August months in 2014-2018, volunteers walked portions of three direct tributaries (Huron Creek, Brass Creek, and an unnamed creek in Hudson Mills Metropark) and made temperature measurements. The temperatures were all recorded late morning through early afternoon. Huron Creek was an average of 71 degrees Fahrenheit (based on 6 measurements, July 21, 2014). Brass Creek was an average of 64 degrees Fahrenheit (based on 15 measurements, August 31, 2016). The unnamed creek in Hudson Mills Metropark was an average of 63.5 degrees Fahrenheit (based on 14 measurements, August 31, 2016).

A temperature logger was set along a shaded bank in the Huron River at the intersection of Zeeb Road (A26) from 2014 through 2018. The logger was set to record the temperature every hour. For the summer month of July and August, the average daily temperature of this location is 73.9, with an average minimum daily temperature of 71.2 (usually occurring in early morning) and an average maximum daily temperature of 77.0 (usually occurring late afternoon).

Temperature data has been collected by HRWC's Chemistry and Flow Monitoring Program where the Huron River crosses North Territorial Road (MH01) on and off between 2003 to 2006 then bimonthly from April through September since 2008. The average water temperature of the Huron River at North Territorial Road is 70.3 degrees Fahrenheit (s=10.2) as measured between 2003 to 2020. From 2010 to 2019, the average temperature is 70.37 degrees Fahrenheit (s=11) with a median of 73.49 degrees Fahrenheit. Temperatures during that period range from 42.8 to 85.5 degrees Fahrenheit. (Tables 2.8, 2.9)

Historic data (>10 years old):
In 2000 and 2009, HRWC installed min/max thermometers at two locations in the Huron River and one in Huron Creek, a small tributary. The minimum and maximum temperatures were checked every week from July through August (Table 2.10)

Table 2.10 Water temperature measurements with a min/max thermometer. Degrees Fahrenheit.

Site (Year)	Range	Avg Min	Avg Max
Huron subwatershed			
A22: Huron Creek (2000, 2009)	58.0-71.0	58.1	68.9
A62: Huron River: Bell Road (2000, 2009)	65.0-82.0	71.3	78.1
A26: Huron River: Zeeb Road (2000, 2009)	65.1-80.0	68.2	76.7
Boyden			
A2: Boyden Creek: Delhi Road (2000-2002, 2009-2010)	47.0-74.0	56.0	67.6
Honey			
A18: Honey Creek: Jackson Rd (2000, 2009)	58.0- 82.0	64.6	73.6
A:22 Honey Creek: Wagner Rd (2001, 2009)	51.5- 79.5	60.0	70.0
Mill			
A31: Mill Creek, Fletcher Rd (2000)	60.2-78.9	63.2	75.6
A32: Mill Creek, Ivey Rd (2000, 2011-2012)	53.0 – 84.0	59.9	77.2
A33: Mill Creek: Jackson Rd (2000, 2011)	57.0 – 75.0	61.4	70.9
A34: Letts Creek, M-52 (2000, 2009)	60.0 – 74.0	62.9	71.6
A55: Mill Creek, Manchester Road (2000, 2001)	52.6 – 82.0	59.3	72.2
A57: Mill Creek, Klinger Road (2001)	54.6 – 82.0	59.1	75.3
A79: Mill Creek, Mill Creek Park (2006, 2009)	60.0 – 82.0	66.3	77.9
A80: Mill Creek, Shield Road (2006, 2010)	61.0 – 81.0	65.8	73.9

2.4.1.11 Dissolved Oxygen

Recent conditions:
Dissolved oxygen measurements for the Huron River at North Territorial Road (MH01), collected twice monthly from April through September through HRWC's Chemistry and Flow Monitoring Program, consistently met and exceeded Michigan's standard of 5 mg/l from 2014 to 2019. Save for one measurement during that period, measurements were within the range of 5.03 mg/l to 13.19 mg/l. From 2014 to 2019, the average dissolved oxygen value at the North Territorial Road Huron River monitoring site was 9.39 mg/l (s=1.9) and the median value was 9.51 mg/l, indicating the general aquatic livability of the Huron River at that site. (Tables 2.8, 2.9)

2.4.1.12 Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

Recent conditions and historic data (>10 years old):
HRWC's Chemistry and Flow Monitoring Program has collected samples for *E. coli* bacteria analysis since 2006. The samples are collected as single grab samples. Over the past ten years, *E. coli* counts measured at the Huron River where it crosses North Territorial Road (MH01) appear to be declining although the trend is not statistically significant (p=0.12). However, most *E. coli* counts collected by HRWC are below both the partial body contact and full body contact standards, with only three samples between 2010 and 2019 over the full body contact standard of 300 *E. coli* per 100 ml.

Between 2010 and 2019, the average *E. coli* value at the North Territorial Road monitoring site was 51 counts per 100 ml (s=212). This average value is skewed by the high counts measured during or post storm events, which are as high as 2,200 counts per 100 ml. The median *E. coli* value of the Huron River at North Territorial Road during the same period was 14 counts per 100 ml, which is well below both state standards. (Tables 2.8, 2.9)

2.4.1.13 Macroinvertebrates

Recent conditions:
As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), the number of pollution sensitive families, and calculates a metric score based on Hilsenhoff's Index of Biotic Integrity. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality, and the lower the value of the Hilsenhoff IBI score. Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples.

The River Roundup Program monitors the Huron River at the Zeeb Road intersection (A26) and the Bell Road intersection (A62) in the Watershed. Furthermore, one small direct tributary is measured as well (Huron Creek in Hudson Mills Metropark, A22). For 2018-2020, all three of these sampling locations have highly diverse macroinvertebrate populations (Table 2.11). The Hilsenhoff IBI rates them as Very Good for the Zeeb Road site and Huron Creek site, and Good for the Bell Road site. The Zeeb Road site and the Huron Creek site are ranked in the top 5 of the most diverse and pollution intolerant macroinvertebrate sites when taken in context with all 61 of HRWC's macroinvertebrate sites across the entire Huron River Watershed, so these are unique and healthy locations.

Historic data (>10 years old):
HRWC has sampled the the Zeeb location and Huron Creek since 1996, and the Bell location since 2000. During this time period, both the Zeeb and Bell location have not undergone a statistically significant macroinvertebrate population shift. Huron Creek, however, has had continual improvement, with significantly more EPT families and sensitive insects in 2020 as compared to 1996.

Table 2.11 Macroinvertebrate Communities at HRWC River Roundup Program Monitoring Sites in the Watershed, 2018-2020 unless otherwise noted.

Study Site	**Sample Frequency[t]**	**Population Trends**	**Avg. Hilsenhoff IBI**	**Avg. Insect Families**	**Avg. EPT Families**	**Avg. Sensitive Families**	**Winter Stonefly (Presence/ Absence)**
Averages Across Huron River Watershed			4.9 (Good)	11.2	4.5	1.2	
A2: Boyden Creek, Delhi Rd	Primary	Sensitive Families Improving	4.8 (Good)	14.0	6.0	2.0	Sampled twice; found once.
A18: Honey Creek, Jackson Rd	Secondary	Sensitive Families Declining	4.7 (Good)	8.3	2.3	0.3	Sampled thrice, found thrice
A20: Honey Creek, Wagner Rd	Primary	Sensitive Families Declining	4.9 (Good)	9.5	3.3	1.3	Sampled thrice, found twice.
A22: Huron Creek, Dexter-Pinckney Road (Main branch tributary)	Secondary	EPT and Sensitive Families increasing	3.8 (Very Good)	15.3	8.3	3.3	Sampled twice, found twice.
A26: Huron River, Zeeb Rd	Primary	Stable	3.9 (Very Good)	18.3	8.0	3.0	Sampled twice, found twice.
A31: Mill Creek, Fletcher Rd	Secondary	Stable	6.64 (Fairly Poor)	13.0	4.0	0.0	Sampled once, not found.
A32: Mill Creek, Ivey Rd	Secondary	Stable	4.1 (Very Good)	11.5	4.5	1.0	Sampled once, found once.
A33: Mill Creek: Jackson Rd	Secondary	Stable	4.8 (Good)	9.7	3.0	0.7	Sampled twice, found twice.
A34: Letts Creek, M-52 (Mill creekshed)	Secondary	Total and EPT families declining	5.7 (Fair)	9.5	4.0	1.0	Sampled twice, found twice.
A55: Mill Creek, Manchester Road	Secondary	Stable	4.2 (Very Good)	16.0	8.0	1.0	Sampled twice, found once.
A57: Mill Creek, Klinger Road	Secondary	Stable	4.2 (Very Good)	9.0	3.0	0.0	Sampled twice, found twice.
A62: Huron River, Bell Road	Secondary	Stable	4.6 (Good)	15.0	5.5	1.5	Sampled twice, found once.
A79: Mill Creek, Mill Creek Park	Primary	Sensitive Families Improving	4.3 (Good)	16.7	8.7	4.0	Sampled thrice, found thrice
A80: Mill Creek, Shield Road	Secondary	Stable	5.4 (Good)	10.0	5.0	2.0	Sampled thrice, found thrice
A96: Mill Creek, Parker Road	Secondary	Stable	6.7 (Fairly Poor)	11.3	3.0	0.3	Not sampled 2018-2020

[t] = Weather and volunteer numbers permitting, primary sites are sampled at every River Roundup and Stonefly Search while secondary sites are sampled every event for one year and then get one year off.

2.4.1.14 Fish

The Huron River throughout most of the Watershed area is considered to be a prime smallmouth bass fishery. The Michigan DNR has established a catch-and-immediate-release fishery on bass from the Mast Road Bridge in Dexter downstream to the Delhi Road Bridge.

A 4 hour MDNR electroshocking sample in the Huron at Zeeb Road in 1999 resulted in 687 smallmouth bass and 158 rockbass, along with many other unlisted non-game species. Also in 1999, another 4 hour MDNR electroshocking sample in the Huron River by the North Territorial bridge resulted in 154 rockbass and 200 smallmouth bass (along with many other unlisted species).

2.4.2 Boyden Creek

2.4.2.1 Creekshed Natural Areas

The creekshed's forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from runoff, and provide wildlife habitat and beautiful places for us all to enjoy. Only about 15% of the creekshed remains as intact natural areas; only a small fraction of these areas are protected from development (about 3% of the creekshed), thanks to Ann Arbor's Greenbelt Program. Without intact natural areas, the creekshed faces an uncertain future. It will be important to keep these lands natural, so they can keep the creek as healthy as possible.

2.4.2.2 Hydrology

Total impervious surface: 4%, 7.53 *square mile*

The low impervious surface area in the upper part of the creekshed allows runoff water to soak into the soil and groundwater. This likely allows for relatively consistent flows throughout the year in the creek. However, stream flow downstream is affected by two impoundments within the suburban development of Loch Alpine. While both dams are designed to maintain outflow that is equivalent to inflow (i.e. "run of the river") seiche and design factors lead to erratic sub-daily flows. Further, drainage from agricultural fields and suburban lawns, channelization of many stretches, and erratic dam controls have contributed to cause more erratic flows than would be expected for this level of impervious surface. Boyden Creek's peak flow was almost twice the reference rate following a storm that was below bankfull in size. Its flashiness index rating of 0.94 makes it one of the 25% flashiest creeks in its drainage size class.

2.4.2.3 Morphology

Recent conditions:

The small Boyden Creek drainage area has a diverse range of land uses. With 59% in agricultural use, many reaches were previously channelized. One of these reaches was assessed for stream bank erosion. It had a unit erosion rate of 0.104 tons/year per linear foot of assessed stream, ranking it as the ninth most erosive reach assessed. Several locations along the assessed stream showed evidence of past channelization and are now cutting into streambanks. Overall, the 0.70 miles of assessed stream erode an estimated 382 tons of streambank away each year – a much greater amount than the 3.25 miles of assessed Huron River streambanks, as a comparison. Streambanks in this creekshed may be good candidates for restoration.

2.4.2.4 Stream Habitat

At a minimum of every five years and occasionally more frequently, HRWC conducts a habitat assessment at the macroinvertebrate monitoring sites (Figure 2.19). The assessment is composed of qualitative observations (riparian width, erosion sites, meandering, woody debris, counts of riffles/pools/runs, desktop observations through aerial photography and GIS) combined with quantitative measurements of stream substrate (substrate size analysis across ten cross section transects).

At Boyden Creek: Delhi Road, the creek habitat is healthy with meanders, riffles, pools, plentiful wood debris, and very wide natural riparian zones. The stream bed is composed of an even mix of sand, gravel, cobble, and muck. That being said, from examination of aerial imagery and GIS stream layers, it is clear that many other parts of Boyden Creek have been straightened into ditches and flow through agricultural fields with little or no natural riparian zones.

2.4.2.5 Phosphorus

Through its Chemistry and Flow Monitoring Program, HRWC has monitored Boyden Creek twice monthly during the growing season since 2014. During the entire monitoring period from 2014 to 2020, Boyden Creek has seen a statistically significant decline ($p=0.005$) in total phosphorus concentrations. During this period, Boyden Creek saw a mean total phosphorus concentration of 0.04 mg/l ($s=0.02$) and a median of 0.034 mg/l. While both the median and median are above the 0.03 mg/l TMDL target for Ford and Belleville Lakes, half of the samples collected in the past three years of complete data (2017-2019) are at or below that target. (Tables 2.8, 2.9)

2.4.2.6 Suspended Solids

HRWC has monitored total suspended solids where Huron River Drive crosses Boyden Creek twice monthly from April to September since 2014. From 2014 to 2020, there is a statistically significant increase in total suspended solids concentrations at Boyden Creek ($p=0.06$). However, the 2020 monitoring season lacked April and May spring runoff data, which could skew the trend. Nonetheless, over the complete record of monitoring from 2014 to 2019, total suspended solids concentrations also demonstrate an increasing trend, but this trend lack statistical significance at the 90% confidence level ($p=0.11$). Total suspended solids concentrations at Boyden Creek remain low, with a range of concentrations from 1.2 mg/l to 28 mg/l, with all concentrations well below the

80 m/l state stormwater threshold. During the complete seasonal monitoring record from 2014 to 2019, mean and median total suspended solids concentrations at Boyden Creek are 6.1 mg/l (s=4.87) and 4.6 mg/l respectively. (Tables 2.8, 2.9)

2.4.2.7 Nitrate and Nitrite

Recent conditions and historic data (>10 years):
Starting in 2012, HRWC's Chemistry and Flow Monitoring Program began processing samples from Boyden Creek twice monthly from April through September for nitrate and nitrite. Both nitrate and nitrite concentrations at Boyden Creek demonstrate increasing concentrations. However, only nitrate presents a statistically significant increasing trend (p=0.004) from 2012 to 2019. Despite increases in nitrate and nitrite, the range of concentrations remain below the EPA's Maximum Contaminant Levels. The range of nitrate values from 2012 to 2019 include a minimum of 0.1 mg/l and a maximum of 1.8 mg/l with a mean of 0.63 mg/l (s=0.31) and a median of 0.60 mg/l. Nitrite values ranged from 0.002 mg/l to 0.048 mg/l, averaging 0.012 mg/l (s=0.008) with a median of 0.010 mg/l. However, seasonal investigative site monitoring of Boyden Creek at BC02, BC03, and BC05 have produced some of the highest nitrate and nitrite concentrations throughout the history of the Middle Huron River Chemistry and Flow Monitoring Program. Nitrite concentrations at BC04 reached 1.7 mg/l, exceeding the EPA's MCL for nitrite. Nitrate samples from BC03 during the 2017 investigative site monitoring consistently were above 3.8 mg/l with maximum values near 5.0 mg/l, indicating potential nitrate and nitrite loading at upstream branches. (Tables 2.8, 2.9)

2.4.2.8 Conductivity

Recent conditions and historic data (>10 years old):

As a part of the River Roundup program from the mid-1990s to the present, HRWC has tests conductivity at Boyden Creek where it intersects Delhi Road, about half-way up the creekshed. HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring. This location averages less than 800 µS over the entire monitoring time period and no statistically significant changes have occurred over time.

In addition to the River Roundup Program, HRWC's Chemistry and Flow Monitoring Program also measures in-stream conductivity at Boyden Creek where it crosses Huron River Drive. From 2014 to 2020, HRWC monitored conductivity every other week from April to September. Conductivity values at Boyden Creek over that time reached a minimum of 242.6 µS/cm and a maximum of 1400.0 µS/cm. Mean conductivity at Boyden Creek was 606.9 µS/cm (s=150.7) and median conductivity was 632.0 µS/cm. Maximum, mean, and median conductivity values are both below the 800 µS/cm threshold, indicating little concern of salt and metal pollutants at Boyden Creek. There is no observable trend in conductivity values from Boyden Creek, as there is a high degree of seasonal variability. (Tables 2.8, 2.9)

It would be expected that road salt can cause spikes of conductivity during periods of snow melt, but snowmelt events have not been monitored.

2.4.2.9 pH

HRWC's Chemistry and Flow Monitoring program has monitored pH at Boyden Creek since 2014 at Huron River Drive. pH values at Boyden Creek fall within the prescribed range under the Michigan Water Quality Standards for surface waters, with a minimum value of 7.2 and a maximum value of 8.5 from 2014 to 2019. During that period, the average and median pH value at Boyden Creek was 8.2 (s=0.2). (Tables 2.8, 2.9)

2.4.2.10 Temperature

Recent conditions:
In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. During the June-August months in 2013-2018, volunteers walked portions of Boyden Creek and made 109 temperature measurements. The measurements range from 53.2 through 78.6 degrees Fahrenheit, with an average of 61.3 and a standard deviation of 6.5. The temperatures were all recorded late morning through early afternoon.

HRWC's Chemistry and Flow Monitoring Program has measured temperature at Boyden Creek near Huron River Drive during the growing season since 2014. From 2014 to 2020, Boyden Creek saw a mean temperature of 69.7 degrees Fahrenheit (s=10.7) and a median temperature of 71.8 degrees Fahrenheit. Temperature values at Boyden Creek range from 43.7 to 83.7 degrees Fahrenheit. (Tables 2.8, 2.9)

Historic data (>10 years old):
In summer 2000-2002 and 2009-2010, HRWC installed a min/max thermometer at Boyden Creek at Delhi Road. The minimum and maximum temperatures were checked every week from July through August. Across 54 readings of the thermometers, the average minimum temperature was 56 degrees Fahrenheit, and the average maximum temperature was 67.6 degrees Fahrenheit. The temperature ranges from 47.0-to 74.0. (Table 2.10)

2.4.2.11 Dissolved Oxygen

Recent conditions:
Dissolved oxygen at Boyden Creek, as measured bimonthly by HRWC's Chemistry and Flow Monitoring Program during the growing season, is consistently above the state standard of 5 mg/l with measured values averaging 8.8 mg/l (s=1.8) with a median of 8.3 mg/l from 2014 to 2020. Only 3 percent of values during that period were below the 5 mg/l standard, with values ranging from 2.7 to 13.3 mg/l. Dissolved oxygen values at Boyden Creek are maintaining and demonstrate no observable or statistically significant trend. (Tables 2.8, 2.9)

2.4.2.12 Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

Recent conditions:
Bacteria in Boyden Creek, in the form of *E. coli*¸ has been analyzed by HRWC's Chemistry and Flow Monitoring since 2014. The samples are collected as single grab samples. In this period. *E. coli* counts at Boyden Creek ranged from 1 to 2,419 counts per 100 ml, with only 7% of samples exceeding the full body contact threshold of 300 counts per 100 ml. From 2014 to 2019, *E. coli* counts averaged 106 counts per 100 ml (s=370) with a median of 7 counts per 100 ml. Save for a few spikes in *E. coli* counts during or after precipitation events, Boyden Creek saw consistent low *E. coli* counts around 10 counts per 100 ml during that period and no observable or statistically significant trends. The impoundment directly upstream of the Boyden Creek monitoring site near Huron River Drive likely leads to the low E. coli counts measured via the Chemistry and Flow Monitoring Program. However, investigative site monitoring upstream of the impoundment during the 2014, 2017, and 2018 monitoring seasons indicate potential E. coli sources in the eastern branches of Boyden Creek. High E.coli counts were observed at BC02, BC04, and BC05, with counts between 300 to 15000 percent higher than those at the downstream, long-term monitoring station near Huron River Drive. (Tables 2.8, 2.9)

2.4.2.13 Macroinvertebrates

Recent conditions:
As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), the number of pollution sensitive families, and calculates a metric score based on Hilsenhoff's Index of Biotic Integrity. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality, and the lower the value of the Hilsenhoff IBI score. Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples.

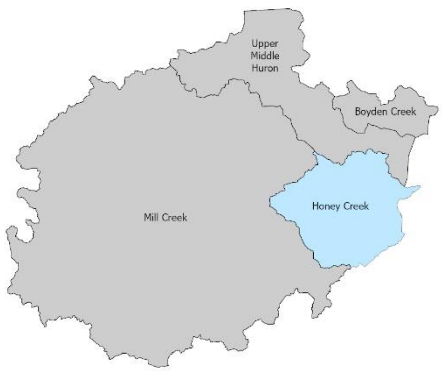
The River Roundup Program monitors the Boyden Creek at Delhi Road, which is located about half-way up the creek. Typically, macroinvertebrate monitoring is done closer to the mouth of the creek, but Boyden is unusual in that two impounded lakes alter the stream system into more of a littoral one right at the mouth of the creek, so it is necessary to monitoring upstream where the stream ecosystem is located. Boyden Creek is rated a "Good" for macroinvertebrates at Delhi Road, with a higher-than-average diversity of total families, EPT families, and Sensitive families, and winter stoneflies are often, though not always, found here in January. In summary, Boyden Creek's macroinvertebrate population can be considered healthy; at least in the upstream section that is monitored. (Table 2.11)

Historic data (>10 years old):
HRWC has sampled at Delhi Road since 1993. In that time there has been plenty of variation in the data, but overall, there is a statistically significant increase in total

macroinvertebrate diversity and EPT diversity, indicating habitat and water quality has improved over time.

2.4.2.14 Additional Data

Fish: HRWC does not have records on Boyden Creek's fish, and it is possible no official MDNR samples or other public records exist for Boyden. However, based on the water temperature, it is likely that Boyden Creek is home to a few species of gamefish, none of which would grow very large in the small creek; species such as smallmouth and largemouth bass and northern pike. Smaller species and suckers would compose most of the fish community, including blacknose dace, creek chubs, mottled sculpins, rainbow darters, and hognose and white suckers.



2.4.3 Honey Creek

2.4.3.1 Creekshed Natural Areas

The creekshed's forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from runoff, and provide wildlife habitat and beautiful places for us all to enjoy. Only 17% of the creekshed has intact natural areas; only a small fraction of these areas are protected from development (about 2% of the watershed, notably Saginaw Forest and Dolph Park). Without its intact natural areas, the creekshed faces an uncertain future. It will be important to keep these lands natural, so they can keep the creekshed as healthy as possible.

2.4.3.2 Hydrology

Total impervious surface: 14%, *20.5 square miles*

Honey Creek runs through a mostly suburban landscape with an amount of impervious surface that would be expected to lead to flashy flows. Flows in the creek are more erratic than a natural reference creek of the same drainage size would be. With a flashiness index of 0.30, it is a bit above the median stream of its size class in Michigan. However, it would likely be even more flashy if not for the significant input flow from the Gelman Sciences dioxane treatment. The current owners of this medical device manufacturer are treating groundwater contamination by pumping large volumes at the source, treating the water to remove dioxane, and discharging the groundwater directly to a branch of Honey Creek. The result is a consistent source of groundwater that would otherwise take a longer time to return to the creek.

Still, Honey Creek can experience high flows for its size. Its measured peak bankfull flow from a 2.6-in rain storm was 407 cfs, which is more than twice the predicted flow in a natural reference creek (142 cfs). These flows are likely starting to cause morphological changes to stream banks and bed throughout the creekshed.

2.4.3.3 Morphology

Recent conditions:

Land development in Honey Creek has produced a mix of uses. Suburban residential areas, with their accompanying impervious roadways and stream crossings, are mixed with more sparsely populated rural parcels including some farm lands. Six reaches of Honey Creek totalling 4.96 miles were assessed for this management plan. Combined they have a mean erosion rate of 0.044 tons/year per assessed linear foot. This is just slightly above the Watershed mean.

Two of these reach assessments produced erosion estimates in in the highest category. One reach is severely impacted by combined impacts from interstate 94 and Jackson Road thoroughfares and their associated stream crossings and culverts. The subsequent altered hydrology has led to degradation of streambanks in this reach. The other has likely been impacted by the combined effects of residential development and steeper than average slopes. Flashy flows have led to significant erosion of stream banks at the lower end of this reach. Both may be candidates for restoration work, though the latter would perhaps benefit from stormwater control as well.

2.4.3.4 Stream Habitat

At a minimum of every five years and occasionally more frequently, HRWC conducts a habitat assessment at the macroinvertebrate monitoring sites (Figure 2.19). The assessment is composed of qualitative observations (riparian width, erosion sites, meandering, woody debris, counts of riffles/pools/runs, desktop observations through aerial photography and GIS) combined with quantitative measurements of stream substrate (substrate size analysis across ten cross section transects).

Honey Creek at Jackson Road flows through a developed commercial neighborhood. There is a vegetated riparian zone around the creek, but it is narrow and full of invasive plants. The creek has several eroding banks contributing fine sediment to the stream substrate, which is about 15% large rocks, 30% medium rocks and gravel, and 25% each of sand and muck. The creek doesn't have defined riffles or pools, but is generally shallow run habitat throughout.

The stream habitat at the downstream Wagner Road is more suited for aquatic life, with a wider riparian zone with some invasive plants but a lower percentage than Jackson Road, and the creek has more defined pool and riffle habitat. The stream substrate has considerably more big rocks than upstream with more boulders and cobble (more than 50% on the stream bed), but fewer medium and small rocks (15%), with sand and muck filling in the remainder of the spaces (35%).

2.4.3.5 Phosphorus

Honey Creek has been monitored twice monthly from April through September by the HRWC's Chemistry and Flow Monitoring since 2003 where is crosses Huron River Drive. Over the course of the monitoring period from 2003 to 2020, Honey Creek has seen a statistically significant decline in total phosphorus ($p=0.01$). Similarly, over the past ten years of complete monitoring data (2010-2019) Honey Creek has seen a statistically significant reduction in phosphorus (p=0.02). Mean and median total phosphorus concentrations in Honey Creek from 2010 to 2019 are 0.056 mg/l (s=0.05) and 0.04 mg/l, both above the Ford and Belleville Lakes TMDL target. Throughout this period total phosphorus concentrations ranged from 0.002 mg/l to 0.324 mg/l. (Table 2.8, 2.9)

2.4.3.6 Suspended Solids

HRWC has a record of growing season total suspended solids data for Honey Creek at Huron River Drive going back to 2003. Over the entire monitoring period from 2003 to 2020 as well as over the past ten years, there has been no observable or statistically significant trend in total suspended solids at Honey Creek. Total suspended solids at Honey Creek have maintained from 2010 to 2019, with an average concentration of 11.2 mg/l (s=26.78) and a median concentration of 4.8 mg/l. During that period concentrations at Honey Creek ranged from a minimum value of 0.8 mg/l to a maximum value of 221 mg/l. Only 2% of samples collected from 2003 to 2020 are over the state stormwater threshold of 80 mg/l for total suspended solids, indicating possible sedimentation due to extreme high precipitation events. (Tables 2.8, 2.9)

2.4.3.7 Nitrate and Nitrite

Recent conditions and historic data (>10 years):
HRWC's Chemistry and Flow Monitoring Program has collected water samples for nitrate and nitrite at Honey Creek near Wagner Road and Huron River Drive bimonthly from April to September since 2003. Nitrate concentrations at Honey Creek are maintaining around the mean and median of 0.5 mg/l (s=0.16) and illustrate no statistically significant trend. However, nitrite concentrations since 2003 are trending downward and are statistically significant at the 95 percent confidence level (p=0.017). Nitrate and nitrite concentrations for Honey Creek remain below the EPA's Maximum Contaminant Levels, with nitrate ranges between 0.03 and 1.30 mg/l and nitrite ranges of 0.0 to 0.06 mg/l. Nitrite values averaged 0.007 mg/l from 2003 to 2019, which is still far below the EPA's MCL for nitrite of 1 mg/l. (Tables 2.8, 2.9)

2.4.3.8 Conductivity

Recent conditions and historic data (>10 years old):

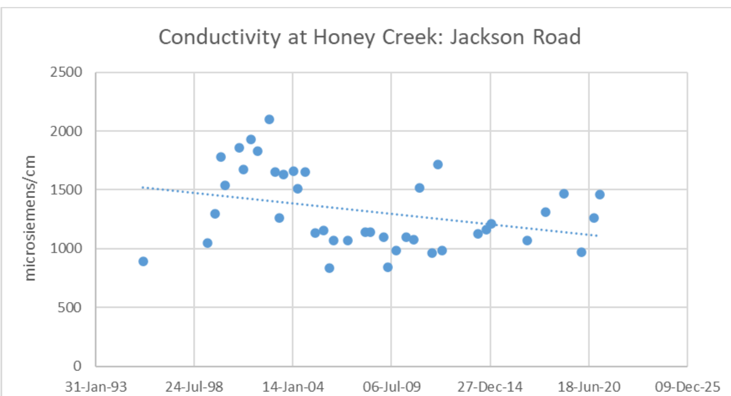
Since the mid-1990s, HRWC has tested conductivity at two sites in this creekshed through the River Roundup program; Wagner Road near the mouth and Jackson Road, about halfway up on Honey Creek. HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring.

Very early in the data record (1995-1999), Honey Creek: Jackson Road was below the 800 µS benchmark, but from 2000 until about 2004, the conductivity was spiking very high, reaching an average of 1700 µS (Figure 2.20). In 2005, the conductivity levels receded and have stabilized since then, with an average of 1154 µS. (Note: The timing of the conductivity spike also correlates with the loss of all sensitive macroinvertebrates at this site; see Macroinvertebrate section).

The average conductivity for Honey Creek: Wagner Road is 1036 µS from 2010-2020. The creek regularly has elevated conductivity levels compared to the 800 benchmark. Levels around 1000 µS do reflect some amount of water quality degradation. However, the results are much better than the heavily urbanized streams seen in nearby Ann Arbor, which regularly range between 1500 and 3000 µS.

In addition to the River Roundup Program, HRWC's Chemistry and Flow Monitoring Program also measures in-stream conductivity at the Honey Creek: Wagner Road site. From 2002 to 2011 and from 2014 to 2020, mean conductivity was 951.6 µS/cm (s=237.8) and median conductivity was 1000.0 µS/cm with a range of values from 242.0 to 1587 µS/cm. During that period, there is a statistically significant decline in conductivity values ($p=0.0006$). However, more recently conductivity values at Honey Creek demonstrate no trend, with average values maintaining around 900 µS/cm from 2010 to 2019. Short term (2010-2019) and long term (2002 to 2020) mean and median conductivity values at Honey Creek are above the 800 µS/cm benchmark, revealing potential salt and metal pollutants. (Tables 2.8, 2.9)

Figure 2.21. Conductivity trends at Honey Creek: Jackson Road (site A18) show a spike in conductivity levels in the late 90s and early 2000s.



2.4.3.9 pH

HRWC's Chemistry and Flow Monitoring program has monitored pH at Honey Creek from 2002 to 2011 and from 2014 to 2020. pH values at Honey Creek fall within the prescribed range under the Michigan Water Quality Standards for surface waters, with a minimum value of 7.1 and a maximum value of 8.4 from 2010 to 2019. During that period, the average pH value at Honey Creek was 8.0 (s=0.3) with a median of 8.1 (Tables 2.8, 2.9).

2.4.3.10 Temperature

Recent conditions:

In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. During the June-August months in 2013-2018, volunteers walked portions of Honey Creek and made 144 temperature measurements. The measurements range from 58.4 through 76.8 degrees Fahrenheit, with an average of 64.5 and a standard deviation of 4.2. The temperatures were all recorded late morning through early afternoon.

Since 2014, HRWC's Chemistry and Flow Monitoring Program has annually measured temperature from April to September at Honey Creek near Huron River Drive. The temperature of Honey Creek as measured by HRWC ranges from 37.8 to 74.3 degrees Fahrenheit. Mean and median temperature values at Honey Creek from 2010 to 2019 are 62.2 (s=7.8) and 63.9 degrees Fahrenheit, respectively (Tables 2.8, 2.9).

Historic data (>10 years old):
In 2001 and 2009, HRWC installed min/max thermometers at two locations in Honey Creek at Wagner and Jackson Road. The minimum and maximum temperatures were checked every week from July through August (Table 2.10).

2.4.3.11 Dissolved Oxygen

Recent conditions:
Measured twice monthly from April through September, dissolved oxygen at Honey Creek is maintaining, with no observable or statistically significant trend. Dissolved oxygen values at Honey Creek hover around 10 mg/l, with an average of 9.89 mg/l and median of 9.73 mg/l from 2014 to 2019. Except for one measurement of 3.94 mg/l, dissolved oxygen values at Honey Creek during that period ranged from 7.55 to 14.42 mg/l. Overall, dissolved oxygen at Honey Creek is suitable for aquatic life (Tables 2.8, 2.9).

2.4.3.12 Bacteria

Note: when discussing E. coli bacteria concentrations, two different analytical methods are used and report in different, but equivalent units. One method uses CFU = coliform forming units and the other uses MPN = most probable number. Generically, they can be referred to as counts.

HRWC has been monitoring Honey Creek near Huron River Drive and Wagner Road during the April through September recreational season since 2006 as part of its Chemistry and Flow Monitoring Program. The samples are collected as single grab samples. Compared to all long-term monitoring sites throughout the Middle Huron River, only two other tributary stations and the Huron River stations have lower mean and median E. coli counts than Honey Creek, since the beginning of monitoring. Honey Creek, at its outflow to the Huron River, has a median E. coli count of 227 per 100 ml and a mean of 491 per 100 ml (s=1202) through 2019, just above the monthly standard of 130 cfu per 100 ml. E. coli counts at Honey Creek range from 5 counts per 100 ml to 12,000 counts per 100 ml (Tables 2.8, 2.9).

However, less than half of samples (40 percent) collect at Honey Creek exceed the full body contact standard of 300 counts per 100 ml, with only 9 percent of samples exceeding the partial body contact standard of 1,000 counts per 100 ml. Over the past

10 years, E. coli counts at Honey Creek are trending downward, however the trend lacks statistical significance (p=0.16).

2.4.3.13 Macroinvertebrates

As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), the number of pollution sensitive families, and calculates a metric score based on Hilsenhoff's Index of Biotic Integrity. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality, and the lower the value of the Hilsenhoff IBI score. Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples.

The River Roundup Program monitors Honey Creek at two locations, right next to the mouth at Wagner Road, and further upstream on the main branch where it crosses Jackson Road. The two locations have approximately the same macroinvertebrate community; Wagner averages one more sensitive and EPT family. Compared to the larger Huron River watershed, their macroinvertebrate diversity is lower than average with approximately 9 total families found as compared to 12. However, Hilsenhoff IBI index rates both as "Good" indicating that there is not a high proportion of pollution tolerant insects here. In addition, both sites regularly hold winter stonefly populations (Table 2.11).

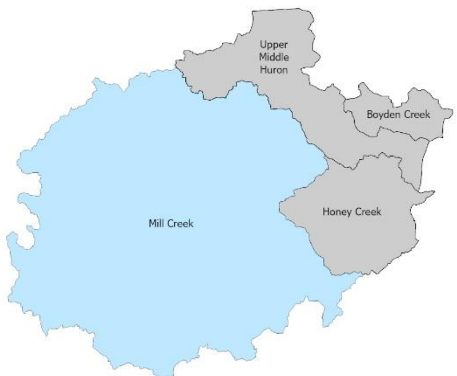
Historic data (>10 years old):
HRWC has sampled at both Wagner and Jackson Road since 1993. At Jackson Road, there was a rapid decline in the Sensitive Families throughout the 1990s and 2000s, as an average of 2 sensitive families were found throughout the 1990s but they had disappeared by 2005. (Note: The timing of this loss of sensitive families correlates with a large water conductivity spike; see Conductivity section). Sensitive families have not been found here since, with a couple of exceptions, as in 2019 one sensitive family has been found, and winter stoneflies, which disappeared from 2009-2015, have been regularly seen since 2016. Therefore it seems possible that the creek's macroinvertebrates could be having a comeback in recent years though continued monitoring would be required to confirm that.

Wagner Road, unlike Jackson Road, held onto Sensitive insects through the 2000s, but since 2017 there has been a significant decline of these families.

In summary, unlike some other creeks in the Huron River Watershed that have had stable macroinvertebrate populations across almost three decades, Honey Creek has seen a lot of changes from the early 90s to the present. Both monitoring sites on Honey Creek show changing populations of marginally healthy insect communities; where Jackson Road had become significantly worse about 10 years ago but is showing signs of improvement, and Wagner Road seems to be heading into a decline currently. The sites will continue to be monitored closely to see if stable populations will develop over time.

2.4.3.14 Fish

Honey Creek is home to a variety of small fish typically found in small cool creeks. The Michigan Fish Atlas, which records presence only, has a June 8, 1999 sample that records blacknose dace, blackside darter, bluntnose minnow, central stoneroller, common shiner, creek chub, green sunfish, and johnny darter in Honey Creek[4]. None of these fish are particularly sensitive to pollution or altered hydrology.



2.4.4 Mill Creek

2.4.4.1 Creekshed Natural Areas

The creekshed's forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from the creek, and provide wildlife habitat and beautiful places for us all to enjoy. About 31% of the creekshed still consists of intact natural areas. However, only a small fraction of these areas is protected from development (about 6% of the watershed, most of it in the Waterloo-Pinckney Recreation Area). Most of the creekshed's remaining natural areas (81%) face an uncertain future. It will be important to keep these lands natural, so they can continue to help keep the creek healthy.

Based on HRWC's Natural Areas Assessment and Protection project of the Huron River Watershed Council (Figure 2.6), in Sharon and Sylvan townships of the Mill Creekshed, several natural areas (9,984 acres) are high priority; however, only 2,916 acres are under permanent protection from development (e.g. Sharon Short Hills and Squires preserves, and the Waterloo-Pinckney Recreation areas). These areas are high scoring because they serve as large groundwater recharge areas for Mill Creek, they are topographically diverse (varied topography provides multiple habitats for plants, which creates higher biodiversity), and much of the forest and wetlands have remain unchanged over decades, increasing the potential that highly diverse native ecosystems exist or can be restored there.

2.4.4.2 Hydrology

Total impervious surface: 4%, 129 *square miles*

While the low impervious surface in the creekshed allows runoff water to soak into the soil and groundwater, many of Mill's streams have been straightened and its wetlands drained for agriculture. These factors (low impervious cover and high channel alteration) combine to produce somewhat altered flows. A bankfull-sized storm (about 2.3-in in 24 hours) would be expected to generate a peak flow of about 496 cfs in a natural reference stream the size of Mill Creek. The USGS measured a peak flow of 964 cfs following a 2.72-in event, which is just under twice the reference size. These larger peak flows are likely further eroding and altering stream banks and beds throughout the Mill Creekshed. Over the last ten years, Mill Creek flows produce a flashiness index of 0.18. This puts it in the flashiest quartile of Michigan streams of similar drainage area size. However, that same index rating would put it in the *least* flashiest quartile of all similar-sized streams in 6 Midwestern states.

2.4.4.3 Morphology

Recent conditions:
By far the largest creekshed in the Watershed, Mill Creek is also the creekshed with the largest amount of agricultural land in all the Huron River watershed. Over the years, many of the streams have been channelized, straightened, and deepened to drain wetlands and allow for a greater amount land to be farmed. Some significant forested area also exists in the creekshed to temper the channelization effects. Overall, 23.13 miles of stream reach were assessed within the Mill Creekshed. These averaged a unit erosion rate of 0.044 tons/year per assessed linear foot, which is not surprisingly very close to the overall average for the entire Watershed.

Five reaches of Mill Creek were evaluated to have significant erosion rates above 0.1 tons/year/ft. Three of these were long stretches of the southern fork of Mill Creek that traverse the agricultural landscape and exhibit evidence of previous channelization and the subsequent effects from being disconnected from natural floodplains. A fourth, small reach was likely impacted by residential and road development, but has good forest cover and floodplain to connect to. The final significantly degraded stream is a highly altered channel with built-up banks that seems to have been designed to drain a large wetland. It is deeply incised with silt beds that accumulate along the sides. These channels have all been evaluated for restoration potential.

2.4.4.4 Stream Habitat

At a minimum of every five years and occasionally more frequently, HRWC conducts a habitat assessment at the macroinvertebrate monitoring sites (Figure 2.19). The assessment is composed of qualitative observations (riparian width, erosion sites, meandering, woody debris, counts of riffles/pools/runs, desktop observations through aerial photography and GIS) combined with quantitative measurements of stream substrate (substrate size analysis across ten cross section transects).

Mill Creek is very large, and the stream habitat quality is diverse, though only in the upper headwaters does the stream escape the influence of agricultural practices. A tributary of the South Fork (site A96) has the highest level of muck (fine sized substrate) of any monitored Mill Creek site with 70% of the streambed composed of that material (Table 2.12). The North Fork of the creek (sites A32, A34, and A31) also has high levels of muck in the substrate. On the other hand, the upper headwaters of the South Fork (A55 and A57) are the sandiest streams. All of these sites have very minimal vegetated riparian buffers; oftentimes there is no riparian buffer.

The main branch of Mill Creek (sites A33, A80, and A79), which starts after the North and South Fork merge, has more rock and gravel substrates compared to upstream reaches. Closer to the mouth of the creek (site A79), there is a higher amount of boulder and cobble, but it must be noted that this region was artificially altered after the removal of Dexter Dam. Sites A79 and A80 are in the City of Dexter and more exposed to low density suburban landuse than agriculture; yet these sites are also downstream of some of the thickest forested areas in the creekshed (along Parker and Baker Road south of the City). This section of the creek has some woody debris and pools.

Table 2.12. Substrate composition of monitored sites in the Mill Creek creekshed

Site	% Boulder /Cobble	% Rock/ Gravel	% Sand	% Muck
A31: Mill Creek, Fletcher Rd	6.5	35.1	11.8	37.4
A32: Mill Creek, Ivey Rd	7.6	45.5	20.5	18.6
A33: Mill Creek: Jackson Rd	12.8	71.9	7.5	2.5
A34: Letts Creek, M-52	6.7	42.0	20.5	23.4
A55: Mill Creek, Manchester Rd	1.7	26.9	48.7	8.4
A57: Mill Creek, Klinger Road	3.9	35.7	47.2	3.9
A79: Mill Creek, Mill Creek Park	39.8	27.3	23.7	8.5
A80: Mill Creek, Shield Road	10.0	49.4	22.6	11.3
A96: Mill Creek: Parker Road	5.4	14.4	4.0	71.0

A habitat survey was conducted by Michigan Trout Unlimited (TU) professional staff in 2016 with a report completed in January 2017[5]. The survey divided the Mill Creek area interest into two segments (approximately 2.25 miles). The first segment was from Sloan Preserve to Shield Road (0.41 miles) and the second segment was from Shield Road to the Huron River (1.81 miles, and running between HRWC's sites 79 and 80.)

TU's habitat report found that Mill Creek in these sections has very high levels of silt (29%) and clay (25%) and low levels of hard substrate of gravel, cobble and boulders. (It should be noted that AATU's habitat study covered a wider area than HRWC's habitat studies, which can explain the difference in results for these areas).

The high levels of silt and clay are likely the result of the dam that existed at Main Street in Dexter permitting the buildup over a long period of time. Some of the boulder structure found in segment 2 was the result of artificial structures placed in the Mill Creek as a part of the management project that included the dam removal. Deep water refuges, wood structure and aquatic vegetation are limited in the areas of Mill Creek that were surveyed. Segment 1 is primarily composed of runs and riffles with little to no significant deep pools. Segment 2 is more diverse with riffles, runs and several deeper pools.

2.4.4.5 Phosphorus

Since 2003, HRWC's Chemistry and Flow Monitoring Program has monitored Mill Creek at Parker Road twice monthly during the growing season. Over the entire sampling period between 2003 and 2020, total phosphorus concentrations at Mill Creek demonstrate no statistically significant trend. However, from 2010 to 2019, total phosphorus concentrations at Mill Creek have seen a statistically significant declining trend (p=0.02). Mean and median total phosphorus concentrations at Mill Creek are still above the 0.03 mg/l TMDL target for Ford and Belleville Lakes, with a mean of 0.067 mg/l (s=0.06) and a median of 0.05 mg/l from 2010 to 2019. Total phosphorus concentrations during that period ranged from 0.011 mg/l to 0.45 mg/l. (Tables 2.8, 2.9)

2.4.4.6 Suspended Solids

Since 2003, total suspended solids data for Mill Creek has been collected bimonthly from April through September by HRWC's Chemistry and Flow Monitoring Program at North Parker Road near Dexter. Total suspended solids concentrations at Mill Creek are steady and demonstrate no observable or statistically significant trend. Mean and median total suspended solids concentrations from 2010 to 2019 are 12.7 mg/l (s=22.38) and 7.1 mg/l, respectively. While mean and median total suspended solids concentrations are well below the state stormwater threshold of 80 mg/l, total suspended solids concentrations rise to 180 mg/l at Mill Creek, largely during high precipitation events. (Tables 2.8, 2.9)

2.4.4.7 Nitrate and Nitrite

Recent conditions and historic data (>10 years):
Since 2003, bimonthly nitrate and nitrite data for Mill Creek at Parker Road has been collected by HRWC's Chemistry and Flow Monitoring Program during the growing season from April through September. Despite an observable decline in nitrite, there are no statistically significant trends in nitrate or nitrite at Mill Creek. All nitrate and nitrite concentrations at Mill Creek measured from 2003 to 2019 remained below EPA's Maximum Contaminant Levels. Nitrate concentrations ranged between 0.05 and 5.10 mg/l and nitrite concentrations ranged from 0.0 to 0.21 mg/l from 2003 to 2019. (Tables 2.8, 2.9)

While still below the EPA's MCL for nitrate, the long-term Mill Creek monitoring site at Parker Road and additional upstream investigative sites at Mill Creek have produced the highest nitrate concentrations throughout the Middle Huron River Chemistry and Flow Monitoring Program, with concentrations reaching 5.1 mg/l. Nonetheless, these concentrations are largely outliers. Measured concentrations from 2003 to 2019 averaged 0.88 mg/l (s=0.62) for nitrate and 0.013 (s=0.02) for nitrite. Medians for nitrate and nitrite during that period were 0.70 mg/l and 0.009 mg/l, respectively.

2.4.4.8 Conductivity

Recent conditions and historic data (>10 years old):

HRWC regularly tests conductivity at the same sites where macroinvertebrates are sampled in the River Roundup program (Figure 2.18); in the Mill Creek Watershed, this is nine locations. Eight of these sites have more than 20 years worth of data; one of these sites (Parker Road) has only recently been monitored. HRWC uses stream water conductivity as an indicator of possible water pollution. A threshold of 800 µS is used as a guideline, above which water quality degradation may be occurring.

Eight of the nine sample sites in Mill Creek do not have conductivity measurements that regularly exceed 800 µS, although an occasional sample with conductivity between 800-900 are in the data record. The only sample site with an 2010-2020 average conductivity greater than 800 µS is Letts Creek at M-52 in Chelsea, with an average measurement of 825. In summary then, this data shows that high water conductivity is mostly a non-issue in Mill Creek.

HRWC's Chemistry and Flow Monitoring Program also measures conductivity during its biweekly outings from April to September. From 2010 to 2019, mean conductivity at Mill Creek ranged from 260.0 to 1478.0 µS/cm. Mean and median conductivity values at Mill Creek are both below the threshold of 800 µS/cm, with a mean of 693.8 µS/cm (s=149) and a median of 702.5 µS/cm. Around 25% of conductivity measurements at Mill Creek from 2010 to 2019 were over the 800 µS/cm threshold, indicating potential pollutant concern. There is no observable trend in conductivity values at Mill Creek, however, there is seasonal variability in values from April through September. (Tables 2.8, 2.9)

It would be expected that road salt can cause spikes of conductivity during periods of snow melt, but snowmelt events have not been monitored.

2.4.4.9 pH

HRWC's Chemistry and Flow Monitoring program has monitored pH at Mill Creek from 2002 to 2011 and from 2014 to 2020. pH values at Mill Creek fall within the prescribed range under the Michigan Water Quality Standards for surface waters, with a minimum value of 6.6 and a maximum value of 8.3 from 2010 to 2019. During that period, the average pH value at Mill Creek was 7.9 (s=0.4) with a median of 8.1. (Tables 2.8, 2.9)

2.4.4.10 Temperature

Recent conditions:
In HRWC's Creekwalking program, volunteers walk (or paddle in deep waters) the waterway and record simple observations, including water temperature. During the June-August months in 2013-2018, volunteers walked portions of Mill Creek and made 365 temperature measurements. The measurements range from 50 through 75.8 degrees Fahrenheit, with an average of 65.6 and a standard deviation of 4.9. The temperatures were all recorded late morning through early afternoon.

A temperature logger was set along a shaded bank in the Mill Creek at the intersection of Jackson Rd. Road from 2014 through 2018. The logger was set to record the temperature every hour. For the summer month of July and August, the average daily temperature of this location is 67.7, with a minimum daily temperature of 64.9 (usually occurring in early morning) and a maximum daily temperature of 70.1 (usually occurring late afternoon).

Since 2014, temperature data has been collected at Mill Creek near Parker Road by HRWC's Chemistry and Flow Monitoring Program. Both long-term (2003-2020) and short term (2010-2019) water temperature averages are around 63 degrees Fahrenheit (s=8.7), with medians around 66 degrees Fahrenheit. Temperature values from 2010 to 2019 range from 40.6 degrees Fahrenheit observed in April to 79.0 degrees Fahrenheit in July (Tables 2.8, 2.9).

Ann Arbor Trout Unlimited (AATU) monitors water temperatures at four locations along Mill Creek: Downtown Dexter, Shield Road, Lima Center, and M-52. Hobo loggers are deployed in late spring and recovered in early autumn. Average July temperatures are typically 67 to 73º and will range from a low of 63º to brief intervals of high temperatures of 80º and above. Average July temperatures have shown a slight increase over the past five years.

Historic data (>10 years old):
Through the 2000's, HRWC installed min/max thermometers at numerous locations in Mill Creek. The minimum and maximum temperatures were checked every week from July through August. The temperatures are in degrees Fahrenheit (Table 2.10).

2.4.4.11 Dissolved Oxygen

Recent conditions:
Dissolved oxygen at Mill Creek, as measured bimonthly by HRWC's Chemistry and Flow Monitoring Program from April through September, is consistently above the state standard of 5 mg/l with measured values averaging 9.48 mg/l (s=2.0) from 2014 to 2019. Except for two measurements, dissolved oxygen at Mill Creek during that period range from 5.95 to 14.34 mg/l. Overall, dissolved oxygen conditions at Mill Creek indicate general aquatic livability (Tables 2.8, 2.9).

2.4.4.12 Bacteria

E. coli monitoring began at Mill Creek in 2006 by HRWC's Chemistry and Flow Monitoring Program. The samples are collected as single grab samples. There has been no observable or statistically significant trend since monitoring began. *E. coli* counts are maintaining, with average counts of 876 per 100 ml (s=1790.4) and a median value of 493 per 100 ml from 2006 to 2019. *E. coli* counts at Mill Creek frequently violate the state water quality standards for *E. coli*, with 66 percent of samples exceeding the full body contact standard of 300 counts per 100 ml and 21 percent of samples exceeding the partial body contact standard of 1000 counts per 100 ml. Monitoring data at Mill Creek presents a wide range of *E. coli* data, with counts ranging from 0 to 14,400 counts per 100 ml. Despite upstream investigative site monitoring of Mill Creek's upstream branches, no upstream *E. coli* sourcing has been identified. (Tables 2.8, 2.9)

2.4.4.13 Macroinvertebrates

As a proxy to overall stream health, HRWC studies the macroinvertebrate diversity of insect families, the number of insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT families), the number of pollution sensitive families, and calculates a metric score based on Hilsenhoff's Index of Biotic Integrity. Typically, the higher the diversity of insects, the more diverse the habitat types and the better the water quality, and the lower the value of the Hilsenhoff IBI score. Since natural variation in weather, flow, and volunteer experience will give different results, HRWC always considers a three-year sample average to produce a more robust summary of results, rather than using individual samples.

Mill Creek is very large, and the macroinvertebrate population can differ greatly depending on the location, ranging from healthy to degraded. HRWC samples nine locations on Mill Creek, and the results from 2018-2020 are summarized in Table 2.10.

There are three notable areas on Mill Creek that have macroinvertebrate populations of higher diversity than the Huron River watershed average and better than average Hilsenhoff IBI scores; these are the upper portions of the Southern Fork (sites A55 and A57, near to M-52), the upper portion of the Northern Fork (site A32, close to Waterloo Rec Area), and close to the mouth at Mill Creek Park (site A79).

On the other hand, there are some monitoring sites in Mill Creek that, while having only a slightly below average insect diversity, have IBI scores indicating a high proportion of pollution tolerant taxa, which in these cases are leeches, mosquitoes, and true bugs, that are known to do well in mucky, slow water and low oxygen environments. Site A31, A34, and A96 have fair to poor IBI scores; site A96 (Parker Road) is third worst across all 61 HRWC sample sites in the Huron River Watershed.

Sites A33 and A80 (both on the main branch of Mill after the merge of the North and South Fork) are rated as “Good” IBIs and have slightly less than average insect diversity as compared to the overall Huron River watershed.

Historic data (>10 years old)

Mill Creek has stable insect populations for the most part. Of the nine sites monitored, seven are not experiencing any statistically significant macroinvertebrate population changes.

Mill Creek at Mill Creek Park (site A79), has had a statistically significant increase of sensitive families since monitoring started in 2005, with the most recent samples in 2019 and 2020 showing 4 sensitive families, which is quite a bit above the typical Huron River watershed stream with an average of 1.2 families. This is the site of the dam removal in 2008 and the stream was greatly altered and restored at this time, and it is gratifying to see after a decade the the insect population is flourishing here.

Letts Creek is a tributary of Mill Creek that flows through Chelsea (A34). This site has had a statistically significantly decrease of total families and EPT families since monitoring starting in the 1990s.

2.4.4.14 Fish

Historically, northern pike were considered to be large and plentiful in Mill Creek, when the stream was still more directly connected to plentiful wetland nursery areas. Agriculture and channelization of stream segments has reduced this population from historic levels.[6]

A 2010, thirty minute, MDNR stream electroshocking survey of Mill Creek at Shield Road (about a 1.6 miles upstream of the mouth) gives the best modern day snapshot of the fishery, albeit pre-trout stocking. The following species were found: bluegill, central stoneroller, common carp, green sunfish, greenside darter, johnny darter, large mouth bass, mottled sculpin, northern brook lamprey, northern hog sucker, northern pike, rainbow darter, rockbass, smallmouth bass, and white sucker.

In 2006, the Ann Arbor Chapter of Trout Unlimited (AATU) began a project to introduce brown trout to a stream in SE Michigan. This process began with the collecting data on stream water temperatures in July and August in several different streams. Temperatures in the Huron River were too warm to support brown trout. However, temperatures in various sections of Mill Creek showed promise with ranges in the cold transitional to warm transitional range designations. In 2008, repairs to the Main Street bridge over Mill Creek required removal of a dam that had been in place for nearly 200 years. The decision was made to concentrate efforts on a 3-mile stretch of Mill Creek extending from Sloan Preserve on Baker Road to the Huron River.

In 2011, working with the cooperation and permission of the MDNR, AATU stocked 500 brown trout fingerlings in Mill Creek. AATU continued to stock 500 trout each year until 2020. Starting in 2014 MDNR has stocked 2,200 trout each year until 2020. MDNR increased their stocking quota to 4,400 trout in spring 2021 and will continue at this level until 2030.

AATU logs catch data reported by anglers on Mill Creek. Since 2014, 216 unique anglers have reported catching brown trout in Mill Creek for a total 675 fish being reported. This is likely an undercount as not all anglers report their catch. Trout up 20 inches have been reported indicating that there is multi-year survival of the stocked trout.

AATU advocates for catch and release of brown trout caught in Mill Creek. Furthermore, AATU requests that anglers refrain from targeting brown trout in Mill Creek during July and August when trout are stressed marked by water temperatures above 70º or when air temperature are above 80º.

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[4] Michigan Department of Natural Resources. 2003. Michigan Fish Atlas 2003 v1.1. Online: http://www.dnr.state.mi.us/spatialdatalibrary/metadata/michigan_fish_atlas.htm
[5] Thomas, K, and Burroughs, B. 2017. Mill Creek: Instream Fish Habitat Assessment. Trout Unlimited Report
[6] Brown, C.J.D., and J.L. Funk. 1945. A fisheries survey of the Huron river, its tributaries and impounded waters. Michigan Department of Natural Resources, Fisheries Research Report 1003, Ann Arbor.

2.5 Impairments and Critical Areas

As shown throughout Chapter 2, there are various pollutants, also known as impairments, that reduce the water quality of the Watershed, and this presents challenges to meeting the designated and desired uses.

Analysis of existing data indicates that the Watershed has areas of medium-quality and low-quality waters that require mitigation of existing impairments. This section summarizes current impairments in the watershed and identifies the sources and causes of those impairments. There are both general impairments which occur across the Watershed and there are also specific impairments that are occurring in particular locations and tied directly to TMDLs.

2.5.1 General Impairments

The authors, with assistance from the Advisory Committee have compiled and updated the information necessary to identify and understand these impairments and their sources and causes. This list of impairments (Table 2.11) is based upon the results of analysis of the data presented in this chapter, Advisory Committee member observations, and citizen input.

Table 2.11. Impairments, Sources and Causes in the Watershed. Order of impairments within and between categories does not imply magnitude of impact

Impairment 1: High Nutrient Loading	
Sources	**Causes**
1. NPDES permitted facilities	Nutrients in effluent
2. Fertilizers from residential, commercial, and golf courses	Lack of buffers Nutrient control ordinances lacking teeth or too permissive Lack of nutrient management plans Overuse/improper application of fertilizers
3. Excessive runoff from developed areas	Lack of BMPs at existing development areas Impervious surfaces Poor storm drain maintenance
4. Legacy nutrients in lake / impoundment sediment	Sediment deposition Resuspension during storm events Dissolution during summer stratification
5. Illicit discharges	Aging sanitary sewer infrastructure Inadequate inspection/detection and repair due to cost Illegal septic application and trailer waste disposal
6. Pet and wildlife waste	Wildlife in storm drains Improper disposal of pet waste Ponds increase habitat for waterfowl, wildlife
7. Failing septic tanks	Old units are too small or don’t meet codes Lack of a required maintenance program Poor maintenance/lack of education

Impairment 1: High Nutrient Loading	
Sources	**Causes**
8. Agricultural runoff from fertilizers/ livestock waste	Lack of nutrient management plans Lack of BMPs (upland and riparian buffers) Exposed soils
9., Loss of ecosystem services that attenuate polluted runoff	Conversion of natural areas (natural green infrastructure) to agriculture, housing, transportation, commercial, manufacturing, etc. and "gray," built infrastructure

Impairment 2: Altered Hydrology	
Sources	**Causes**
1. Loss of riparian vegetation	Conversion of riparian woodlands, wetlands, grasslands, and flood plains to agriculture and development.
2. Runoff from developed areas	Lack of BMPs at existing development areas Impervious surfaces Removal of woodland/forest, wetlands, and other pervious areas
3. Runoff from construction sites, new development	Removal of woodland/forest, wetlands, and other pervious areas Decentralized development increasing imperviousness Rerouting channel for development Lack of resources for enforcement/inspection Site exemptions Lack of education on alternatives
4. Engineered drains and streams	Loss of connection between stream and floodplain from channelization Loss of storage and infiltration capacity Removal of riparian buffer
5. Impoundment of streams	Dam construction Natural damming

Impairment 3: Sedimentation, Soil Erosion	
Sources	**Causes**
1. Loss of native vegetation and soils	Conversion of natural area and ecologically developed soil system to agriculture and development.
2. Eroding stream banks and channels	Flashy flows Channelization Drain maintenance Eroding crossing embankments Clear cutting/lack of riparian buffers
3. Construction sites	Clear cutting/lack of riparian buffers Lack of resources for enforcement/inspection Lack of soil erosion BMPs and BMP education Insufficient penalties for noncompliance with ordinances Exposed soils Site exemptions

Impairment 3: Sedimentation, Soil Erosion	
Sources	**Causes**
4. Developed areas	Lack of BMPs at existing development areas Impervious surfaces Clearcutting/lack of riparian buffers
5. Dirt, gravel roads	Poorly designed/maintained road stream crossings Poor road maintenance
6. Sediments in impoundments	Legacy sedimentation, settling, then resuspension Ineffective maintenance of dams
7. Agricultural field runoff	Lack of BMPs (upland and riparian buffers) Exposed soils

Impairment 4: Pathogens	
Sources	**Causes**
1. Illicit Discharges	Aging development sanitary sewer infrastructure Illegal septic application and trailer waste disposal Incomplete inspection/detection and repair due to cost Lack of education
2. Failing septic tanks	Old units are too small or don't meet codes Lack of a required maintenance program Inadequate enforcement by Health Departments Poor maintenance/lack of homeowner education
3. Illegal/improper septage application	Lack of adequate septage disposal facilities
4. Pet and wildlife waste	Wildlife in storm drains Improper disposal of pet waste (runoff from paved areas) Ponds increase habitat for waterfowl, wildlife
5. Livestock waste from agricultural operations	Lack of BMPs

Impairment 5: Salts, Organic Compounds and Heavy Metals	
Sources	**Causes**
1. Legacy pollution	PCBs in numerous water bodies (Table 1.3) PFAS from industrial facilities; fire-fighting foam Excessive mercury in Four Mile Lake Illegal dumping
2. Developed areas	Lack of stormwater BMPs PAH pollution from coal tar driveway sealants Pharmaceuticals/Endocrine Disruptors in the water Waste incineration (atmospheric deposition) Illegal dumping Illicit connections
3. Roads	Auto emissions Lack of BMPs during road de-icing Poor road maintenance
4. NPDES permitted facilities	Inadequate inspection Lack of BMPs (upland and riparian buffers)
5. Turfgrass chemicals from residential, commercial lawns	Improper lawn care Illegal disposal
6. Agricultural runoff	Lack of BMPS (upland, riparian buffers)

Impairment 6: High Water Temperature	
Sources	**Causes**
1. Loss of upland and riparian native vegetation and soils	Conversion of natural areas and soils to development and agriculture
2. Directly connected impervious areas	Heated stormwater from urban areas Lack of groundwater recharge
3. Eroded soil areas	Soil erosion from channel and upland
4. Solar heating	Lack of vegetated canopy in riparian zone

Impairment 7: Debris/Litter	
Sources	**Causes**
1. Roadways, parks, urban areas, residential areas	Illegal littering/dumping Unsecured garbage containers and vehicles Inadequate refuse containers

2.5.2 Specific Impairments: Critical Areas

In order to establish an effective plan for addressing the key threats and impairments in the watershed, it is helpful to determine which areas in the watershed are contributing the most to its impairment. These "Critical Areas" provide direction for further, more specific analysis.

The first step in identifying critical areas is to examine the TMDL coverage of impaired waters detailed in Table 1.2. These areas require specific analysis and treatment activities to address the listed impairments. Specific loading calculations for these areas are discussed in the following sections.

2.5.2.1 Phosphorus Critical Areas

In December of 1993, a 12-month phosphorus loading analysis was initiated by EGLE to investigate the water quality of the Middle Huron. The analysis showed that Ford and Belleville lakes were impaired as they failed to meet water quality standards due to phosphorus enrichment, which contributed to nuisance algae blooms. Based on water quality sampling and accepted mathematical models, a phosphorus TMDL of 50 µg/L at Michigan Avenue and 30 µg/L in Belleville Lake was established for the months of April to September. This TMDL was originally approved by the U.S. EPA in 2000 and then updated in 2004 and 2010. It was completely revised and approved by EPA in 2019 (Appendix A). This revised version ramped the phosphorus concentration target down to 30 µg/L in Ford Lake, while keeping the Belleville Lake target at 30 µg/L. It also extended the total load from six months to 12 months, covering the entire year.

According to EGLE, meeting the goals of the TMDL should result in the attainment of water quality standards for Ford and Belleville Lakes, in addition to meeting the requirements of Water Quality Standard R 323.1060(2) which states "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi, or bacteria which are or may become injurious to the designated uses of the waters of the state."

The TMDL estimates that the annual total phosphorus load to Ford Lake is 76,620 lbs/year. This estimate is based on point source reporting, and a land use model. The TMDL states that EGLE monitoring data shows a significant decline in phosphorus concentrations at river monitoring sites that is also consistent with a 20% decline in phosphorus concentrations observed by HRWC and an 11-23% decline observed by Dr. John Lehman. An estimated 31% of the EGLE-estimated phosphorus load was derived from direct point sources, 12% was from stormwater (MS4) sources, mostly within other sections of the watershed, and the remainder (57%) was from nonpoint sources. Most of the load contributed from this watershed comes from these nonpoint sources. According to the EGLE model, agriculture makes up 44% of the nonpoint sources. Of the three middle Huron watersheds, the upper watershed has the largest agricultural area and the greatest percent of cover.

HRWC assessed monitoring data collected since 2003 to estimate loading from tributary drainages at multiple times since the original TMDL was developed. Most recently, HRWC worked with Dr. Tim Maguire to develop landscape-adjusted, April-September seasonal loading estimates for multiple drainages in the Middle Huron watershed using monitoring data from HRWC's Chemistry and Flow Monitoring Program. Across the most recent five years (2014-2018), total phosphorus loads ranged from 6,149 to 34,410 lbs per season with an average of 18,692 lbs/season. This 6-month mean translates to an estimate of 37,384 lbs for a complete year. This represents a 53% reduction in phosphorus loading from the estimate in the original TMDL.

Despite this decline in loading to Ford Lake, neither Ford nor Belleville Lake is showing any trend in lake phosphorus concentrations, based on periodic lake monitoring by EGLE. Because of this, the revised TMDL set new loading goals. EGLE used two lake models to estimate that each lake would need to reach a total phosphorus concentration of 30 µg/l to reach a healthy aquatic trophic status. Maintaining current trends of load reductions, and increasing reductions with activities recommended in Chapter 4 of this plan may eventually reduce phosphorus concentrations over the very long term (one or multiple decades).

The revised TMDL sets annual and daily load targets for Ford Lake as found in Table 2.12, and Belleville Lake. The Belleville Lake targets rely primarily on load reductions from Ford Lake upstream, internal lake management, and stormwater MS4 reductions.

Table 2.12 Ford Lake TMDL Loading and Target Load Goals

	EGLE Current Load Estimate (lbs/yr)	**TMDL Goal (lbs/yr)**	**Reduction (%)**	**TMDL Goal (lbs/day)**
Nonpoint Load Allocations				
Huron River Upstream	19,000	15,000	21%	41.1
Urban	3,000	800	73%	2.2
Agriculture	19,000	7,000	63%	19.2
Other	500	500	0%	1.4
Internal Load	2,000	480	76%	1.3
Precipitation, Deposition	130	130	0%	0.4
LA Total	**43,630**	**23,910**	**45%**	**65.5**

Point Waste Load Allocations				
WWTPs				
Ann Arbor	22,000	8,980	59%	24.6
Chelsea	600	560	7%	1.5
Dexter	270	180	33%	0.5
Loch Alpine	510	95	81%	0.3
Thornton Farms	200	45	78%	0.1
Other				
Chrysler-Chelsea Proving	40	40	0%	0.1
Sweepster	100	100	0%	0.3
Thetford/Norcold	40	40	0%	0.1
UM Power Plant	20	20	0%	0.1
Ann Arbor Drinking Water Plant	30	30	0%	0.1
Point WLA Total	23,810	10,090	58%	27
Aggregate Stormwater MS4s	9,180	2,500	73%	7
WLA Total	32,990	12,590	62%	34
Margin of Safety	NA	Implicit (0)		0
Total Load	76,620	36,500	52%	100

The TMDL target goal requires that the entire Middle Huron watershed reduce phosphorus loading by 52% from the EGLE loading estimate. This load from upstream sources has certainly been reduced, based on EGLE and HRWC monitoring. However, since lake concentrations have not changed significantly, it is necessary to continue to reduce loading from upstream sources. Since the lake concentrations are very slow to change, it is likely that it will require decades of low loading, in addition to active lake management, to reduce in-lake phosphorus concentrations.

Creekshed Breakdown

In an effort to determine critical areas for reducing phosphorus inputs, HRWC continues to monitor the watershed and estimate loading and changes in loading from tributary creeksheds and subsections of the Middle Huron watershed. Table 2.13 presents two sets of estimates of total phosphorus loading. The first estimates are based on four years of early monitoring program data and were produced using USGS P-load software. The second set were produced by a landscape-integrated GIS model that incorporated stream discharge and TP concentrations collected across the entire Huron River watershed for the most recent five years through 2018. Both are established in the table as mass-balance models. Certain caveats for the 2014-2018 model should be considered. The estimate for the river at N. Territorial Road is likely overestimated due to a lack of sufficient data upstream.

Table 2.13. Estimates of Total Phosphorus Loading

Location	TP Mean Daily Load Est. (2003-2006)	TP Mean Daily Load Est. (2014-18)	Difference (%)
Huron @ N. Territorial (upstream, incoming water effects)	38.34	59.15	35.2%
Mill Creek	25.26	40.72	38.0%

Boyden Creek		4.60	
Honey Creek	5.07	3.43	-47.8%

In summary, while phosphorus loading into Ford and Belleville Lakes has decreased by 29% since sampling began in 2003, the TP Mean Daily Load estimates are showing that inputs have only increased substantially from both the incoming waters that are outside of this plan, and more interestingly, from Mill Creek. Mill Creek contributes by far the greatest phosphorus load to Ford and Belleville Lakes with a 38% increase since 2006 according to the modeling.

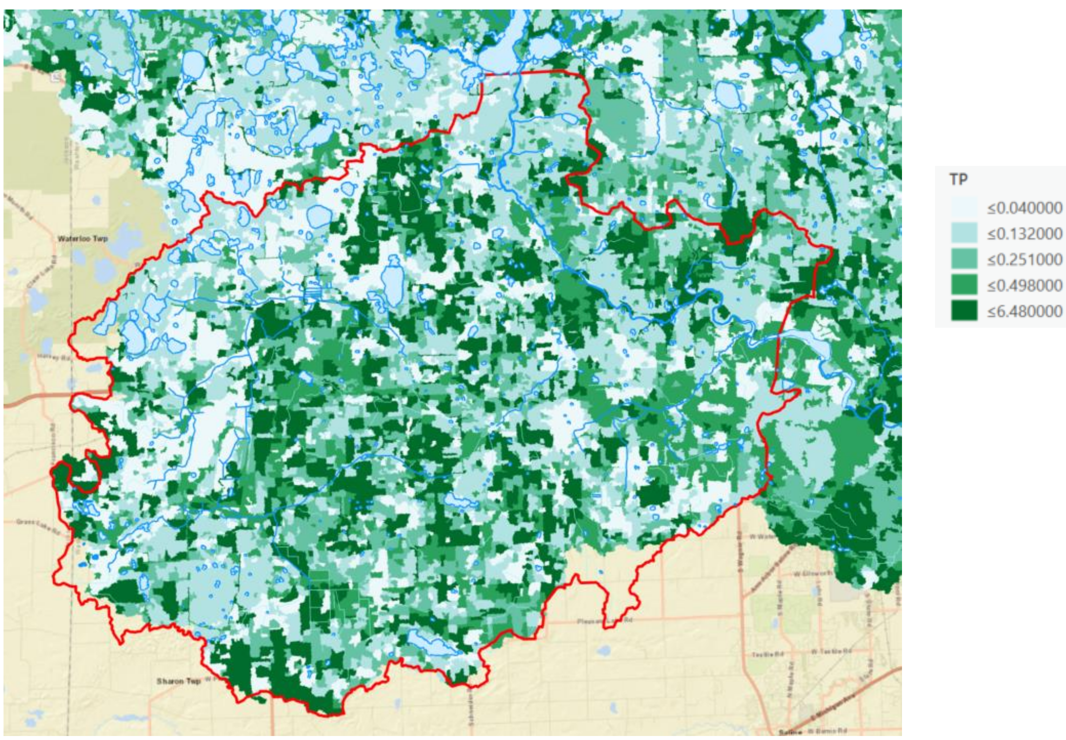
Since the majority of land in Mill Creek is in agricultural use, it seems that activities focusing on reducing phosphorus loss from farm fields would be of greatest benefit.

A Soil and Water Assessment Tool (SWAT) analysis was conducted on the region to understand total phosphorus loading rates based on landuse and management practices. Results from Mill Creek are shown below; the darkest colored polygons represent top priority critical phosphorus areas (Figure 2.22)

The BANCs analysis (Bank Assessment for Non-point source Consequences of Sediment, Appendix G) gets at these critical phosphorus areas in another way; by assessing the amount of sediment eroding into the creek. Figure 2.17 shows the highest erosive reaches in the Watershed.

Recommendations will be presented in chapter 4 in regards to dealing with agriculture.

Figure 2.22. Total Phosphorus loading rates from SWAT model (in kg/ha)



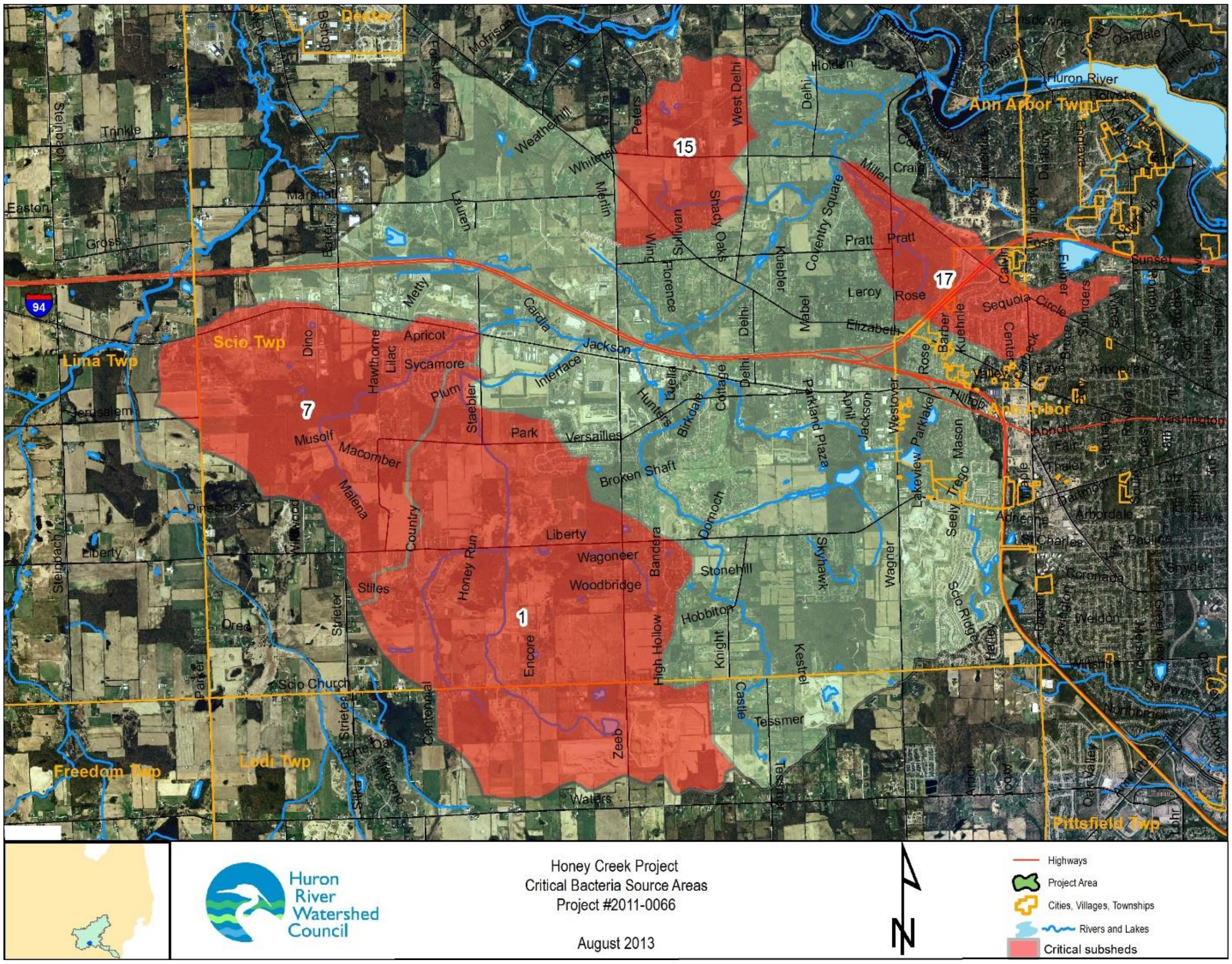
2.5.2.2 Honey Creek Bacteria TMDL

A TMDL was developed and approved in 2009 (Appendix B) to address the bacteria impairment in Honey Creek. Subsequently, a watershed management plan was developed and approved by EGLE in 2014 to implement activities to address the goals in the TMDL (Appendix E). Following that, HRWC and partners conducted an implementation project to carry out a number of recommended activities from the WMP. Below is the critical area analysis from the WMP with some updates from monitoring following implementation.

The study of the Honey Creek watershed was designed to identify likely sources of bacterial contamination to the creek. Water sampling points were distributed at tributary end points to isolate watershed sections geographically. Samples were evaluated for bacterial genetics to determine likely animal sources. Stream reaches with consistently high bacteria counts were surveyed for visible signs of bacteria sources. Key watershed areas were evaluated with a windshield survey to identify residential and agricultural practices that may be contributing bacteria to Honey Creek. Finally, interviews were conducted with representatives of area residents to confirm practices.

Water quality sampling indicated that there were occasional sample events at all sites that exceeded the single sample TBC standard. However, several sites were more generally below the standard and even below or near the 30-day standard. These areas will not be the focus of remedial efforts, and thus are not critical areas. The areas that remain are defined as the critical subwatershed bacteria source areas (Figure 2.23). Gaining control over bacterial contamination sources in these critical areas should lead to lower bacteria levels in the main section of Honey Creek and result in the creek achieving state standards for TBC. These critical areas are designated by subwatershed codes that correspond to sample site numbers.

Figure 2.23. Critical bacteria source subwatershed areas in the Honey Creek watershed. Numbers indicate subwatershed designation and are referenced to downstream sampling stations.



Through the course of investigation, it was determined that multiple sources are contributing bacteria to Honey Creek. All five species markers that were selected for bacteria source tracking were positively identified in multiple samples at multiple locations. However, some markers are more critical to human health and others were more predominant at specific sample sites. The presence, especially the predominance, of the human marker in samples is of particular concern. The presence of human source markers in bacteria was identified in samples from all critical areas. The human marker predominated in subwatershed 15. Sampling in area 15 also suggested a non-runoff source. This combined information suggests that subwatershed 15 should be a high-priority target for investigation and remediation of human fecal contamination sources. Other critical areas should also be investigated for human sources, however, due to the presences and relative predominance of human sources throughout sampling in critical areas.

Other sources are more difficult to define geographically. Bovine, or cow manure source markers were identified in all but one sample, even in subwatersheds such as 17 that have little agricultural land use area. This source should be addressed throughout the watershed. Similarly, canine markers were identified in all critical areas. This source should be addressed in all residential areas within critical subwatersheds or across the entire watershed. Likewise, goose source markers were found in all source areas, though that source did not predominate in areas 1 or 7. Equine or horse fecal source markers were found in all critical areas, though less often in areas 7 and 15. Surprisingly, it was a predominant source in a sample from area 17 despite little evidence of horse ownership in that subwatershed, though there was evidence of horse traffic in the area. Identification and remediation of horse sources in area 17 are likely localized to the end of that stream, as little evidence of horses was found elsewhere.

The implementation project included activities to address all the different bacteria sources and critical areas. The post project data summary from 2020 (Appendix H) concludes that Honey Creek continues to exceed the state standards for bacteria levels and that implementation efforts have not had enough time to show results in lowered bacteria counts. These implementation projects should continue and be re-evaluated every two years.

2.5.2.3 Statewide Bacteria TMDL that Includes Mill Creek

The latest TMDL for the Watershed is Michigan's statewide TMDL for bacteria (Appendix C), which was approved by the U.S. EPA on July 29, 2019. Mill Creek, North Fork, (MI-4090005203-01) and Mill Creek (MI-04090005204-02) are both listed in the report with an E.Coli impairment. (Figure 1.2, Table 1.2). The data show that Mill Creek branches all exceeded the TBC standard, though the easternmost branch was somewhat lower and often below the standard. Therefore, only that eastern branch can be removed from the critical area in which to apply remediation activities. No implementation plan has yet been developed by affected stakeholders.

To remove the reaches from the impaired waters list, it will need to meet the water quality standard for pathogens. For the TMDL, the standard organism count of 130 per 100 milliliters (ml) as a 30-day geometric mean between May 1 to October 31 was used.

Further analysis of sampling data concluded that all five of the markers tested for genetic markers or bacteria source tracking (BST) analysis were present at all Mill Creek sites. This indicates broad contamination from a variety of mammalian bacteria hosts including humans, pets, livestock, and wildlife. While all of the DNA markers tested were prevalent, the bovine markers were the most broadly identified. Bovine markers were positively identified more than 50% of the time at every sampled site. The absence of active cattle and dairy farms proximate to these sites indicates that there may be active bovine bacteria applications occurring in the forms of manure or compost. To a lesser degree, the remaining four genetic markers also tested positive at many sites throughout the watersheds, demonstrating a need to develop a multi-faceted action plan to greatly reduce bacteria entering the Mill Creek watershed.

The diversity and quantity of bacteria, as measured by E. coli, entering Mill Creek drainages are driven by rainfall. After significant rainfall events, bacteria levels increased at a majority of the sites sampled, signifying that the bacteria source is largely driven by stormwater runoff. Only three sites showed a pattern indicating a dilution of bacteria concentration with additional rainfall. In these instances, upstream sources of bacteria are likely constant point sources. While human markers were identified in samples from some sites and could suggest low levels of septic failure, human sources were not identified as the predominant source in Mill Creek streams.

Additional sampling of Mill Creek is needed to gain a better understanding of geographic patterns and understand seasonal and yearly variations in the bacteria regime and sources of contamination.

2.5.2.4 Fish Consumption Advisory on the Huron River: Perflurooctane Sulfonate (PFOS) Impairment

Most of the Huron River, from the crossing at North Wixom Road in Milford all the way to Lake Erie is listed as failing to meet the Fish Consumption designated use in the 2020 EGLE Integrated Report, including the Huron River section contained in the Watershed of this Management Plan. [1] According to the Integrated Report**, "**A water body is considered to not support the fish consumption designated use if either the MDHHS has issued a site-specific fish consumption advisory for that water body or ambient water column concentrations exceed WQS (water quality standard)."

In August 2018, EGLE reported high levels of polyfluoroalkyl substances (PFOS, a family of synthetic chemicals) were found in dangerous concentrations in the tissues of fish from Kent Lake. Further testing revealed high levels in numerous places in the Huron and the Michigan Department of Health and Human Services issued a "Do Not Eat Fish" advisory for the length of the Huron River as noted previously. Groundwater and surface water testing was conducted, including in the Upper Middle Huron Watershed.

In March 2019, the former Chrysler Scio Introl Division facility located in Dexter (Mill Creek Creekshed) was found to have up to 1700 ppt PFOS+PFOA in their groundwater. The site was designated as a "PFAS site", which is when "one or more groundwater sample(s) exceed(s) the Part 201 cleanup criteria for groundwater used as drinking water. At the time of the discovery of contamination the criteria was 70 parts per trillion (ppt) PFOS + PFOA." [2] The Part 201 values for PFOS and PFOA are now effectively lower (16 parts per trillion for PFAS and 8 parts per trillion for PFOA) due to the establishment of Maximum Contaminant Levels (MCLs) in sources used for drinking water.

Surface water sampling was conducted in numerous places across the Huron watershed but most pertinently at Huron at Delhi Road downstream of Chrysler Scio. The sample at this location was significantly higher as compared to sample blanks with an average concentration of 21.9 parts per trillion (ppt) per sample. This is a simplification of a complex analysis but details can be found in the previously referenced report. EGLE's work on PFAS in the Huron River Watershed and the entire state is ongoing and rapidly changing. Up to date information can most reliably be found on the Michigan PFAS Action Response Team website, https://www.michigan.gov/pfasresponse/.

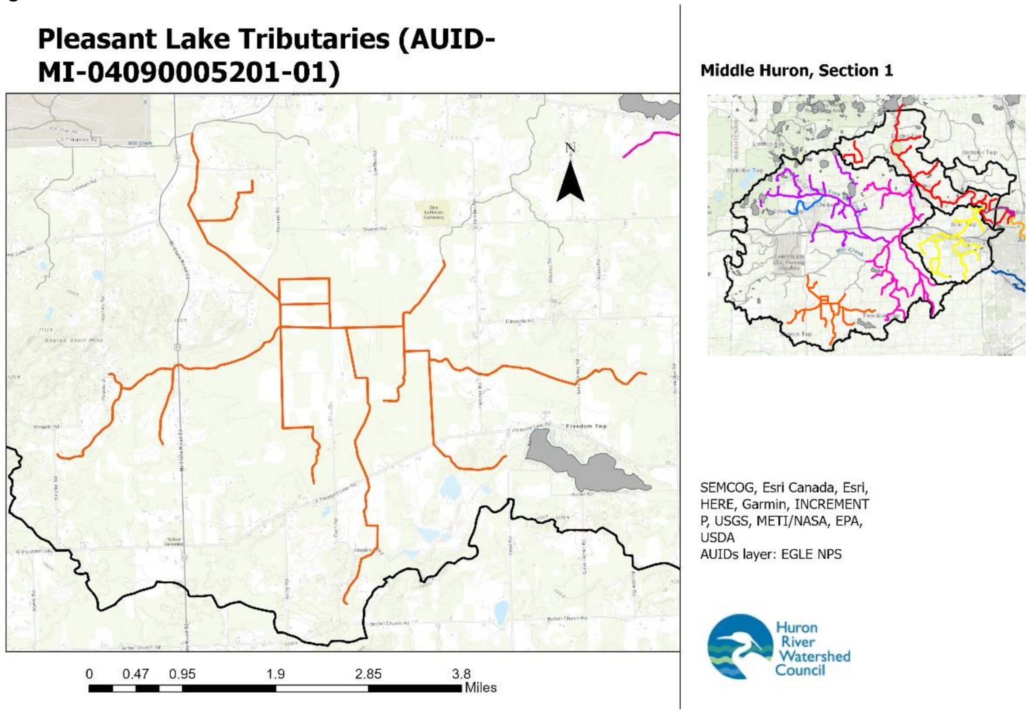
Legacy pollution issues are complicated and expensive. Ongoing operations that release PFOS to the environment can be fixed, such as the first high source of PFOS found in the Huron Watershed from an industrial facility in Wixom, which was able to drastically reduce their input. Yet contaminated groundwater poses a high challenge for cleanup and it is not clear when PFOS levels in the Huron will fall enough for the "Do Not Eat" fish advisory to be lifted. This could be an issue that persists for decades to come. In any case, in terms of needed next steps, further water monitoring is needed to discover new sources of PFOS and to expand testing of PFOS in fish fillets to better understand how the bioaccumulation in fish population changes over time.

2.5.2.5 Pleasant Lake Tributaries—Aquatic Life and Wildlife Impairment from Habitat Alterations and Flow Regime Modification

The Pleasant Lake Tributaries are a series of agricultural streams found in Sharon and Freedom Township in the southern section of the Mill Creek creekshed. The streams have been highly straightened and channelized and have little natural character remaining; indeed, looking at a map of the streams makes it clear that they make right hand turns, circle back on themselves, and it is not obvious which Mill Creek downstream branch the water even flows to, as the topology is very flat in the area. (Figure 2.24). Most of the length of the tributaries are maintained as drains by the Washtenaw Water Resources Commissioner (County drain office). Straightened agricultural drains suffer from a loss of riparian cover, loss of connection between stream and floodplain, loss of storage and infiltration capacity, and be more prone to flashy flows and bank erosion. Two long stream reaches and one shorter one were evaluated using the BANCS methodology in this drainage area. The two of the reaches were rated as having a moderate erosion rate and the other one has a low erosion rate, so it appears that the stream banks are relatively stable. Thus, the altered hydrology and perhaps sediment deposition from runoff are the major concerns in the drainage area.

While restoring these streams back to a natural system is not a practical project, there are several practices that land and water conscious farmers can adopt to lessen the impact of farming and provide habitat for aquatic life and wildlife. Reducing sediment runoff from farm fields should be the practice focus here. Agricultural streams in other areas have also benefited from two-stage channel partial restorations. Efforts to restore or vegetate stream buffers would also be beneficial in this area. Overall, this drainage area should be a critical area for cost-share or pay-for-performance funding projects to address altered hydrology and sediment runoff.

Figure 2.24. Pleasant Lake Tributaries



2.5.2.6 Letts Creek—Aquatic Life and Wildlife Impairment from Causes Unknown

Lett's Creek is tributary to the North Fork of Mill Creek with a watershed size of 18.8 miles. The 4.2 mile section closest to its mouth is listed in EGLE's 2020 integrated report as being impaired for Aquatic Life and Wildlife with the pollutant listed as unknown.

HRWCs has conducted a fair amount of sampling on this section of Lett's Creek and can provide some context though not a diagnosis of the problem. The following is quick synthesis from the more detailed sampling results in section 2.4.4.

Landuse: The non-attaining section of Lett's Creek flows through the City of Chelsea along several parcels marked as Industrial by the 2020 SEMCOG landuse data.[3] Upstream of that, this section of Lett's Creek flows from agricultural lands and single-family housing.

The whole upstream creekshed may be contributing to the non-attainment of this downstream section. Overall, Lett's creekshed is 59% agriculture, 21% single family housing, 4%Industrial, and the rest is an approximate even division of the other land-use categories shown in Table 2.4.

Stream Substrate: Stream substrate along the M-52 area is a mix of fines, gravel, and rocks and does not show any particular problem or difference from healthier areas of Mill Creek (Table 2.10).

Macroinvertebrate Population and Trends: Data from the HRWC's River Roundup has the macroinvertebrate population below that of the overall Huron Watershed averages for insect, EPT, and sensitive family diversity. These populations are also statistically significantly declining over time (Table 2.9).

However, winter stoneflies (very sensitive to pollution) are regularly found in January. As mentioned in section 2.3.2, when insect diversity is lower than expected but winter stoneflies are present, pollutants connected or related to stormwater runoff (i.e. nutrients or sediment) are more likely to be the problem. When stoneflies are absent year-round the problem would more often be persistent toxic pollutants rather than runoff issues because there is typically little to no run-off in January.

Water chemistry: Letts Creek has not been sampled as an investigative site through the Chemistry and Flow monitoring program. A representative site should be selected for sampling with concurrent samples at the long-term site downstream in Mill Creek at Parker Road. This sampling would provide information on relative concentrations of nutrients and sediments, as well as bacteria.

Bank assessment: The main Letts Creek reach was not selected for evaluation by the BANCS protocol, but one major upstream branch and one small tributary were. Each were estimated to have moderate erosion rates of 0.052 and 0.018 tons/year per linear foot respectively. It seems, albeit from limited sampling, that streambank erosion is not likely the proximate cause of declining macroinvertebrates.

Overall, the most likely cause of macroinvertebrate decline appears to be sediment and nutrient runoff from upstream. HRWC has observed increasing phosphorus concentrations from other parts of Mill Creek, though Letts Creek has not specifically been sampled. This sampling should be a priority. If confirmed to have higher nutrient or sediment levels, runoff reduction practices, especially for agricultural properties would be warranted.

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[1] [1] EGLE, 2020. Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report, Appendix B2. https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-12711--,00.html. Accessed June 2021.

[2] EGLE, 2020. INVESTIGATION OF THE OCCURRENCE AND SOURCES OF PERFLUORINATED AND POLYFLUORINATED ALKYL SUBSTANCES (PFAS) IN THE HURON RIVER WATERSHED USING POLAR ORGANIC CHEMICAL INTEGRATIVE SAMPLERS (POCIS). https://www.michigan.gov/documents/pfasresponse/Investigation_of_the_Occurrence_and_Sources_of_PFAS_in_the_Huron_River_Watershed_Using_Polar_Organic_Chemical_Integrative_Samplers_POCIS_705675_7.pdf. Accessed 2021.

[3] Southeast Michigan Council of Government. https://semcog.org/gis. Accessed 2021

Chapter 3: Climate Change and Threats

3.1 Introduction

A dramatic increase in the concentration of greenhouse gases in Earth's atmosphere is causing warmer global temperatures.[1] The effects of these warmer temperatures manifest in different ways at a regional scale based on geography, topography, and other natural climate factors. In the Great Lakes region, and specifically in southeast Michigan, changes in precipitation and temperature have been observed in the historical data records, and models predict many changes will grow in frequency and magnitude. Because natural systems have evolved within a range of relatively stable climate conditions, it is critical to consider the implications of current and future deviations from historical climate conditions when managing natural resources.[2] The watershed management planning process is a critical time to capture and consider impacts of climate change on river systems. It is also an effective time to consider how the prioritization of strategies should adapt to dynamic conditions and how communities can prepare for extreme events. This chapter summarizes the best available climate information relevant for planners in the region and discusses the implications of changes in precipitation and temperature on critical watershed variables.

3.2 Climate Data Summary

The observed and projected changes in the climate data relevant to the Huron River watershed are consistent with the changes observed across southeast Michigan (described by NOAA as Michigan Climate Division 10: Southeast Lower Michigan)[3] and at a high-quality, long-term observational station at the University of Michigan (located in the Middle Huron watershed). More broadly, they are consistent with trends described for the Upper Midwest and Great Lakes region. Air, water, and land surface temperatures are rising. The form, seasonal timing, and volume of precipitation is changing. Heavy precipitation events are becoming more frequent and more severe. These changes are directly affecting watershed management, planning, and implemented best practices in the Huron River watershed.[4] [5] [6] [7] [8]

3.2.1 Ann Arbor and Regional Climate Summary

- The average air temperature across southeast Michigan increased by 2.4°F from 1950 through 2019.
- Average air temperatures in southeast Michigan are expected to rise by approximately 3.1°F to 5.2°F by 2050, relative to 1980-1999.
- Total annual precipitation measured in Ann Arbor increased by 44.6% from 1951 through 2019, relative to the 1951-1980 reference period.

- In the Midwest, the total volume of precipitation falling within the heaviest 1% of precipitation events increased by 42% since 1958.[9]
- Total annual precipitation will likely increase in the future, though types of precipitation will vary (i.e., more winter precipitation in the form of rain). [10]

Table 3.1 Historic climate normal and projected changes in key climate parameters for the Huron River watershed and southeast Michigan. Data provided in this table is based on observational data in the Global Historical Climate Network-Daily (GHCN) dataset, projections from Climate Model Intercomparison Project Phase 3 (CMIP3) and Phase 5 (CMIP5), RCP8.5, and a methodology for Dynamical Downscaling for the Midwest and Great Lakes Basin.[11][12][13]

Climate Parameter	Historic Ann Arbor (1981-2010)	Change by Mid-Century, 2040-2059 (RCP8.5)	Change by End of Century, 2070-2099 (RCP8.5)
Average Temperature	49.8°F	3.1 to 5.2°F	6.5 to 10.0°F
Winter	27.1°F	2.0 to 4.4°F	5.0 to 8.5°F
Spring	48.4°F	1.9 to 5.5°F	4.6 to 11°F
Summer	71°F	4.0 to 6.4°F	8.2 to 12.0°F
Fall	52.2°F	3.2 to 5.9°F	6.9 to 11.7°F
Average Low Temperature	40.4°F	3.3 to 5.4°F	6.7 to 10.5°F
Average High Temperature	59.1°F	3.1 to 5.3°F	6.4 to 9.8°F
Days/Year Greater than 90°F	8 Days	13 to 30 Days	31 to 64 Days
Days/Year Greater than 100°F	2 to 4 Days	3 to 17 Days	11 to 38 Days
Days/Year Less than 32°F	122 Days	27 to 23 Fewer Days	Not Available
Total Annual Precipitation	36.7 in.	0.3 to 3.8 in. (1.0 to 10.3%)	1.3 to 6.2 in. (3.5 to 16.9%)
Winter	7.9 in.	-0.5 to 2.5 in. (-6.3 to 31.2%)	-1.48 to 1.79 in. (-18.7 to 27.8%)
Spring	9.3 in.	-0.7 to 2.27 in. (-7.5 to 24.4%)	0.04 to 2.9 in (<-1% to 31.2%)
Summer	11 in.	-0.7 to 2.9 in. (-6.4 to 26.4%)	-1.0 to 0.8 in. (-9 to 7.3%)
Fall	9.4 in.	-0.4 to 0.6 in. (-4.3 to 6.4%)	0.53 to 1.89 in. (5.6 to 20.1%)
Heavy Precipitation Days/Year (>1.25")	3.7 Days	0.4 to 2.8 Days	2.4 to 2.8 Days/Year

3.2.2 Average and Extreme Temperatures

3.2.2.1 Average Temperature

The average air temperature in southeast Michigan has risen 2.4°F, which is consistent with much of the Great Lakes region. The more localized Ann Arbor area, however, has seen a more moderate increase of 1.0°F from 1951 to 2019, and the historical annual average temperature from 1980-2010 was 49.8°F. Average seasonal temperatures have also increased. Winter and spring temperatures have risen at a faster rate and warming has been distributed relatively evenly between daytime high temperatures and overnight lows.

Relative to the 1980-1999 historical reference period. Average temperatures in Ann Arbor are projected to increase by approximately 3.1 to 5.2°F by mid-century under a high emissions scenario that's consistent with the historic trajectory of increasing emissions (RCP 8.5, often described in the past as a “business as usual” scenario). The projected warming is distributed throughout the year, with the summer and fall season having somewhat higher projected ranges.[14]

3.2.2.2 Hot Days

The number of days per year with high temperatures exceeding 90°F have begun to increase slightly over time. Year-to-year variability is high, however. Days exceeding 100°F are statistically infrequent, and the average annual occurrence has remained relatively flat and within the range of annual variability. Most years on record have experienced 2 to 4 consecutive days over 90°F, with events of 5 to 7 consecutive days occurring less frequently. By mid-century (i.e., 2050), models suggest an increase of anywhere from 13 to 30 more days per year over 90˚F, and an increase of 31 to 64 more days per year over 90°F by end of century. Models are not able, however, to tell us if those days will be consecutive or not.

The number of days per year with high temperatures at or above 95˚F has shown little to no change since the middle of the 20th century. Events of consecutive days experiencing maximum temperatures over 100˚F are also quite rare and have not significantly increased or decreased in frequency. By mid-century (i.e., 2050), models project 3 to 17 more days per year over 100˚F, and an increase of 11 to 38 days per year over 100°F by end of century. However, such extremely hot days will not likely occur consecutively.

Heat waves can result from a combination of different drivers including high humidity, daily high temperatures, high nighttime temperatures, stagnant air movement, etc. In the future, models project an increase in the number of days experiencing high temperatures that could lead to additional heat waves, especially since air stagnation events are projected to increase. There is greater certainty that summer nighttime low temperatures will continue to increase, thereby making it more difficult to cool off at night during extended heat events. In addition, any periods of future drought may also contribute to extreme heat.[15] [16]

3.2.2.3 Cold Days

From 1981-2010, Ann Arbor experienced 122 days per year that fell below freezing (32°F), on average. Historical records show this number has decreased already. The city is projected to experience fewer nights below 32°F with decreases of 23 to 27 days by mid-century.

Significant for many natural ecosystems and built environments, models project modest decreases in the number of days falling below 20°F, with about 3 to 10 fewer days per year dropping below this threshold.

Days with temperatures at or below 10˚F are relatively common and have not experienced any clear trends over time. Consecutive days at or below 10˚F also common, and typically last for 2 to 7 days with less frequent occurrences lasting 8 to 15 days. In the future, there are projected to be substantially fewer 10°F cold days, so this type of event could become rare. Some models project few or no cold days dropping below this temperature by the mid or late century.[17]

3.2.2.4 Changing Seasonality

The Watershed experienced approximately 170 to 180 days per warm season (reference period of 1981-2010) in which the minimum temperature remains above 32°F. This is referred to as the growing season length or freeze-free season. With warmer temperatures, the growing season length is expected to last for a longer duration each year, with many studies projecting growing seasons 1 or 2 months longer by 2100. The parameter of climate is strongly influenced by hyperlocal factors, including local land use, so while the broad trajectory of a warmer, longer growing season is clear regionally, actual observations in specific locations will vary.

3.2.3 Precipitation and Flooding

3.2.3.1 Total Precipitation

The amount of total annual precipitation in Ann Arbor has increased by 44.6% (13.5”) from 1951 through 2019. An increase in precipitation was observed in all four seasons, with the winter seeing the greatest percentage increase of 68.1% (3.9”). On average, most models project total annual precipitation in southeast Michigan to increase by 5 to 11 percent by mid-century compared to the period 1980-1999. The methodology presented in table 3.1 projects a broader range, though most models used in that analysis also project increases above 5%. Precipitation projections have a broad range of uncertainty, however, and seasonal variation and interannual variability are expected to increase in magnitude, potentially creating multi-year periods that either much wetter or much drier than the prevailing long-term trend.

3.2.3.2 Seasonal Precipitation Totals and Form

Across the Great Lakes region, projected changes in seasonal mean precipitation span a range of increases and decreases. This broad regional uncertainty is due in part to uncertainty in how the Great Lakes themselves will respond to warmer conditions. Generally, evaporation and decreasing soil moisture may play an increasingly important role on the region’s hydrologic cycle at the end of the century, reducing available moisture for precipitation. On the other hand, there is also evidence that warm, humid air masses advected farther north from a changing Gulf Stream pattern may deliver more precipitation to the Great Lakes basin. In the winter and spring, the region is projected to experience wetter conditions as the global climate warms. By mid-century, some of this precipitation may manifest in the form of increasing snowfall, but projected warmer conditions by end of century suggests such precipitation events will most likely be in the form of rainfall.[18]

There has been a slight decreasing trend in historic heavy hourly snowfall (events with snowfall over 1”) with varying year-to-year conditions, and little to no change in hourly snowfall exceeding 2”. Generally, warmer temperatures in the future will cause some winter precipitation to fall in the form of rain rather than snow. As a result, annual snowfall is projected to decrease by 7” to 17” by mid-century, and decrease by 20” to 40” by end of century. Unlike areas in lake effect snowbelts, the Huron River watershed is not anticipated to see significant effects on precipitation due to potential changes in lake effect snow patterns. It is plausible that southeast Michigan may see some years without measurable snowfall by the end of the 21st century.

3.2.3.3 Rain Free Periods

Drought (defined here as periods of 3 weeks with less than 0.45” of rainfall) has been highly variable year-to-year, with slight decreasing trends in summer and fall events and a slight increasing trend in spring events. In the future, even though more annual precipitation is projected overall, more is anticipated to fall in shorter, extreme events. Thus, there will be longer periods of time that experience no rainfall, increasing the potential for drought. Most models project this effect to be most pronounced during the summer months. The drought conditions of 2021, along with the extreme rain events of June 25th-26th, are a prescient example of the types of weather conditions that will become more likely in the future.

3.2.3.4 Extreme Precipitation

The frequency and intensity of severe storms has increased. Ann Arbor has seen a 41.2% increase in the number of heavy precipitation events (36 storms from 1951-1981 compared to 51 storms from 1981-2010). Ann Arbor experienced an average of 3.7 days per year with precipitation totals that exceeded 1.25” from 1981-2010, and approximately 1 day per year with totals exceeding 2”. Daily precipitation events exceeding 3” are rare and generally occurred once every 5 to 10 years.
Future projections of extreme precipitation vary tremendously at sub-regional scales and between individual models. There is broad agreement, however, that heavy precipitation events will continue to become more frequent and increase in magnitude. Southeastern Michigan is projected to experience approximately an 0.4 to 2.8 (11 to 78%) increase in days of 1.25” precipitation events by mid-century. Heavy precipitation events of more than 2” in a day (i.e., 24-hour period) are projected to increase by no more than one day (0.25 to 1 days) by mid-century and increase by slightly more (0.75 to 1.25 days) by end of century. Changes in the frequency of precipitation events of more than 3” in a day are difficult to project at the regional and subregional scale due to their relative infrequency, though most models project increases in frequency at a rate faster than that of smaller magnitude storms.

A 2020 study found that human activity is causing the intensification of extreme events across North America. With relatively conservative warming of 1°C, storms that historically would have been expected to occur every 20, 50, or 100 years will likely become 4 to 5 times more likely. Storms that historically would have been expected to recur in 20, 50, and 100 periods were projected to occur every 1.5 to 2.5 years, on average, with +3°C of global warming. This would represent a 13- to 40-fold increase in the occurrence of catastrophic storms. Warming of 3°C or more is well within the range projected by global climate models in when humans fail to substantially reduce global carbon emissions by 2050.[19]

3.2.3.5 Flooding

Flooding results when rainfall volumes exceed the capacity of natural and built infrastructure to handle precipitation. Stormwater managers look at several different "design" storms (inches falling over a certain length of time) when designing and managing their systems. These "design" storms are effectively the probability of any given amount of precipitation falling in a set period of time, based on historical experience. Monitoring over time shows that the volumes falling during these "design" storms are increasing.

Table 3.2 below shows precipitation volumes in inches for both Bulletin 71 and Atlas 14, following the format: (Bulletin 71/Atlas 14). Bulletin 71 used data through 1986, and Atlas 14 added more recent data from 1987-2011.[20] [21] The percent change is reported in brackets. All percent change values are positive which means they are larger in Atlas 14. This data shows how the "design" storm thresholds have increased over time. Note that Table 3.2 does not account for projected changes in these design storms. Broadly, future changes are expected to follow or exceed historical rates of change, with larger storms seeing a greater rate of change.[22] While total annual precipitation for the Midwest is projected to increase by 5-10% by mid-century, heavy storms likely to occur once in 25 years are projected to increase by 20 percent.[23]

Table 3.2 Observed Changes in Precipitation Frequencies for the City of Ann Arbor from NOAA Bulletin 71 and NOAA Atlas 14.

	1-Yr	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
1-hr	0.88/0.969 [10%]	1.06/1.14 [8%]	1.29/1.44 [12%]	1.47/1.70 [16%]	1.69/2.07 [22%]	1.87/2.38 [27%]	2.05/2.69 [31%]
12-hr	1.63/1.82 [12%]	1.97/2.06 [5%]	2.39/2.50 [5%]	2.72/2.90 [7%]	3.13/3.54 [13%]	3.46/4.09 [18%]	3.79/4.68 [23%]
24-hr	1.87/2.09 [12%]	2.26/2.35 [4%]	2.75/2.83 [3%]	3.13/3.26 [9%]	3.60/3.93 [9%]	3.98/4.50 [13%]	4.36/5.11 [17%]

3.3 Effects on River Systems and Natural Areas

River systems of the Upper Midwest face numerous effects due to climate change. Water quality, water quantity, the watershed's ecosystems services, and its functions as natural habitat will all face changes and may become impaired.

3.3.1 Effects on Forests

Changing temperatures may change the distribution of trees and plants as well as their growing season.[24] [25] [26]

Natural ecosystems in Michigan are being altered by warming temperatures, changes in precipitation, changes in land-use, and by an influx of invasive species. These factors commonly exacerbate the negative effects of each other.[27] Warmer temperatures are driving many tree species northward, and many native species well-suited to their historical climate have not been able to migrate as fast as their optimal climate range is shifting. Tree species currently near the northern extent of their suitable range may decline in number as they will not likely be able to migrate fast enough to outcompete species suited to encroaching climate conditions from the south. Species currently populating forests in more southern extents of their range will likely continue to shift northward in distribution. Maple, Beech, and Birch forest stands are vulnerable to climate change and associated stresses. Sugar maples, for example, may become less productive while red maples, several variety of oaks, and hickory may gain a competitive advantage.

The migration of native species northward is uncertain, however, as the fragmentation of midwestern forests and the flatness of the terrain raise the possibility that the ranges of particular tree species will not be able to shift to future suitable habitats within the Midwest.[28] To reach areas 1.8°F (1°C) cooler, for example, species in southern Michigan's relatively flat terrain must move up to 90 miles (150 km) north to reach cooler habitat, whereas species in mountainous terrain can shift higher in altitude over much shorter latitudinal (north–south) distances.[29]

3.3.1.1 Increased Stressors on Forests

Changes in climate will allow nonnative, invasive plants, insects, and pathogens to expand their ranges.[30] [31] [32] Pests and diseases will also become further established with warmer winter temperatures, and some pest insects have already been able to expand their ranges northward.[33]. Increased spring precipitation has been favorable to bur oak blight in Iowa and some parts of Illinois.[34] Forest pests and pathogens also disproportionately stressed ecosystems.[35] [36]

Non-native species and invasive species, on the other hand, particularly those limited by the northern extent of their temperature range, are often expected to spread rapidly and out-compete native species. It is also possible that nonnative plant species will take advantage of shifting forest communities and unoccupied niches if native forest species are limited. [37] [38] Nonnative invasive species such as honeysuckle, reed canary grass, and common buckthorn will likely be favored by future conditions brought on rapidly by climate change.[39] The reproduction and survival of emerald ash borers, the destructive invasive insect that attacks native ash trees, will increase due to warming winters in the region. Mortality of black ash trees, is even more likely in the future than current conditions as winter temperatures continue to rise.[27]

3.3.2 Effects on Wildlife

Rapid climate change through the 21st century will stress most species in southern Michigan and accelerate the rate of species declines and extinctions with potentially severe implications for loss of biodiversity. Interactions between climate change and other stressors, such as invasive species, habitat loss and fragmentation, and hydrologic modifications.

As with forests and other ecosystems, Michigan's relatively flat topography and high latitude position will force wildlife to shift their ranges (or retreat) particularly fast relative to species in other parts of the continental U.S. to keep up with the pace of even moderate rates of projected warming. Wildlife movements will often be limited by critically fragmented and diminished natural land cover, or lack of appropriate aquatic habitat. The presence of human-created barriers, such as large tracts of uninterrupted agricultural land or developed areas will exacerbate challenges for wildlife. The Great

Lakes, and Michigan's abundant inland lake systems also create natural barriers to migration for terrestrial wildlife. The combined effect of these natural and human-created stresses puts wildlife in the Midwestern United States at particular risk.[40]

3.3.2.1 Changes in Bird Nesting and Migration Patterns

The wintering ranges of at least 305 North American bird species has shifted northward with warming temperatures by more than 40 miles since 1966. The trend is closely related to increasing winter temperatures and increasing overnight low temperatures, which have been rising in Michigan and in connected bird migration corridors.[41] Overall, the migration routes and wintering areas of birds have also shifted away from ocean and Great Lakes coasts since the 1960s. A shift away from the large water bodies may relate to warming winter temperatures. Inland areas tend to experience more extreme cold than coastal areas, and those extremes are becoming less severe as the climate warms overall, making previously less hospitable zones more hospitable.[41]

The seasonal timing of bird migration has also changed. Many bird species are migrating northward earlier in the spring and/or later in the fall. In extreme cases, warmer temperatures and available food supplies have allowed some bird populations to remain resident in one location and have not migrated. For long-distance migrants, change in migration timing can desynchronize birds from the phenology of their food sources, as every species may adapt in different ways, with different capacity, and at different rates.[42]

Riverine habitat, wetlands, and other habitat types that bloom and emerge from winter earlier due to their proximity to water may provide increasingly critical oasis habitat and corridors through varying conditions for migrating birds. This may be particularly true in areas dominated by agriculture where nearby natural habitat is sparse, or in areas near migratory routes and adjacent to expansive agricultural areas like the Huron River watershed.[43] [44] [45] The Mill creekshed is such an area where preservation of riparian corridors among agricultural areas could have significant benefit for migratory birds.

3.3.2.2 Effects on Fish and Aquatic Species

For freshwater and coastal species in southeastern Michigan, interactions between climate change, changes in land cover, and changes in hydrology will have significant effects. Land cover plays a very important role in determining the hydrologic and energy balance of a natural system. The removal or alteration of vegetation can and will shift these balances in ways could increase run-off, promote flooding, reduce precipitation and nutrient uptake, and deprive species of cool, shady relief, all of which would put stress on sensitive species and habitats.

Changes in air temperature and precipitation will affect water temperature and flow in streams and in groundwater inputs to spring ponds. Many lakes in Michigan and in the Huron River watershed stratify during the summer, with the coldest layer at the bottom. As air and water temperatures warm and the seasonality of precipitation and runoff changes, the stability and duration of deep coldwater layers will be affected, reducing the suitability for coldwater fish. Dissolved oxygen will also be depleted to an extent stressful or harmful for many fish species during periods of prolonged stratification. The result may be the decline of coldwater fish populations.[46 47]

The effects of climate change on freshwater mussels is still a developing area of research. There is broad concern among experts that rising temperatures may be negatively affecting freshwater mussel species, but there are relatively few studies applicable to any specific region of the country of the mussel species native to the Huron River watershed. Studies continue to indicate cause for concern and further caution.[48]

3.3.4 Effects on Wetlands

Michigan and other northern latitudes are not immune to drought levels that stress ecosystems. Some climate models project an increased risk in summer droughts for the Great Lakes region, but the long-term, broad effects of such droughts on wetland areas is still uncertain. There is greater concern for some specific effects, such as loss of spawning habitat for fish species like pike due to increased temperatures, concentration of precipitation into larger storms, and greater evaporation.[49]

Climate change may negatively impact vernal pools and other seasonally dependent wetlands. While climate models project increases in annual precipitation totals, the range of future projections in seasonal precipitation totals is large.[50] Future evaporation rates over land areas in the late-spring, summer, and early fall are also expected to increase with warmer temperatures, which may polarize wet and dry seasons, stressing or eliminating vernal pools as viable habitats.[51]

3.3.4 Effects on Erosion

Increased stream flow destroy habitat and scour the banks causing greater erosion. A greater frequency and magnitude of heavy precipitation events likely means the region will experience increased runoff, more rapid erosion, more pollutants being carried to the streams and river, and heavier sediment loads that can cause issues for fish life. The Middle Huron watershed straddles many particularly vulnerable landscapes that straddle both agriculture and areas of new, rapid urban and suburban development. These landscape types, without proper management practices, can erode rapidly as they are repurposed for residential and commercial development, or if the current management practices in agricultural areas are insufficient.

3.3.4.1 Related to agricultural landscapes

Riparian zones in agriculture areas such as those in the Upper Middle Huron are especially vulnerable to erosion due to climate change without improvements in management practice.

Soil erosion by water is one of the major environmental threats to sustainable crop production.[52 53] It also adversely affects drainage networks, water quality, and recreation.[54 55] Increasing heavy precipitation frequency and magnitude increases soil erosion and the sediment transport capacity of surface runoff from agricultural lands, which could increase total soil erosion and sedimentation into the Huron River and its tributaries.[56] Therefore, increasing soil erosion rates will not only reduce agricultural productivity, but will also accelerate the loss of carbon stocks and stored soil nutrients.[57] In turn, this diminishes the cohesiveness of soil, creating a positive feedback for greater erosion.[58]

The proportion of U.S. land area that experienced extreme precipitation remained steady until the 1980s but increased rapidly since then.[59] In the coming century, this expansion is expected to continue to increase. Because much of the historical change has occurred within the lifetimes of active farmers and growers, it is common that practices learned during or before the 1980s are still being applied to areas now at much high risk of erosion. Conservation strategies that are still being implemented to reduce erosion and increase carbon sequestration often use obsolete estimates of expected conditions. Strategies should be improved by considering current and projected future climate extremes and changing local factors. In the Huron River watershed, this warrants greater collaboration and awareness-building among farmers, scientists regulators, and conservation organizations. Additional protective measures will be needed to safeguard progress that has been made to reduce erosion and water quality degradation.[60]

3.3.5 Effects on Water Quality

3.3.5.1 Sewage Overflows and Treatment Plant Discharges

Climate change will intensify other stresses on aging infrastructure in the Huron River watershed. In recent years, the increase in heavy downpours has contributed to the repeated discharge of untreated sewage to the river or its tributaries in several communities. While communities with combined sewage-overflow systems are more vulnerable to sewage discharges due to extreme precipitation events, communities with separate sanitary and storm sewers are also at increasing risk. Insufficient storage and treatment capacity at wastewater treatment plants is a major factor.

3.3.5.2 Related to agricultural landscapes

Many water quality effects derived from agricultural land management are related to soil water excess. Southeastern Michigan has seen an increase in annual precipitation with the largest percentage increases in the spring and fall. These shifting precipitation patterns coupled with more extreme precipitation events may harm water quality by increasing the transport of sediment, nitrate, and phosphorus to surface water bodies. There is evidence that annual variation in nitrate loads are related to annual precipitation amounts especially in the presence of extensive subsurface drainage where significant leaching may occur. Parts of the Watershed area, particularly the Mill creekshed, are extensively subsurface drained areas and these drains could carry nitrate from the during saturated soil conditions and heavy precipitation events, conditions expected to become more likely in the future.[61]

Stronger, more frequent storms particularly in both extended wet periods and following extended dry periods will likely increase surface runoff and erosion. The mechanism for erosion differs in these conditions. During particularly wet periods, transport over saturated soil can increase the distance which nutrients and sediment are carried. It can also destabilize roots systems and compromise the integrity of subsurface soil. Following dry periods, surface soils may be compromised, and rapid transport of surface sediment is possible. Potential increases in soil erosion with the increases in rainfall intensity show that runoff and sediment movement from agricultural landscapes will increase. [62]

The heavy rain event of June 26th, 2021 provided an example of the heavy rain on dry soils scenario. Multiple observational stations throughout the watershed recorded 4 to 6 inches of precipitation in 24 hours, with some stations recording the majority of that rainfall within a 3-hour period. Depending on the specific station precipitation total and the duration considered, the precipitation event was a 100- to 1000-year storm.[63] But at least two other similar magnitude rain events have been observed in southeast Michigan since 2014, indicating the past recurrence intervals, which do not account for future climate change projections, are now extremely likely to underrepresent the actual annual recurrence probability of these heavy storms. This rain event followed months of moderate drought conditions as described by the National Integrated Drought Monitoring System.[64] Rapid sediment transport was observed in many locations along creeks through agricultural areas in the Huron and neighboring watersheds. Turbidity in the Huron River was observed to be very high for at least 72 hours following the rain event, with Mill Creek contributing a significant sediment plume to the main stem of the Huron. Casual observations made by recreators in the river corridor reported significant woody debris and sediment buildup, creating safety hazards for paddlers. In addition to triggering advisories for paddlers to avoid the river during high flow, several paddlers reported avoiding the river due to its opaque appearance. These conditions following heavy rain on dry events are likely to continue to increase in frequency in the future. Effects in the Upper Middle Huron observed during this event, such as runoff loads, erosion, and sediment transport, provide a qualitative indication of vulnerabilities likely to become substantially more severe.

3.3.5.3 Waterborne Disease and Heat

Changing climate conditions are altering the distribution and prevalence of waterborne illnesses around the globe and within the United States, making it possible for disease vectors to become established in areas that were previously inhospitable to them.[65]

Warming temperatures may be increasing the risk of infectious waterborne diseases in Michigan. Of particular concern for much of Michigan is Legionella. Legionella is a naturally occurring bacteria usually found in warm water. Exposure through inhalation of mists or vapors from contaminated water can cause lung infections known as Legionnaires’ disease or, in rare cases, Pontiac fever, collectively known as legionellosis. Legionella is the most frequently reported cause of water-related disease outbreaks in the U.S. and is usually associated with exposure to water in conditions of heat, stasis, and aerosolization that optimize transmission. Roughly 200 cases of Legionellosis are reported to the CDC from Michigan each year. Legionella species colonize outdoor water reservoirs including potable water systems and cooling towers, and the organisms grow rapidly at temperatures between 85°F to 110°F. Studies in the eastern U.S. and Europe suggest that Legionnaire’s disease outbreaks may be associated with warm humid weather, possibly due to increased Legionella growth stimulated by warming of potable water in reservoirs and plumbing. Warm temperatures may also increase population contact with recreational waters, increasing the opportunity for exposure to pathogens in the water.[66]

3.3.5.5 Harmful Algal Blooms

Globally, climate change is driving increases in magnitude, duration, number of affected waterbodies, and health risks of harmful algal blooms. [67]Unless additional conservation actions are taken, the growing frequency and severity of intense spring rainstorms in the Great Lakes region throughout this century will likely increase the number and extent of harmful algal blooms and "dead zones" in southeastern Michigan, though the effects on any specific river or lake system is uncertain. More total spring precipitation and stronger storms, combined with the greater availability of phosphorous due to current agricultural practices, means that greater amounts of the nutrient could be scoured from farmlands and into surface waters, fueling algae blooms and hypoxic zones. [68] [69]

The agricultural practices that contribute to increased availability of phosphorous from fertilizer include no-till farming, a method of planting crops without plowing. The technique reduces soil erosion but also leaves high concentrations of reactive phosphorous in the upper surface soil, where it can be more readily flushed out during substantial rainfall. The combination of these factors has caused the western Lake Erie basin to reverse some of the nutrient loading reductions experienced since the 1990s.[70] While Huron River watershed drinking water sources are not particularly vulnerable to HABs (only Ann Arbor draws its drinking water from river surface waters), the Huron River watershed contributes nutrient runoff to Lake Erie, a drinking water source that has suffered significant impacts to drinking water due to the presence of HABs.[71]
HABs do affect recreation on the Huron River. Most directly, swimming and fishing suffer, though repeated water quality issues may dissuade people from recreating near the river corridor even when there is little or no risk. Cyanobacteria in HABs is toxic and a skin irritant. Nutrient loading from agricultural and other sources in the above the Middle Huron have contributed to the outbreak of HABs in urban communities along Ford and Belleville Lake. Under future climate conditions (warmer summer temperatures and increased runoff) and without remediation of confounding factors, HABs will be more likely on sections of the Huron River in the future. [72]

3.3.6 Effects on Infrastructure

Effects of climate change on infrastructure in southeast Michigan are wide-ranging. Some effects, like the direct damage to stormwater infrastructure or built structures crossing waterways are virtually certain in the absence of intervention, due to the precipitation trends observed and projected. Some of these effects have already been recorded in the Huron River watershed. Heavy precipitation events have led to flashy flows which have overwhelmed stormwater drains, led to flooding, and damaged to infrastructure (bridges, roads, businesses, and residential homes). In some cases, high water tables and a changing groundwater-surface water interface has required deeper wells to protect drinking water.[73]

As the failures of the Sanford and Edenville Dams on the Tittabawassee River demonstrated in 2020, dams are inherently vulnerable to an increasingly severe heavy precipitation and flooding events. Dams have failed on the Huron River in the past as well, and such failures will become more likely across the country due to climate change and aging infrastructure.

Likewise, bridges, pipelines, and other infrastructure that cross waterways, especially rivers, will also become increasingly vulnerable to scouring and erosion.[74] The Middle Huron Watershed includes many urbanized areas that have a significant number of intersections with aging infrastructure. These intersections may be a substantial risk factor for the river over decades without attention or intervention.

Wastewater treatment facilities have been overwhelmed, resulting in damage and, more frequently, the release of untreated sewage.

The Dexter wastewater treatment plant was one such facility. In 2011, as construction just ended on an equalization basin meant to contain a 25-year storm event, the area was hit with a 100-year storm that flooded the new basin out. Staff were forced to bypass treatment units to relieve the hydraulic loading, releasing wastewater effluent that did not go through tertiary treatment to Mill Creek. Staff have learned to watch weather reports and anticipate operations in advance of storms to prevent failure from happening again. In Dexter, projects done to repair manholes and sewer lines have been effective in stopping storm surges from infiltrating the wastewater system.

3.4 Implications for Action Planning

3.4.1 Implications for Infrastructure Design and Planning

As described above, the changes in the recurrence of design storms between NOAA Bulletin 71 and NOAA Atlas 14 demonstrate that size and frequency of storms communities need to prepare for has already shifted. Recent studies indicate that the observed trend will continue or accelerate in the future. From Bulletin 71 to NOAA Atlas 14, the sizes of all design storms increased. The 100-year, 24-hour design storm, for example, increased in magnitude by 17% due to both an increase in the frequency and severity of precipitation events. By 2100, 25-, 50-, and 100-year design storms over the Great Lakes region and northeastern United States may occur every 1.5 to 2.5 years, a 10 to 40-fold increase in anticipated frequency relative to the recent past. This implies that much of the infrastructure in the watershed may be insufficiently designed to safely manage and attenuate the current distribution of storms and will be less able to manage future design storms.

The likely increase in the severity and frequency of severe storms carries implication for many elements of built infrastructure. Infrastructure in the intended path of stormwater management will be most affected. This includes drainage networks, culverts, and retention areas in place to present harmful or damaging runoff. Changing storm sizes also likely mean more areas will be vulnerable to flooding, yet floodplains as defined by FEMA do not include projections of future conditions or even guidance for planning future infrastructure in areas potentially vulnerable in the future.

3.4.1.1 Implications for Dams

Notably, given the recent dam failures along the Tittabawassee River, current regulations use past flow conditions for assessing the condition and capacity of dams. High-hazard dams, like many of those that exist in the Middle Huron River, are generally built and maintained to safely manage 200-year floods. The recurrence interval of those floods is affected by the recurrence intervals of extreme precipitation events and underlying total seasonal precipitation. The relation of storm size to in-stream flows is usually not quantified in most watersheds. The coupling of hydrological and climatological models is often an expensive and practical barrier to such assessments, but even if such information was readily accessible, regulations don't require account of future potential changes in flow. Multiple trends in climatological and hydrological data from across the U.S. indicate this is a major vulnerability for dams and other in-stream infrastructure. The precipitation event that factored in the 2020 collapse of the Edenville and Sanford Dams was a 500-year weather event over much of Michigan, dropping an excess of 7.5 inches in 48 hours, yet an event of similar magnitude happened just 34 years prior over the same area of Michigan, and other low probability precipitation events have occurred more frequently than historical data suggests they should. It is probable that dams, bridges, and other in-stream, built infrastructure will face storms and flow conditions within their anticipated lifetime that are beyond their design specifications and for which their condition rating does not address.

3.4.1.2 Proactive Planning for Dynamic Flood Risk

Proactive planning for continually increasing risk to infrastructure is warranted. The anticipated costs of climate change effects are expected to accelerate in coming decades, and required changes to infrastructure will become more costly and more challenging over time due to aging infrastructure and even greater weather variability. The ability of communities to adapt or avoid local-scale effects of climate change in the future relies heavily on actions taken before the adaptation are critical and necessary. The risk of catastrophic natural disasters is also likely to increase, and rebuilt infrastructure will better prepare communities for addressing potentially unavoidable failures during unprecedented weather events.

Preparing for future storms is challenging for communities without mandates in state or federal regulation, without critical data, and without available funding for large infrastructure projects. Some communities in the Middle Huron watershed currently use available historical data for design storms and, in the absence of quantitative assessment, apply an additional conservative factor to account for future infrastructure needs. This estimated factor assumes a 10-50% increase in the size of the applicable design storm, depending on the community, specific application, cost, and other factors. A more robust and sustainable approach is needed to quantify needs in specific watersheds and reliably fund large infrastructure projects.

3.4.1.3 Green Infrastructure

In many cases, building infrastructure to manage future storms and floods will be impossible or impractical, either due to costs or the rate of change in design storms. In such cases, the use of green infrastructure and natural areas conservation should be incentivized wherever possible to mitigate the pace and magnitude of future changes. Relying on natural ecosystems to attenuate stormwater, runoff, and flooding is inherently dynamic, whereas built infrastructure will always be at least partially static and likely to become obsolete in the future.

HRWC's Natural Areas Assessment Program has mapped the remaining natural areas in the watershed and ranked them by a host of ecological criteria, as described in Chapter 2.1.3.2. Figure 2.6 provides a good guide to determining the most important areas of natural green infrastructure to protect. Another set of data to consider comes from The Nature Conservancy, and it maps, on a national scale, natural areas that provide resilience to climate change. A "Resilient" area is a place buffered from climate change because it contains many connected micro-climate that create different climate options for species in which to seek refuge from extreme weather changes. "Climate corridors" are narrow conduits in which movements of plants and animals becomes highly concentrated. A "Climate Flow Zone" is like a corridor but less concentrated. Areas with "Confirmed Diversity" contain known locations of rare species or unique communities based on ground inventory.[75]

The EPA, USGS, the Trust for Public Land and numerous other state, federal, and private firms have found that Green Infrastructure either direct cost savings or value through indirect environmental services such as improvements to public health, though estimates range widely on the amount saved and hyperlocal factors play a major role in cost-benefit analysis.[76]

3.4.2 Citizen Science, Education and Individual Action

Rapid changes in climate and the associated risks of flooding, erosion, and water quality are still not widely understood by many residents and community leaders. The HRWC, municipalities, and community partners will need to continue programs that inform residents and entities about the risks and potential solutions to the challenges we face. Continued and expanded citizen science programs that engage and educate watershed residents is one effective strategy that both serves to inform people and monitor changes over time. HRWC and partners intend bring members of the public into such citizen science efforts and provide an open forum to address any changes observed.

Individual household and property owner actions can amount to significant solutions. Landscaping decisions that reduce runoff, nutrient loading, and municipal stormwater treatment can significantly relieve burdens on built infrastructure while reducing overall community costs, for example. Rain gardens, rain barrels, using less fertilizer for aesthetic purposes, and planting appropriate vegetation are all strategies that can have significant and positive local impact.[77]

3.4.3 Dam Operator Communication and Dam Management

Changing climate conditions and development patterns that lead to less predictable and more extreme flows will require re-evaluating the way Huron River dams are controlled in response to large, sudden storms, how the lifespan of the dams may shorten, how equipped dams are to manage the range of projected storm sizes, and how maintenance costs may change in response to these factors. The designation of larger floodplain areas will likely be necessary in the event of a dam failure, which would require more greater insurance costs for dam owners and a greater number of nearby property owners required to hold flood insurance.

The installation of additional stream gages along the Huron River and its tributaries would be informative to dam operators in forecasting currently unpredictable flows. Over time, a network sufficiently dense stream gages would provide an effective understanding of how storm size and duration over various locations in the watershed translate to flows elsewhere downstream.

Stream gages and additional communication among dam operators will be essential to ensure that downstream dam operators can effectively respond to management actions taken by dam operators upstream. Toward this goal, HRWC currently facilitates a network of Huron River dam operators and is working with researchers at the University of Michigan to install stream gages throughout the watershed and monitor flows following precipitation events.[78]

3.4.4 Development Planning and Land Protection

The Great Lakes region and the Upper Midwest is one region of the United States where many experts expect to see gains in population driven by people migrating from other areas.[79] The summer climate of Michigan will likely hit and subsequently pass what most people feel are optimal summer temperatures.[80] In combination with abundant recreational waters, the Great Lakes region is predicted to remain attractive for tourism, residence, and business are other parts of the country, like the Southern United States, face climate conditions unsustainable for agriculture. Population dynamics are driven by many unrelated factors, but many of these factors indicate our region will see an increase in population, and an increase for housing, through the middle of the 20th century.

Added development pressure could stress watershed health as pervious surfaces and wetlands are developed and more impervious surface constructed. Communities are advised to take a proactive approach to planning, zoning, and land protection in anticipation of accelerated population growth.[81] Protecting existing undeveloped land should be a priority for communities with limited fiscal capacity due to the high rate of economic benefit. The Trust for Public Land has found that land protection creates a $4 to 10 return on investment for every $1 spent on land protection.[82]

In particular, the use of pervious pavements to reduce concentrated runoff during heavy precipitation events, as has been demonstrated throughout the watershed, are recommended. Even better is planning that reduced the amount of artificial pervious or impervious surface needed entirely. Actions that accomplish this at the community scale may be include putting in place proactive ordinances to reduce parking requirements, zoning for higher density in urbanized areas, and prioritizing sustainable transportation means like buses, trains, and bicycle routes. Maintaining existing natural infrastructure or utilizing green infrastructure options when possible is recommended.

3.5 Emerging Research

The scientific understanding of the cascading effects physical, ecological, built, and social systems of the planet continues to evolve rapidly. This advance of scientific knowledge is even more pronounced at regional, subregional, and watershed scales. As new information emerges, best practices will also need to readily adapt.

The causes of global climate change, as well as the projected trajectories of many fundamental climate characteristics of southeast Michigan, are clear, however. It is extremely unlikely that the trajectory of observed and contemporary changes in climate will deviate to such a degree to fundamentally alter watershed management priorities or planning objectives over the coming decades.
Several iterative datasets and comprehensive reports serve the Huron River watershed particularly well due to their tailored focus to our regional climate and other local factors. These resources are peer-reviewed and vetted at multiple levels and at every phase of collection and production. Some of these key resources, used to guide this and other Huron River watershed management plans are described below:

Data and climate summaries are periodically compiled by the Great Lakes Integrated Sciences and Assessments (GLISA) team at the University of Michigan and Michigan State University, most recently in 2019. The summary data and narratives rely on multiple datasets from numerous sources. More information can be found at https://glisa.umich.edu.

The Fourth National Climate Assessment, the most recent iteration of a report mandated by The Global Change Research Act of 1990, was written to help inform decision-makers, utility and natural resource managers, public health officials, emergency planners, and other stakeholders by providing a thorough examination of the effects of climate change on the United States. It provides chapters detailing effects by region and by type of impact. The supporting technical materials for this and previous iterations of the report also provide a sound, vetted summary of many complicated fields of study, many of which have implications for watershed management. More information can be found at https://nca2018.globalchange.gov/chapter/front-matter-about/.

The Midwest Technical Input Team to the Third National Climate Assessment, the previous iteration of the process outlined above, was the first such team to be led by experts from Michigan State University and the University of Michigan. While the scope of the Fourth National Climate Assessment followed a similar approach as the Third iteration and updated much of the relevant information, many of the references and key findings of the Midwest Technical Input Team provide relevant guidance for Michigan watersheds. More information can be found at: http://glisa.umich.edu/resources/nca

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Chapter 4: Action Plan for the Middle Huron Watershed, Section 1

Watershed management planning provides the opportunity for communities and other stakeholders to assess the current condition of their watershed, and to peer into the future to see what the watershed will look like if they simply maintain the status quo. The quality of life that a community desires for its future residents often does not coincide with the realities of the direction in which the community is headed.

This chapter details a set of goals and objectives to ensure that the designated and desired uses in the watershed will be met. Because surface water quality is ultimately a function of what water carries off of the land, much of the discussion will focus on how human activities impact the land and actions that can be taken to improve human land use from a water quality/quantity perspective.

4.1 Goals and Objectives for the Watershed

The designated and desired uses for the Watershed (Chapter 1) provide a basis from which to build long-term goals and objectives. Long-term goals describe the future condition of the Watershed toward which the communities will work. No single community or agency is responsible for achieving all of the goals or any one of the goals on its own. The goals represent the desired end product of many individual actions, which will collectively protect and improve the water quality, water quantity and biology of the watershed. The communities of the Watershed will strive together to meet these goals to the maximum extent practicable by implementing a variety of BMPs over time, as applicable to the individual communities and agencies, relative to their specific priorities, individual jurisdictions, authority, and resources.

Due to the complex ecological nature of the response of watersheds to management practices, it is difficult to predict when these goals will be met. Ultimately, long-term goals can never be said to be fully achieved, because there is always more that can be done. The stakeholder communities will continuously strive to meet these goals by implementing best management practices (BMPs) that are recommended for addressing the goals. The stakeholder communities will understand what progress is being made to achieve these goals by using an iterative process of implementing recommendations and evaluating the effects by regularly monitoring the river or population for change and degree of improvement. Much progress has been made since this WMP was originally drafted in 1994 and then updated in 2000, 2008, and now 2022.

The long-term goals and objectives as agreed upon by the Advisory Committee are presented in Table 4.1. Short-term objectives are presented for each goal, which are achievable and measurable. Progress has already been made toward the achievement of many of these objectives at this point.

The goals and objectives are listed in Table 4-1. These were determined in discussion with the Advisory Committee after reviewing the previous version of this plan, progress made to date, and the current list of impairments, sources and causes, all of which is based on analysis of relevant data as presented in previous sections of this plan. The Committee determined that the combined actions implied by these goals and objectives would be the most effective way to address watershed impairments.

Table 4.1. Goals and Objectives for the Watershed, links to the Recommendations in Table 4.2, and the Designated and Desired Uses they address. The long-term goals objectives and short-term objectives are not in any particular order of priority.

Long-Term Goal	**Short-Term Objective**	**Connection to Recommendation, Table 4.2**	**Uses Addressed**
1. Reduce Flow Variability Preserve natural infiltration and the recharge of groundwater, by protecting and restoring open spaces and natural recharge areas, installing infiltration BMPs, and reducing the amount of impervious area.	a. Implement stormwater management requirements that minimize flow fluctuations in receiving waterways, and associated bank erosion, channel widening and habitat destruction.	A, B	Designated Uses: Warmwater fishery, Aquatic life and wildlife Desired Uses: Coordinated development; Hydrologic functions
	b. Implement local ordinances, strategies and projects that: 1. Prevent unnecessary modification of the Huron River, its tributaries, and adjacent riparian areas.	PE3	
	2. Maintain and restore hydraulic function of floodplains and floodways by discouraging their alteration and encouraging restoration.	PE3, S4, D	
	c. Implement stormwater detention through GSI, both constructed and natural.	S3, PE5, C	
	d. Monitor flow dynamics of the river and tributaries through established monitoring program.	S1, S4, S5	
2. Reduce nonpoint source loading and reduce soil erosion and sedimentation, so that TMDL goals are met for Ford and Belleville Lakes, and all streams meet their designated uses.	**Short-Term Objective**		Designated Uses: Warmwater fishery; aquatic life and wildlife; partial and total body contact recreation; industrial water supply; public water supply Desired Uses: Coordinated development; hydrologic functions
	a. Implement stormwater management requirements that minimize pollutant loading to receiving waterways by capturing and treating or infiltrating the smaller, more frequent storm event.	A, B	
	b. Implement local ordinances, strategies, and projects that: 1. Minimize the adverse effects of stormwater runoff from new highways and streets.	S4, MR1	
	2. Encourage the use of native landscapes and reduced dependence on chemical applications.	S3, PE5, PE6	
	d. Maintain stable oxygen levels in Ford and Belleville Lakes	All	

	e. Improve application and enforcement of soil erosion and sediment controls both during and after construction activity.	B	
	f. Identify and repair the most eroded and susceptible stream channels and banks.	S4, D, MR1	
	g. Maintain water quality monitoring programs to measure progress toward TMDL goals.	S1	
	h. Investigate and remediate bacterial sources to waterways	S2, PE4, E, F	
	i. Reduce phosphorus and sedimentation from agricultural sources	PE2	
	k. Increase education on BMPs among property owners and developers.	PE2-6	
	l. Advocate against any new NPDES discharge permits	PE1	
3. Protect and restore natural features to provide for stormwater treatment, wildlife habitat, and climate change mitigation	**Short-Term Objectives**		Designated Uses: Warmwater fishery; aquatic life and wildlife; industrial water supply; public water supply Desired Uses: All
	a. Implement local ordinances, strategies, and programs that: 1. Preserve natural infiltration and the recharge of groundwater, by protecting and restoring open spaces and natural recharge areas and reducing the amount of impervious area.	PE5,S3, PE6,C	
	2. Promote buffering of waterways from the direct impacts of stormwater-related pollution.	PE6	
	b. Monitor water quality and biota to measure progress.	S1, S5	
	c. Educate local decision makers and the public about the benefits of critical habitat protection.	PE3	
4. Increase public awareness and involvement in protecting water resources to achieve reduction of water pollution and hydrologic impacts to the watershed.	**Short-Term Objectives**		Designated Uses: all Desired Uses: all
	a. Conduct on-going programs to raise the public and practitioners' awareness of watershed management and nonpoint pollution issues and solutions.	PE1-6,E,G	
	b. Increase opportunities for public involvement in the protection of watershed resources.	PE1-6, E	
5. Gain broad implementation of watershed management plan and associated plans	**Short-Term Objective**		Designated Uses: all Desired Uses: all
	a. Promote intergovernmental coordination and cooperation in land use planning, natural resource protection, nonpoint source pollution control and stormwater management.	H, G	
	b. Increase public awareness of progress in WMP implementation.	PE1-6	
	c. Maintain an adaptive monitoring strategy that yields data to measure progress toward achievement of WMP goals and objectives.	S1-5	

4.2 Recommended Actions to Achieve Watershed Goals and Objectives.

4.2.1 Recommended Prioritization

To best achieve the long-term goals above, which were first developed in 1994, and in consideration of the new data and problems that have arisen and been laid out in Chapter 1-3 of this plan, the 2022 authors and stakeholders have developed a series of recommendations for implementation from 2022-2032. The table on the next several pages is a series of actions organized by stakeholder and category.

HRWC actions are those that HRWC can and should take the lead on, though often these actions require support from other plan stakeholders. As HRWC is the author and likely primary user of this management plan, these are presented first. They are broken into three categories: Study, Policy and Education, and Maintenance and Restoration. The order in which they are presented does imply a certain amount of priority, where actions listed first within each category are expected to be able to be implemented first and most easily, in some cases with money and programs already on hand and established. Recommendations harder to implement due to cost or being less developed, more conceptual ideas are listed more closely to the bottom of each category.

Stakeholder actions are those that are the primary responsibility and priority of the non-HRWC stakeholders of this plan, such as the County, Cities, and Townships within the Watershed. HRWC often serves in an advisory or partnership role for these recommendations. These are actions are not listed in any particular priority or category because the priority will be different for each stakeholder, depending on the threats they are facing. For example, the City of Dexter, with little remaining natural area, will have the assessment of natural areas as a lower priority than Webster Township, which is full of fields and forests.

If all recommendations are implemented, it is anticipated that, over time, all TMDLs will be reached, watershed functions will be restored, and the goals above will be met.

Each of the actions are described more specifically below the table.

Table 4.2. Summary of 10-Year Watershed Improvement Strategy, 2022-32

Lower ← Priority → Higher

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2022-2032	Lead Agency*	1. Success Measures 2. Link to long terms goal and short term objectives (Table 4.1)
HRWC—Study					
S1. Targeted Monitoring in AUID areas that fail to meet designated uses	All	2022-2032	$75k-$100k	HRWC, EGLE	1. Identification of pollution sources 2.1d, 2g, 3b, 5c
S2. Conduct bacterial source identification	Bacteria/ multiple	2022-2029	$120k	HRWC, municipalities	1. # human sources IDed and remediated; reduced bacteria concentrations 2. 2h, 5c
S3. Assessment and Prioritization of Natural Areas	All	2022-2032	$100k	HRWC	1. # natural areas assessed; prioritization scheme created 2. 1c, 2b, 3a, 5c
S4. Conduct a stream crossing structure study to prioritize infrastructure fixes	Altered flow regimes, habitat destruction	2022-2027	$60k	AATU, HRWC, WCWRC	1. Prioritized list of restoration targets 2. 1b, 1d, 2b, 2f, 5c
S5. Develop a long-term temperature, precipitation, and flow network	Altered flow regimes	2027-2032	$175k upfront, $30k/yr for upkeep	HRWC, University of Michigan	1. # automated stations developed; continuous real-time flow, precip, temperature data 2. 1d, 3b, 5c

Lower ← Priority → Higher

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2022-2032	Lead Agency*	1. Success Measures 2. Link to long terms goal and short term objectives (Table 4.1)
HRWC—Policy and Education					
PE1. Review and comment on all new discharge permits in TMDL area	Phosphorus/ new sources	2022-32	Unknown	HRWC, partners	1. No newly permitted dischargers of phosphorus effluent 2.2l, 4a, 4b, 5b
PE2. Incentivize agricultural practices to reduce nutrient loading	Nutrients	2022-32	$430k	HRWC, RCPP, farmers	1. Modeled phosphorus loss reduction 2. 2i, 2k, 4a, 4b, 5b
PE3. Pass and Enforce River Friendly Ordinances	All/Multiple	2022-32	$180k	Municipalities, HRWC	1. Ordinances and policies passed 2. 1b, 3c, 2k, 4a, 4b, 5b
PE4. Septic Inspection, Education, Mapping, and Remediation Program	Pathogens/ Human	2024-32	$200K	WC Environmental Health, HRWC	1. Inspection call rate; annual septic remediations 2. 2k, 2h, 4a, 4b, 5b
PE5. Develop and implement a Green Stormwater Infrastructure strategy and program	All/ Runoff	2022-24 plan 2024-32 implement	$200k - $20M	HRWC, Municipalities, Washtenaw County	1. Reduced impervious surfaces; Increased baseflow and reduced flow variability; reduced nutrient and bacteria concentrations and loading; monitoring 2. 1c, 2b, 2k, 3a, 4a, 4b, 5b
PE6. Buffer Enhancement Program	All/ Runoff	2024-27	$65K	HRWC, Washtenaw	1. Linear feet established; % streams properly buffered;

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2022-2032	Lead Agency*	1. Success Measures 2. Link to long terms goal and short term objectives (Table 4.1)
				County, municipalities	monitoring 2. 2b, 2k, 3a, 4a, 4b, 5b
HRWC—Maintenance and Restoration					
MR1. Targeted stream channel restoration (High priority)	Biota/ sediment	2022-32	$500k - $5M	HRWC, municipalities, WCWRC	1. Increased DO levels; improved channel morphology; biota monitoring 2.2b, 2f
HRWC Recommendation Summary	**Total**	**2022-32**	$2M-$8M	HRWC	
Stakeholder Recommendations					
A. Maintain and implement stormwater management plans	All/ stormwater	2022-32	$1M-$10M	Municipalities, county agencies,	1. Numerous. See individual stormwater plans; references provided in text 2. 1a, 2a
B. Enforce rules, standards and ordinances for stormwater management	All/ new stormwater	2022-32	$1M - $5M	WCWRC	1. Reduced runoff and nutrient/bacteria concentrations; monitoring 2.1a, 2a, 2c

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2022-2032	Lead Agency*	1. Success Measures 2. Link to long terms goal and short term objectives (Table 4.1)
C. Natural Areas Protection	All/Multiple	2022-32	$10M	Municipalities, land conservancies	1. # of acres of natural areas put into permanent protections from development 2. 1c, 3a
D. Implement infrastructures fixes at stream crossing structures.	Biota/ sediment/ altered flow regimes	2025-2032	$100k-$1M	WCWRC, WCRC	1. # of Road Stream crossing fixes implemented 2.1b, 2f
E. Pet waste ordinance education and enforcement	Pathogens/ Pet waste	2025-32	$18,000	Municipalities	1. Resident knowledge from survey; call volume; violation # 2. 2h
F. Place doggie bag stations at target locations	Pathogens/ Pet waste	2025-32	$27,500	County, municipalities	1. Stations established; use rate; pounds removed; monitoring 2.2h, 4a, 4b
G. Targeted enforcement of phosphorus fertilizer law	Nutrients/ runoff	2027-2032	$7,000+	EGLE, municipalities	1. Violations eliminated; lbs TP removed; TP monitoring 2.4g, 5b
H. Climate Action Planning	Altered flow regimes/ Nutrients/ Runoff	2022-2032	$1M-$1B	Municipalities	1. # of ordinances adopted to reduce GHG emissions and increase climate resilience; Reduction of impervious surfaces 2. 5b

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2022-2032	Lead Agency*	1. Success Measures 2. Link to long terms goal and short term objectives (Table 4.1)
Priority 2 Activities Summary	**Total**	**2022-32**	$13M - $25M plus costs of H		

* Agency Acronyms:

AATU: Ann Arbor Trout Unlimited
HCMA: Huron Clinton Metropark Authority.
HRWC: Huron River Watershed Council
RCPP: Resource Conservation Partnership Program
WC: Washtenaw County
WCWRC: Washtenaw County Water Resource Commissioner
WCRC: Washtenaw County Road Commission

4.2.2. HRWC- **S**tudy Recommendations

S1. Targeted Monitoring in AUID areas that fail to meet designated uses

In section 2.5, the authors have highlighted critical areas in the Watershed that fail to meet the entirety of their designated uses. These areas include Honey Creek (bacteria), Mill Creek (bacteria), Huron River (PFOS), Pleasant Lake Tributaries (Habitat/Flow Alterations), and Letts Creek (pollutant unknown). Furthermore, through HRWC monitoring efforts, issues have been found in Boyden Creek phosphorus levels.

Monitoring should be conducted for these specific problem areas to elucidate sources and illuminate possible solutions.

WMP stakeholders should keep EGLE informed of areas of recurring foam suspected of containing high levels of PFOS/PFAS, will recommend state sampling in those areas, or should pursue independent sampling through qualified service providers. Continued attention needs to be paid to the river below the Dexter-Sweepster-Chysler-Palladin plant to verify EGLE findings and remediation plans, and to make sure risks are adequately communicated to nearby residents. Periodic sampling at the mouth of Mill Creek may help understand any transient nonpoint sources of PFOS/PFAS to the Huron River, such as runoff from agricultural fields on which biosolids containing PFOS/PFAS were applied.

HRWC's Chemistry and Flow program monitoring will continue at Honey and Mill Creek sites to track bacteria trends. Bacteria source tracking (BST) has already distinguished human source areas from other sources (i.e. pet waste and manure) in these creeksheds. Additional investigative sites should be added in Letts creekshed. BST could be useful to identify human and other sources contributing to Boyden Creek. More detail on bacteria follow-up can be found in recommendation PE4.

At Lett's Creek, which suffers from "pollutant unknown", a broad swathe of parameters could be considered here to pinpoint problems. At a minimum, sensors could be installed measuring continuous flow, conductivity, temperature, and dissolved oxygen. HRWC's Chem/Flow program should make Lett's Creek a investigative site for the 2022-2023 spring-fall monitoring. The macroinvertebrate monitoring program should ensure that regular monitoring is conducted here.

Timeframe: 2022-2032
Milestones:

- 2022-2024: Develop monitoring plans and process results from first efforts.
- 2024-2032: Continue monitoring and follow up results with conversations with EGLE and other relevant regulators.

Cost: PFOS: Approximately $600 per sample. $60,000 over a multiyear period could be expected. *HRWC Chem/Flow Program:* $4,000 annually per monitoring sites; estimated 4 new sites needed. Total: 75k-100k
Potential funding sources: Section 319, Middle Huron Partnership
Success Measures: Letts Creek is given a known pollutant in the next EGLE integrated report. Amounts and sources are further quantified in the other problem areas.

S2. Conduct bacterial source identification

In section 2.5.2.2 and 2.5.2.3, the authors show that Honey Creek and Mill Creek are listed for on bacterial impairment. While much effort has been put into understanding the bacterial inputs in Honey Creek (Appendix B, H,) over the last ten years, there is more to be done here as well as in Mill Creek (Chapter 2.5.2.3) An implementation plan was created and carried out for Honey Creek, but an implementation should yet be written for Mill Creek.

This project aims to determine the presence, absence, and sources of bacteria in the watershed through a suite of potential monitoring techniques. By utilizing genetic analyses, canine source detection, and ambient water sampling, the project will evaluate fecal indicator bacteria sourcing. For any positive human detections, HRWC and WCWRC and the Washtenaw County Department of Environmental Health will contact any suspected homeowner to remediate any failing septic systems or illicit connections.

HRWC and local partners can also execute outreach and education strategies to property owners in the impaired creekshed on pathogen problems as well as home and pet owner remediation actions. This would be made much easier if remediation funding is available to subsidize a portion of this sometimes-burdensome cost on the homeowner. These recommendations are described more fully in PE4.

Timeframe: 2023-2029
Milestones:

- 2023-2024: Write a Mill Creek *E.Coli* monitoring and implementation plan
- 2024-2026: Identification of bacteria impairments
- 2028-2029: Conduct follow-up monitoring

Cost: Staffing costs for planning and writing; fecal indicator bacteria monitoring, analysis, source identification, and follow-up: $120,000;
Potential funding sources: Section 319
Success Measures: Number of human sources identified and remediated; bacteria monitoring (see chapter 5)

S3. Assessment and prioritization of natural areas for conservation and protection

As discussed, in section 2.1.3.2, the Watershed's remaining natural areas are of utmost importance to protect for their ecosystem services. Of the 37,000 acres of natural areas in the Watershed, only 8000 acres are protected as public and park lands. HRWC has used GIS methods to determine the relative importance of these natural areas (Figure 2.6) but has only visited a small number of them to conduct on-the-ground assessments of their plant communities, hydrological characteristics, and other important components. Many more field visits of likely high quality natural areas are possible (Figure 2.7). In addition, more GIS modelling opportunities have been developed to provide ecosystem services valuation on a per-parcel basis. There exists a need to add further GIS and field-based prioritization to show which of the natural land parcels are most important to preserve in order to retain the ecosystem services they provide. HRWC should request that EGLE conduct the Landscape Level Wetland Functional Assessment (LLWFA) for the whole Watershed area. The LLWFA results could be added to HRWC's prioritization scoring methods.

Timeframe: 2022-2027
Milestones:

- 2022-2023: Enhance GIS modelling to provide ecosystem services valuation by parcel in the Watershed
- 2022-2025: EGLE conducts LLWFA and HRWC incorporates results in prioritization scoring
- 2022-2025: Conduct natural area surveys in the Watershed
- 2027: Develop a set of recommendations for the WMP stakeholders that map and list the priority natural areas in the watershed.

Cost: $100k
Potential funding sources: NRCS (Regional Conservation Partnership Program), Clean Water Act section 319, Clean Water and Drinking Water State Revolving Loan Fund, foundations
Success Measures: # of field assessments; ranking model or scheme; final prioritized list developed

S4. Conduct a road-stream crossing study to prioritize infrastructure fixes

Throughout the Watershed, stream crossing structures (culverts and bridges) are in various states of functionality. In the last two years (2020-2022), the creeks have had water levels consistently higher than the long-term median, and due to climate change, this is a trend that is going to continue. However, it is largely unknown to what extent culverts and bridges restrict water flow and fish passage with the current high flows. Furthermore, improperly sized or failing road-crossing structures have upstream and downstream erosive effects.

Mill Creek stakeholders, in particularly Trout Unlimited, have a vested interest in fish passage throughout the creekshed, as they seek to manage trout and other fish populations in the creek. Furthermore, the WCWRC and WCRC have interest in maintaining water quality, reducing erosion, and preventing flooding throughout the Watershed.

A methodical survey should be established to visit and assess the conditions of every road crossing in the creekshed and from that information an ordered list built that can be shared with the WCWRC and the Washtenaw County Road Commission to help with prioritization of fixes. HRWC has experience in conducting such surveys. In 2016 HRWC used the Great Lakes Road Stream Crossing Inventory protocol[1] to survey Norton Creek. The same process could be conducted for Mill Creek along with the other creeksheds in the Watershed as funding permits. This is a different study than the results from the BANCs analysis (recommendation 1L) as it focuses on the area immediately surrounding road crossings and the results are most applicable to hard engineering and construction.

Timeframe: 2023-27
Cost: $60k
Potential Funding Sources: NRCS, 319, Trout Unlimited
Success Measures: # of road crossings assessed, prioritization list created

S5. Develop a long-term temperature, precipitation, and flow network across the Watershed.

As discussed in Chapter 3.4.1.2, preparing for future storms is challenging for communities without mandates in state or federal regulation, without critical data, and without available funding for large infrastructure projects. Some communities in the Middle Huron watershed currently use available historical data for designing infrastructure to handle storms that are not accurate with a changing climate. This is a particular challenge for dam operators, as mentioned in Chapter 3.4.3, who need real-time flow data and modern communication tools to properly watch for floods and upstream dam failures. Furthermore, with greater rainfall comes more erosion, which causes greater sediment and nutrient flow through the waterways.

Therefore there exists a need to collect current weather and flow data with more accurate, modern approaches that will give us the ability to make decisions on how to best manage humans systems, watersheds, and streams. More robust and sustainable approach is needed to quantify needs in specific watersheds and reliably fund large infrastructure projects.

We recommend create an observational network of weather and water condition observational stations that allows the coupling of climate and hydrologic data or long periods of time. That will improve our understanding of the watershed response to various weather patterns. A goal should be to quantitatively understand how the watershed responds at the creekshed scale when a major precipitation event occurs in the watershed. That connection, based on quantitative, observational data collected over time, will establish the observational basis for tailoring climate and hydrologic models to the watershed. This coupled climate-hydrologic model would allow us to assess existing conditions in the watershed and project how climate change will alter hydrologic conditions in the future. That information can be used to inform decisions around infrastructure and ecological vulnerability.

Timeframe: 2027-2032

Milestones:

- 2027: Install the first weather monitoring station or successfully collect and utilize data from existing weather observing stations in the watershed. Improve currently existing HRWC flow station at North Territorial Road to allow wireless connection, user friendly websites, and automatic data processing.
- 2032: Expand the network across the whole Huron River Watershed, with 1 weather station per county within the watershed, and with 1 flow sensor at the mouth of every major tributary and multiple along the main branch of the Huron River. Existing weather observing stations that collect the relevant data may be used to reduce costs or improve watershed coverage.

Cost: $2,500 for weather stations; $400 for flow devices; plus $150k for staff time to write computer code and process data. Total: $175k total for the Watershed. Costs of network implementation are high, and ongoing maintenance and staff time will be required of about $30k per year.

Potential funding sources: GLRI, Foundations, NRCS

Success Measures: # of automatic stations, continuous real-time flow data, precipitation, and temperature.

4.2.3. HRWC - **P**olicy and **E**ducation Recommendations

The MS4 communities within the Watershed, forming together the Middle Huron Partnership, have committed to implementing a Public Education Plan (PEP), which is referenced in Appendix J.

The following recommendations are those that take concepts from the PEP and expand upon them, combining public outreach with policy and packaged up as a set of projects that address the long-term goals and short-term objectives of this WMP and that could be implemented within the next 10 years. These projects both directly address impairments in the watershed while providing teaching opportunities to inform and engage the public.

PE1. Review and comment on all new discharge permits in TMDL area.

The TMDL for Ford Lake and Belleville Lake concludes that there is excess phosphorus entering the lakes from current sources. The policy establishes phosphorus loading limit goals for all identified sources as well, and in some cases states how EGLE staff believe that the sources can be reduced to the stated goals. These targets are then used as guidelines to set limits within NPDES discharge permits. Given that the lakes exceed the TMDL, the addition of new phosphorus sources within the TMDL watershed would be counterproductive. It is imperative to the success of all the phosphorus reduction activities going forward that no new sources be added to counteract these nutrient reduction efforts. To prevent new sources from being added, HRWC and partner agencies commit to participate fully in public response to new permit applications. In this public response, the partners will request that EGLE give full consideration of the effort made within the watershed to control existing phosphorus sources and uphold the goals of the TMDL by rejecting any new source permits.

Timeframe: 2023-2032
Milestones: Review and comment on all discharge permit applications.
Cost: HRWC and partner staff time. Likely a negligible cost.
Potential funding sources: General staffing budgets.
Success Measures: Zero new phosphorus discharge permits; monitoring (see chapter 5).

PE2. Incentivize agricultural practices to reduce nutrient loading

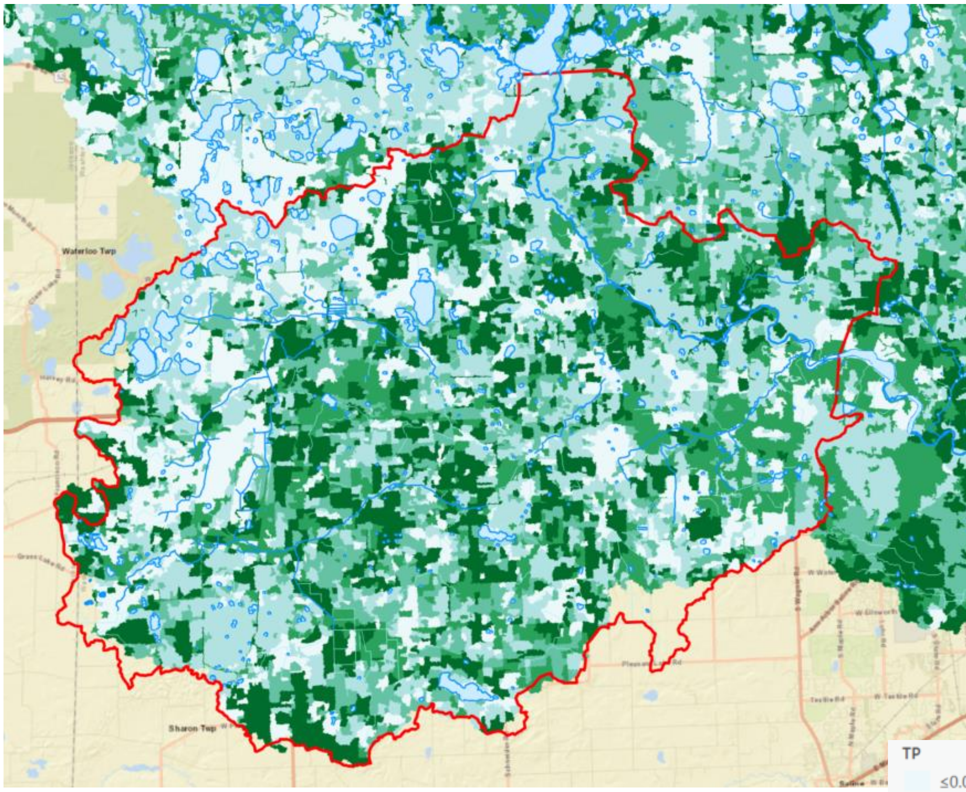
As indicated in chapter 2, 44% of the Watershed is under agricultural production. Chemistry monitoring indicates that, in the creeksheds with large areas of agriculture (i.e. predominantly Mill Creek, but also parts of Honey and Boyden Creeks), total phosphorus concentrations remain high. Agriculture is likely a significant source of nutrient loading, as fertilizers are applied annually to increase crop yields. HRWC has had some limited success in encouraging some changes in agricultural practices through the Whole Farms for Clean Water Program. Program staff have learned anecdotally that area farmers have not received good enough information about the nutrient content of their soils. Further, practices such as targeted fertilizer application and subsurface injection have allowed farmers to reduce overall application and significantly reduce phosphorus loss (by >80% on some fields). Continued education and outreach to farmers is necessary to increase participation and further funding is necessary for "pay-for-performance" incentives based on phosphorus loss reductions.

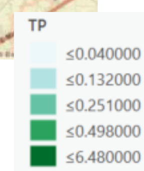
Timeframe: 2023-2028
Milestones:

- 2023-2024: Publish program report with results. Begin distribution to local farmers, especially those working large acreage in areas modeled to show high phosphorus loss potential (Figure 4.1). Seek continued program funding.
- 2024-2026: Adapt outreach based on farmer response. Establish new incentive contracts and verify results.
- 2026-2028: Adapt programming based on farmer participation and practice results. Summarize modeling and monitoring results in program report. Seek continued program funding if results continue to be positive.

Cost: Implementation of marketing and outreach plan: $30,000; Incentive payments: $300,000; Technical assistance: $100,000, Total: $430,000
Potential funding sources: Section 319, GLRI, Foundations, NRCS, Resource Conservation Partnership Program (RCPP)
Success Measures: Modeled phosphorus loss reduction; total phosphorus monitoring (see chapter 5)

Figure 4.1. Total Phosphorus loading rates from SWAT model (in kg/ha)





PE3. Pass and Enforce Water Friendly Ordinances

To protect water, you need to protect the land the water drains from. This fact is a constant struggle in a world that tries and often fails to balance ecosystem needs with the demands of a human civilization. People need places to live and work, but people and animals need clean water and clean land. Fortunately, local governments have regulatory tools at hand to allow development while protecting the important natural areas that are mandatory in maintaining water quality and other important ecological functions (see 2.1.3.2). Tools include wetland, woodland, riparian buffer, and other natural feature protection ordinances; and, regional planning to direct development away from natural areas.

We recommend that all local governments in the Watershed adopt the following local government policies for water quality protection:

1. Identify high priority natural areas
2. Adopt land protection funding program
3. Master planning to direct development away from sensitive areas
4. Overlay zoning of areas that need extra protection,
5. Setbacks and buffers from natural features like waterways, wetlands, woodlands,
6. Wetland protection ordinance
7. Reduce impervious surfaces through site design
8. Green Stormwater Infrastructure requirements to mimic ecosystem services of natural green infrastructure that was destroyed by development.
9. Pet waste pickup

HRWC has previously (2006) developed a Cost and Ordinance Worksheet (COW) to determine which local municipalities have which of these ordinances. HRWC will need to revise these COWs by conducting a survey of the Watershed's municipalities to see where they have these policies and where they don't.

HRWC will work with municipalities in getting new policies passed, by sharing model policies and advocating and educating local decision makers. To accomplish this, HRWC will recruit motivated individuals from local Watershed governments or citizenry for a series of trainings that provide intensive technical assistance including how to conduct an audit of current policies and will give recommendations on adopting necessary policies to provide clean water and natural area protections.

HRWC has run such activities in recent years for other areas of the Huron River Watershed under our "Change Makers" program. Based on our experience, we estimate it takes about $15,000 per municipality to conduct audits of their master plans, hold trainings which consist of multiple in person sessions over a one year period, and work directly with each Community in providing technical advice.

Timeframe: 2022- 2032
Milestones:

- 2024-2032: Run highly motived government elected official, employees and/or citizens from each of the 12 Core Communities (Table 1.1) in the Watershed through HRWC Change Maker's program
- 2032: Every municipality in the Watershed has policies that cover these nine priority areas.

Cost: $180k ($15,000 per Core Community)
Potential funding sources: Foundations, HRWC general operations
Success Measures: # of new ordinances or policies adopted

PE4. Septic Inspection, Education, Mapping, and Remediation Program

While many homeowners in the Watershed are connected to wastewater infrastructure provided by Ann Arbor, Dexter, Chelsea, or a neighborhood sewer system, there are numerous homes outside municipal boundaries that rely on individual septic treatment. Septic System Inspection Programs are meant to identify and correct failing septic systems that discharge human waste into groundwater or on the surface, and directly or indirectly into surface water HRWC's. Monitoring has shown that failing septic systems are causing *E.Coli* in Honey Creek (Appendix H) , but there hasn't been a good process yet set in place for dealing with this issue.

Washtenaw County's "Time of Sale" Ordinance requires that prior to any residential property transfer: 1) the septic system must be inspected by certified inspectors, 2) a report must be submitted to the Environmental Health Regulation Department and 3) the seller must receive an authorization letter from the Department. For properties where the "Time of Sale" ordinance has not triggered an inspection and authorization, county health officers are more limited in their ability to identify and inspect septic systems. Over 4,300 systems have been evaluated annually, countywide, with over 540 septic system corrections documented to date.

HRWC recommends a behavior-change based education program among homeowners to increase voluntary frequent maintenance and inspection of septic systems and repair and replacement of those identified to have problems. Behavior-change projects involve using observational research, focus groups, surveys, and other data to identify the barriers that property owners face in regard to implementing a change in their actions. The desired target behavior for septic systems is more frequent voluntary inspections (not just a Time of Sale) and maintenance. Possible barriers, which would be determined as a part of the behavior change research, are cost of maintenance to property owners, lack of understanding the importance of maintenance, how to maintain their system, remembering to maintain it, and who to call for help, concern regarding ordinance violations and penalties, funding for replacement costs, among others. After identifying specific actions and barriers, HRWC and the County would develop and pilot test strategies that help residents overcome these challenges. Successful strategies could be implemented on a larger scale. Some possible strategies are included below:

Washtenaw County's existing Time of Sale program can serve as the basis for an expanded effort to reach residents who are new homeowners with septic systems to increase inspections and remediate those that are failing. Additionally, HRWC and the County could use results from IDEP inspections and canine source detection confirmations to then target residents for expanded programming that initiates or increases inspections and maintenance of septic systems.
This new program could remove barriers such as cost and expertise by providing inspections free of charge to residents in target areas and a list of qualified contractors to remediate failing systems. An additional element to the program should be added to help finance failing systems for residents who lack the means to pay for expensive fixes. The availability of assistance may help to address barriers on the part of homeowners to participate in the inspection program. The program could host workshops on septic system care and maintenance that would be promoted by direct mail and offer a free "Water Efficiency" kit for those who attend.

HRWC and partners in the health department could also map the actual location of septic tanks and drain fields to update and convert records to Geographic Information Systems or other digital tools. Systems could be built to automatically send emails and educational reminders to homeowners that include messaging and material targeted to program participants to increase awareness about septic systems and their effect on water quality, and educate watershed residents on best practices for maintaining, and identifying and correcting failed septic system. Such a tool could also be used to track the oldest and most likely to fail systems.

Projects that use behavior change marketing techniques to address failing septics could have great impact on reducing *E.coli,* but will not be without significant challenges. Concerns regarding costs to correct violations required by Ordinance and fear of penalties will make voluntary participation in research and evaluation by the target audience very difficult.

Timeframe: 2024-2032

Cost: Behavior-change based educational program: $150,000 for surveys, staffing, and material development. Resident-monetary assistance for inspections, maintenance and remediation of unknown number of connections $100,000 total. Digitizing records; building educational tools. $50,000. Total $300,000
Success Measures: Differential in number of inspection requests (pre-post information distribution), number of septic remediations in target areas, survey results, monitoring (see chapter 5).

PE5. Develop and Implement a Green Stormwater Infrastructure (GSI) Strategy and Program

As mentioned in chapter 3.4.1.3, Green Infrastructure, under the reality of climate change and the ever-growing need to attenuate stormwater, runoff, and flooding effects, built infrastructure like will always be at least partially static and likely to become obsolete in the future. In many cases, building infrastructure to manage future storms and floods will be impossible or impractical, either due to costs or the rate of change in design storms. However, natural ecosystems are inherently dynamic. The use of green infrastructure and natural areas conservation should be incentivized wherever possible to mitigate the pace and magnitude of future changes.

HRWC developed a process to incorporate available geographic, aerial and other remotely collected information to identify opportunities for Green Infrastructure projects for stormwater treatment.[2] Figure 4.1 shows a map of GSI opportunities in the Chelsea area. Opportunities are identified for streets, large lots, and roofs. Projects and programs already exist in the watershed, such as Washtenaw County's residential Rain Garden Program,[3] and numerous public and private GSI projects that are inventoried across the county.[4] The Huron Clinton Metropark Authority has Stormwater Management Plans with GSI components for each of the Metroparks in the Watershed (Hudson-Mills, Dexter-Huron, Delhi) (Appendix I)

Across the plans and programs, hundreds of projects have been identified of many types including residential rain gardens, community rain gardens, native restoration, green roofs, water quality units, and infiltration practices.

So many GSI efforts are already underway, but there is plenty of space for growth in this arena. A program to incorporate key GSI retrofit designs along key roads or other publicly owned properties based on targets identified in the GSI Opportunities Map should be developed, as well as large business properties. Public and private property owners or managers would need to participate as willing partners. New and redevelopment projects in the watershed should also be encouraged to use GSI approaches. This program would promote the use of designs that slow and settle runoff waters from impervious surfaces like roads, drives and sidewalks and infiltrate as much of the runoff as possible. Slowing run-off waters will reduce stream flashiness, addressing the top long-term goal of reducing flow variability in the Watershed. This also allows a greater portion of runoff to be filtered through groundwater, removing pollutants, and where bacteria will not reproduce, thus reducing stormwater runoff sources of contamination. Research on bacteria reduction indicates that few structural BMPs work to significantly reduce bacteria levels in stormwater runoff. However, properly designed detention or retention basins have been shown to reduce bacteria in outflow. Existing detention ponds and stormwater systems in critical areas of the watershed should be evaluated for retrofit opportunities to capture, settle and treat stormwater runoff, as well.

Ideally, all impervious surface within the watershed would be captured and treated at some level, whether it be detention ponds, underground storage or GSI. Based on an analysis of the watershed, there are about 10.23 mi^2 or 6,550 acres (5%) of impervious surface. At a conservative 7:1 ratio of impervious surface to treatment area, **an appropriate goal would be to develop at least 936 acres or 41 million square feet of GSI or other treatment in the watershed.** Based on standard designs, this implies the need for 61.5 million cubic feet of total storage capacity. EGLE 319 funding may have additional requirements for BMPs beyond the 7:1 ratio. Furthermore, this 936 acres is a conservative estimate as this value is based on current conditions and as additional areas are developed the number should be adjusted to match.

Achieving the benchmark of 936 acres (41 million square feet of GSI) will not occur without significant effort— more than what can be provided by the WMP stakeholders alone. Fully implementing GSI in this part of the watershed means more than increasing the adoption of rain gardens and other GSI on residential properties and on public land and parks. Targeting commercial property owners, churches, and non-profit property owners to install rain gardens as a means of controlling stormwater runoff and beautifying their landscapes would provide an additional untapped avenue of community engagement and GSI implementation. We recommend an outreach campaign using a behavior change marketing approach to increase the voluntary adoption of rain gardens among these target groups. Each target group would need its own marketing strategy.

At its core, behavior change marketing requires significant understanding of the target audience. This includes observation-based research, focus groups and surveys of the target demographic to understand their current knowledge levels and their barriers to implementation, which could range from costs, lack of knowledge, motivation, and access to resources among other things. With this data as guide, the educational campaign would develop and pilot test strategies to reduce or eliminate identified barriers and increase motivation for adopting the desired behaviors. Some possibilities include educational materials that use beautiful photography and appeals to GSI's benefits to the community and low-cost maintenance; trainings on how to plan, implement, and maintain GSI; tours of beautiful and successful GSI; increasing access to contractors that provide GSI design, installation and maintenance; identifying and supporting early adopters and influencers; establishing peer-to-peer social networks; and more. Successful strategies would then be used on a larger scale. One challenge to this educational campaign is that business owners are not necessarily properly owners, but are often renters, and the motivation of a renter versus a property owner will likely vary. Possible target locations for this project are both downtown areas of Dexter and Chelsea, where multiple local businesses are congregated closely to each other, or commercial suburban spawl, like the hundreds of businesses stretching multiple miles along Jackson Road in Honey Creekshed.

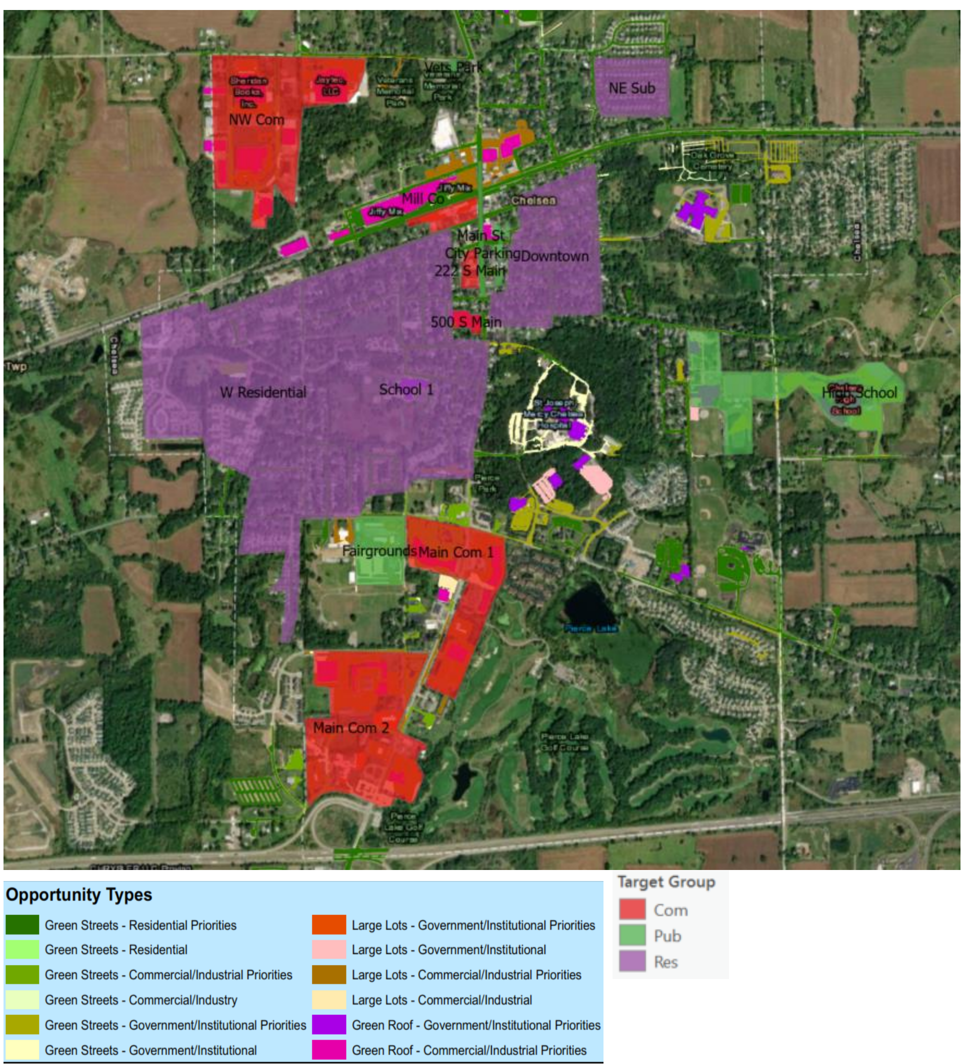
Timeframe: 2022-2032
Milestones:

- 2022-2023: Estimate current treatment area (or storage capacity) and set a 10-year goal for new development

- 2022-23: Identify primary GSI project targets and develop a strategy
- 2022-2023: Develop a marketing strategy for primary and secondary targets
- 2023-24, develop a self-funding program to identify, fund, design, install, and maintain GSI projects
- 2025-2030: Conduct a multiyear education campaign targeted at businesses
- 2024-2032: Implement program and install projects

Cost: Highly variable, depending on project, but usually lower than conventional cost of construction or reconstruction and maintenance. $20k to form and launch program. Up to 150,000 for a multiple year educational campaign with surveys, staffing and products.
Potential funding sources: Section 319, local government match, local agency or private investment
Success Measures: Reduced runoff volume, pollutant concentrations, and bacteria concentration measured from projects compared to conventional development, monitoring

Figure 4.2. Green Stormwater Infrastructure opportunities in the City of Chelsea and surrounding area. (Colors represent different types of GSI)



PE6. Develop a buffer enhancement program

Vegetated stream buffers are valuable permanent measures for water quality and habitat enhancement. Buffer zones are strips of undisturbed native vegetation, either original or reestablished, bordering a stream, river, or wetland. These buffer zones also are known as riparian buffer zones, referring to the zone along a waterway or waterbody where the water meets the shore. The trees, shrubs and plants, and grasses in the buffer provide a natural and gradual transition from terrestrial to aquatic environments

To reap all the benefits of buffers, they should be at least 100 feet wide on either side of a stream – both intermittent and perennial. Though not optimal even buffers 10 feet wide could provide many benefits, and this could be a possible solution in highly urbanized or agricultural regions.

These areas are critical for wildlife habitat, storing water during periods of high-water flow, and protecting lakes and rivers from physical, chemical, and biological pollutants. Establishing buffers that protect riparian corridors, especially floodplains, wetlands, and steep slopes, offers a way to filter material with active microbes before they enter the stream. Restoring natural vegetation in bacteria hot spots also discourage Canadian geese populations from congregating. Planting and maintaining native grasses and sedges at common geese or animal access areas to replace some of the turfgrass will help reduce E. coli counts.

As mentioned in 3.3.2.1, Changes in Bird Nesting and Migration Patterns, climate change is shifting bird's migration patterns among other effect, and in light of these challenges, buffer zones are all the more important for providing critical oasis habitat corridors, especially in agricultural dominated areas like Mill Creek.

Since relatively little of the Watershed is covered in impervious area, there are a lot of opportunities for buffers. Much of the land is managed in agriculture use, so the buffers will need to be voluntary through practice incentives or purchased as easements. Some buffers could be added in conjunction with streambank restoration (see 1N above). Buffers should be targeted along stream reaches that are impaired by bacteria or for biota.

We recommend starting a stream based, behavior-change based, buffer enhancement educational program. Many of the best management practices for stream shorelines are a variation of what HRWC and EGLE already teach about lake shorelines, however, these stream landowners may not necessarily see that connection or even be familiar with the concept and are likely to have different motivations and barriers to adopting best shoreline practices. The approach would include techniques such as observation based research, focus groups and surveys to identify the motivations for and barriers to creating and maintaining buffers, be it roadblocks like costs, aesthetics, lack of information, knowledge, or motivation. The educational program would then develop and pilot test strategies to best mitigate these challenges and inspire stream landowners to build buffers and keep and restore protective riparian buffers. Successful strategies that are identified could then be implemented on a larger yet targeted scale to measure results in the targeted group. Follow up surveys would show change in knowledge and behaviors and follow up monitoring could show direct physical results. This educational program would start small by directly targeting streamside property owners on specific properties, like those who live on streams assessed by BANCs for example, but the products and ideas from this program could eventually be scaled to cover the whole Huron River Watershed.

Property owners in agricultural, urban, and suburban areas face different challenges and the education program would have to distinguish between these. There are some resources that already exist for agricultural property owners to utilize. The Wildlife Habitat Incentive Program (WHIP) is available through the Natural Resource Conservation Service (NRCS). The Conservation Reserve Enhancement Program (CREP) offers additional incentives to encourage landowners to implement practices that will help reduce sediment and nutrients and will improve wildlife habitat, while also removing bacteria and microbes. The USDA Farm Service Agency (FSA) provides an annual land rental payment, including a CREP special incentive payment, plus cost-share of up to 50 percent of the eligible costs to plant grasses or trees on highly erodible cropland, establish vegetated buffers along streams, restore wetlands, provide shallow water areas for wildlife, and restore habitat for rare and declining species. Additionally, the entire watershed is in the target area for HRWC's Whole Farms for Clean Water program, which provides incentive payments for phosphorus loss reductions, which buffers provide.

Timeframe: 2025-30
Cost: Multiple year educational campaign, $150,000 for surveys, staff time, and products. Funds could be provided to participants to help kickstart buffers: @ $500/ac for 80 ac: $50,000; mailing, site visits, planning, technical assistance, reporting: $25,000. Total: $225,000.
Success Measures: # landowners participating, # and % of riparian acres buffered, monitoring (chapter 5)

4.2.4. HRWC- **M**aintenance and **R**estoration Recommendations

MR1. Targeted stream channel restoration to reduce channel erosion

As noted in Chapter Two, the assessment of stream channels in the Watershed determined that most channels show relatively little evidence of bank erosion risk. However, there are a few stream segments that should be repaired and restored to a more natural state. A restored channel, with a more moderated delivery of stormwater to the river provided by GSI efforts, will accentuate the river's resiliency to ability handle climate-related impacts. GSI planning and implementation is proposed for the more developed areas in the watershed. This will help to reduce nutrient inputs and slow flows from runoff events to reduce erosion and bed scouring. The added infiltration from GSI practices will increase groundwater flow and even out flows during the longer dry periods that are expected under the changing climate regime.

Stream channel restoration is proposed for the highest priority stream reaches that were identified in the BANCS inventory (Appendix G). Seven priority restoration projects were identified through this process (Table 4.3). Restoration projects should proceed after upstream flow can be shown to be stable, but most of the impacts to these channels are from alterations to isolate the streams from farm fields. The altered hydrology is not likely due to runoff from built-up or impervious areas. While the target reaches would benefit from GSI or other flow control in their contributing areas, bank restoration can be beneficial on its own.

Table 4.3. Priority Stream Restoration Reaches

Reach ID	Stream Name	Reach Length (linear ft)	Erosion Rate (tons/yr/ft)	Total Erosion (tons/yr)	Notes
432	Mill Creek, SW fork	1,634	0.236	384.8	Banks appear artificially high on the south side of the stream. An easement could be purchased and two-stage bank established, at minimum.
501 427	Mill Creek, main S fork	18,850	0.212	2,062.5	Two long reaches of mostly straight channel that has been isolated from floodplain. Two-stage banks on both sides should be added in phases in partnership with farmers.
588	Honey Creek, S branch	2,543	0.153	151.8	Reach has been heavily impacted by the development of I-94 and Jackson Blvd. crossings. Culverts should first be assessed for blockage, failure, or misalignment. Possibly, a realignment or resizing effort may be needed. Ample floodplain is available.
474 401	Mill Creek, small tributary	4,106	0.123	189.2	Small, often dry, flashy tributary near Dexter that has some evidence of severe bank erosion. May be partially caused by development. Riparian room to stabilize small section at downstream end, though runoff storage/infiltration is also needed.
373	Honey Creek tributary	8,019	0.107	859.4	Unstable stream W of M-14. Altered hydrology has severely eroded banks in smaller sections, especially at bends, some threatening property. Natural floodplain could offer room for restoration, but all in residential area in need of source control.
368	Mill Creek, N Fork	3,483	0.104	363.6	Altered channel (straightened and deepened) in area with high water table, cutting

					across 2 farm fields. Potentially tiled. Restored hydrology and wetland restoration required to reduce bank erosion.
538	Boyden Creek, W branch	8,312	0.104	381.6	Small stream in mostly good shape, with small segments of high erosion likelihood. Riparian area formerly golf course. Could be stabilized then allowed to restore as floodplain returns to natural.

Restoring streams to more natural channel configuration provides the template for restored ecosystem function that will support the return of a healthy biological community once flashy flows are mitigated. The existing floodplain should be connected where possible to allow for flooding from smaller as well as larger storms to better establish floodplain communities and provide better riparian habitat. Restoration projects identified for the Honey Creekshed are particularly important as those reaches have impaired biological communities. Some sites in Mill Creek near restoration priorities are also declining and could improve following stream restoration.

Specific restoration projects will need to be identified and restoration designs developed that are based on site-specific survey data that was beyond the scope of the rapid assessment survey. This more detailed survey data can be used to develop a more precise erosion estimate, which can further be used to derive sediment and phosphorus loading reduction estimates from the restoration projects.

All stream restoration projects require EGLE Non-Point Source Division review and approval. Possible stream restoration practices that can improve stream function may include, but not be limited to the following:

- *Grade controls* including the creation of step pools using natural materials such as logs or stone from the surrounding watershed
- *Form-based restoration* that could include the use of anchored deflectors or log jams to deflect energy from eroding banks, slow stream velocity and introduce complexity to stream form. In some cases, native rock and wood can be used to create larger deflection as with “J-hooks.”
- *Connectivity restoration* may be possible in some places by flattening bank slopes and allowing the stream channel to reconnect with available floodplain. Additional flood storage can also be constructed within this floodplain in wetland or oxbow features.
- *Channel complexity* can be added where there is insufficient room to connect to floodplain features or allow a channel to meander. Two-stage channels with periodic or continuous benches along one or both sides of a channel that has over-widened can allow natural features to recover and create needed flow diversity. Natural log benches can be used to stabilize banks and allow low-flow accumulation of sediments.
- *Riparian restoration* can be added to almost any channel corridor by adding a matrix of native grasses, forbs and live stakes to help stabilize banks and provide needed cover.

- *Wetland restoration* can be included where the water table is high by restoring the natural hydrology, breaking drain tiles and removing dikes. Connecting streams to wetlands can slow and cool flows, settle out sediments and filter pollutants and nutrients.

Timeframe: 2023-2032
Milestones:

- 2023-25: Identify capital improvement and grant opportunities and schedule projects.
- 2024-2032: recommend restoration improvements to development projects.
- 2024-2032: Implement and construct public and private restoration projects

Cost: Highly variable, depending on project. A small (~1,000 lf), low construction project is estimated at $50,000, but could range to $100,000 with permitting or construction difficulties. Larger projects with more earth movement required can cost multiple millions of dollars. An estimate for 7 projects is $500,000 to $5,000,000
Potential funding sources: Stream restoration grants, local government match; local agency or private investment; mitigation funding.
Success Measures: Increased DO levels; improved channel morphology dimensional measures and substrate characterization; biota monitoring (see chapter 5)

4.2.5. Stakeholder Recommendations

A. Maintain and Implement Stormwater Management Plans

As mentioned in 3.3.5.1 and 3.3.6, the recent increase in heavy downpours has contributed to the repeated discharge of untreated sewage to the river or its tributaries in several communities. While communities with combined sewage-overflow systems are more vulnerable to sewage discharges due to extreme precipitation events, communities with separate sanitary and storm sewers are also at increasing risk. As seen with what happened in Dexter in 2011, continued efforts to reduce stormwater leakage into the sanitary sewers are effective for lessening the chances for untreated sewage run off. These actions, as well as priority actions 1E, 1F, and 1G, are all actions that are described more fully in community Stormwater Management Plans (SWMPs).

All MS4s in the Watershed submit completed Stormwater Management Plans (SWMPs) along with permit applications to EGLE every five years. The SWMPs included specific activities conducted by individual MS4s to control and manage the quality and quantity of stormwater flowing through and out of their systems. The inclusion of the SWMPs in this WMP are meant to indicate that these MS4 communities do prioritize proper stormwater management for the betterment of the Watershed’s water quality, and where appropriate, the BMPs within the SWMPs should be considered for funding under 319 dollars.

Readers should refer to SWMPs from individual municipal and county agencies to find activities beyond those specified within this WMP. SWMPs are available for the following municipal organizations in this Watershed: City of Dexter[5], Washtenaw County Water

Resources Commissioner[6], Washtenaw County Road Commission[7]. The City of Chelsea has elected to use the County's plan as their guidance.

Timeframe: 2022-2032
Milestones:

- 2026: Revise plans and resubmit for permits.
- Ongoing: Implement recommendations of each individual SWMP, including:
    - Upgrading aging parts and maintaining system components
    - Implementing GSI projects

*Cost: Permitting:*Development of SWMPs and permit applications: $25k. $50k total. Costs of Repairs to SW systems: Difficult to estimate. $10k - $100k annually, on average though years with major repairs or upgrades will exceed the average considerably. $1M - $10M total.

Potential funding sources: Primarily paid for with general funds, county budgets, stormwater utility funds, and agency budgets. Larger system upgrades should take advantage state and federal grant and low-interest loan programs like the state revolving fund. Municipalities without a stormwater utility should consider the cost of developing one against the cost of upgrading the system to maintain a satisfactory level of service.

Success Measures: Monitoring results, % of systems meeting satisfactory or equivalent ratings, # problems corrected, lbs of sediment cleared, wildlife accesses blocked (bacteria source)

B. Enforce rules, standards and ordinances for stormwater management

The Washtenaw County Water Resource Commissioner developed rules and engineering standards for new and re-development to help reduce pollutant concentrations and bacteria in surface water by preventing flooding, modulating flow, treating storm water, and discouraging geese by using native landscape buffers near waterways and ponds. WCWRC's program provides likely the greatest protection from stormwater impacts from new and re-construction projects across the state. The current standards and rules require infiltration of storms up to the bankfull event, in most cases, and controls flow to pre-development rates. All municipalities in the county have adopted stormwater ordinances which refer to these stormwater standards. WRC staff review development proposals to ensure they meet WRC standards. Projects that do not meet standards must be redesigned or adjusted in order to receive municipal building permits.

Timeframe: ongoing
Milestones: 2023, 2030: Report on standards outcomes
Cost: Not tracked specifically. Estimates are $400 - $4,000 per project, depending on complexity. Annual estimate: $100k - $500k. 10 years: $1M - $5M
Potential funding sources: Funded directly by WCWRC.
Success Measures: Reduced runoff compared to previous standards, monitoring (see chapter 5)

C. Natural Areas Protection.

Stakeholder partners, including municipalities and land conservancies throughout the Watershed, should pursue acquisition, conservation easements or otherwise preserve natural areas.

Through the use of HRWC's existing prioritization and the accomplishment of Recommendation S3 (field assessments and enhanced ranking system), high ranking natural areas should be permanently protected through acquisition and conservation easements.

Current land protection programs include the City of Ann Arbor's Greenbelt program, Scio, Webster, and Ann Arbor townships' land preservation programs, and Washtenaw County's Natural Areas Protection Program. These programs are funded through a land protection millage levied on property taxes. These kinds of protection programs should be implemented by all municipalities in the Watershed

Other protection funding includes Clean Water Act Section 319, State Revolving Loan Programs, Carbon off sets purchased by companies and municipalities with carbon neutrality goals, NRCS funding through their Regional Conservation Partnership Program, and foundations.

Conservation easements purchase can run from $5000 an acre to $15,000 an acre, depending on the location of the property and assessed value of the property.

Timeframe: 2022-2032
Milestones:

- By 2032: At least 1000 new acres of the highest priority natural areas in the Watershed is purchased or put into a conservation easement.

Cost: $5000- $15,000 an acre for easements; approximately $10M for 1000 acres.
Potential funding sources: see text above
Success Measures: # of acres protected

D. Implement infrastructure fixes on stream crossing structures

As discussed in 3.3.6, as we proceed into the future, infrastructure, bridges, pipelines, and other infrastructure that cross streams, will become increasingly vulnerable to scouring and erosion due to increasing storm size.[8] The Middle Huron Watershed includes many urbanized areas that have a significant number of intersections with aging infrastructure. These intersections may be a substantial risk factor for the river over decades without attention or intervention.

With the results from recommendation S4, and other preexisting knowledge and data, WCWRC and the Washtenaw County Road Commission should design, install/reinstall, and maintain stream crossing structures to provide for aquatic passage, habitat connectivity, and fluvial geomorphic functions, all within the lens of climate change effects.

Timeframe: 2022-32

Cost: $100k- $1M per road crossing depending on severity of fixes needed.
Success Measures: # of road crossing intersection fixes successfully implemented

E. Pet waste ordinance education and enforcement

Pet waste ordinance development was suggested as a River Friendly policy in recommendation PE3.

After such ordinances are passed, and in areas where the ordinance already exists, we recommend an educational campaign to educate the general public on the impacts of pet waste on surface water quality and the existing local regulations concerning pet waste. Efforts will work to increase public awareness of local pet waste ordinances and drive behaviors to reduce pet waste entering storm drains. In addition, HRWC will work with other watershed municipalities on the development, adoption and implementation of ordinances requiring the removal and proper disposal of pet waste with fines for infractions, through the sharing of educational materials.

Timeframe: 2022-2032
Milestones:

- 2022-23. Draft ordinance developed, revised and passed in Scio Township
- 2024. Education Materials distribution.
- 2025-2032. Ordinances in other municipalities enacted.
- 2026-2032. Follow-up education and surveys.

Cost: Elected official time in review and enactment: $15,000.
Potential funding sources: Section 319, local government match
Success Measures: Ordinance enactment, volume of calls about ordinance, ordinance enforcement rate, monitoring (see section 5).

F. Place doggie bag stations at target locations

Local municipalities and park systems, including the County, Townships, and HCMA should install pet waste stations at local parks, frequently recreated public areas, and other likely high-concentration areas to reduce bacteria contamination of stormwater. This should reduce pet waste in high traffic areas, subsequently reducing the amount of E. coli entering the watershed via pet waste. Local municipalities and homeowner associations to install pet waste stations, including free bags and trash receptacles, and ensure proper maintenance. Based off use of stations and feedback from station managers, the property owners should modify the placement of the stations or expand the network. This activity should be done in conjunction with activity E.

Timeframe: 2022-2032
Cost: 50 dog waste stations @ $150 ea.: $7,500; technical assistance, installation, maintenance labor: $20,000. Total: $27,500
Success measures: Number of stations installed, bag volume utilized, pounds of feces removed

G. Climate Action Planning

Chapter 3 describes the changes in climate already occurring and those to come, and the impact on all the sources of impairments addressed in this watershed management plan. Each municipality and resident in the Watershed must take action to reduce greenhouse gas emissions to the greatest extent possible and as quickly as possible, to avoid the most catastrophic impacts. Municipalities must act build to resilience against the inevitable increased flooding, extreme temperatures, habitat degradation, and other impacts the Watershed is already suffering.

The City of Ann Arbor has created an ambitious plan, A2Zero, for city operations and the entire community to reach carbon neutrality by 2030. Washtenaw County has pledged for its municipal operations to reach neutrality by 2030 and for community-wide neutrality by 2035. The county is creating its carbon neutrality plan currently. Other municipalities, businesses, institutions, and residents throughout the Watershed should engage with the county planning process and use the resulting climate action plan as a guide and resource to enact climate action policies.

Timeframe: 2022-2032
Cost: Highly variable depending on actions, $1M-$1B
Success Measures: municipalities creating climate action plans, enacting policies that will reduce community greenhouse gas emissions, enacting policies to increase climate resilience.

4.3. Impairment Loading Implications

4.3.1. Ford Lake and Belleville Lake Phosphorus Impairment

The TMDL for Ford Lake sets a maximum load goal for total phosphorus at 36,020 lbs/year entering the lake, not counting the internal lake load, or 36,500 lbs/yr with the internal load. The most recent loading analysis using river flow and monitoring data estimates, which account for source reduction activities up to the current date, estimates the current loading rate into Ford Lake is 37,384 lbs/yr. If all primary actions are within the more proximate Middle Huron River, Section 2[9] plan are fully implemented, HRWC estimates that an additional 3,241 lbs will be prevented annually from entering the lake, bringing the total phosphorus load to 34,143 lbs/yr. This load reduction would be more than sufficient to meet the TMDL load target. The further activities recommended in this upstream, Section 1 plan will provide a sufficient margin of safety, and the plan is thus quite conservative for addressing the phosphorus nutrient impairment. It may still require many years at these low loading levels for the internal load within the lakes to decrease significantly, and therefore reduce mean TP concentrations to water quality targets.

4.3.2 Honey Creek and Mill Creek Bacteria Impairment

As indicated in chapter 2, no specific loading targets were set for the *E. coli* TMDL since it is concentration based. It is quite difficult to estimate loading reductions for pathogen impairments. It also is not entirely appropriate to focus on load reductions since the impairment itself is based on point counts or concentrations. The focus is better placed on activities to reduce *E. coli* sources.

The E. coli TMDL Implementation Plan for Honey Creek was developed to establish an effective strategy to reduce potential sources through a set of implementation activities. Please refer to that plan found in Appendix B for more details on activities, impacts, schedules and cost estimates.

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[1]Michigan Department of Natural Resources. 2011. Great Lakes Road Stream Crossing Inventory. https://www.michigan.gov/documents/dnr/Great_Lakes_Road_Stream_Crossing_Inventory_Instructions_419327_7.pdf. Access June 2022.

[2] Huron River Watershed Council. 2014. Green Infrastructure Opportunities. https://www.hrwc.org/our-watershed/protection/surrounding-land/green-infrastructure/green-infrastructure-opps/

[3] Washtenaw County Water Resources Commissioner. Undated. Rain Gardens. https://www.washtenaw.org/647/Rain-Gardens.

[4] Washtenaw County Water Resources Commissioner. Undated. Green Infrastructure. https://gisappsecure.ewashtenaw.org/public/greeninfrastructure/.

[5] City of Dexter, 2022. Stormwater Management Plan, https://www.hrwc.org/wp-content/uploads/MH1-WMP-DexterDPW-SWPPP-Mester-draft-.pdf. Accessed June 2022

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Chapter 5: Evaluation and Conclusions

5.1 Evaluation Methods for Measuring Success

Objective markers or milestones will be used to track the progress and effectiveness of the Action Plan management practices in reducing pollutants to the maximum extent possible (see Table 4.2). Evaluating the management practices that are implemented helps establish a baseline against which future progress at reducing pollutants can be measured. The U.S. EPA identifies the following general categories for measuring progress:

1. **Tracking implementation over time.** Where a BMP is continually implemented over the permit term, a measurable goal can be developed to track how often, or where, this BMP is implemented.
2. **Measuring progress in implementing the BMP.** Some BMPs are developed over time, and a measurable goal can be used to track this progress until BMP implementation is completed.
3. **Tracking total numbers of BMPs implemented.** Measurable goals also can be used to track BMP implementation numerically, e.g., the number of wet detention basins in place or the number of people changing their behavior due to the receipt of educational materials.
4. **Tracking program/BMP effectiveness.** The goal of BMP effectiveness monitoring is to demonstrate if a specific BMP was successful in improving water quality in a specific location. Measurable goals can be developed to evaluate BMP effectiveness, for example, by evaluating a structural BMP's effectiveness at reducing pollutant loadings. A public education campaign's effectiveness can be measured with social indicators as from a Social Indicators Data Management and Analysis (SIDMA) survey which quantifiably addresses how the campaign reached the target audience. A measurable goal can also be a BMP design objective or a performance standard.
5. **Tracking environmental improvement.** The ultimate goal of the NPDES storm water program is environmental improvement, which can be a measurable goal. Achievement of environmental improvement can be assessed and documented by ascertaining whether state water quality standards are being met for the receiving water body or by tracking trends or improvements in water quality (chemical, physical, and biological) and other indicators, such as the hydrologic or habitat condition of the water body or watershed.

Although achievement of water quality standards is the goal of plan implementation, the Steering Committee members need to use other means to ascertain what effects individual and collective BMPs have on water quality and associated indicators. In-stream monitoring, such as physical, chemical, and biological monitoring, is ideal because it allows direct measurement of environmental improvements resulting from management efforts. Targeted monitoring to evaluate BMP-specific effectiveness is another option, whereas ambient monitoring can be used to determine overall program effectiveness. Alternatives to monitoring include using programmatic, social, physical, and hydrological indicators. Finally, environmental indicators can be used to quantify the effectiveness of BMPs.

Environmental indicators are relatively easy-to-measure surrogates that can be used to demonstrate the actual health of the environment based on the implementation of various programs or individual program elements. Some indicators are more useful than others in providing assessments of individual program areas or insight into overall program success. Useful indicators are often indirect or surrogate measurements where the presence of the indicator points to likelihood that the activity was successful. Indicators can be a cost-effective method of assessing the effectiveness of a program because direct measurements sometimes can be too costly or time-consuming to be practical. A well-known example is the use of fecal coliform bacteria as an indicator of the presence of human pathogens in drinking water. While *E. coli* is now the preferred indicator of bacterial contamination, fecal coliform has been successfully used for more than a century and is still in widespread use for the protection of public health from waterborne, disease-causing organisms.

Table 5.1 presents environmental indicators that have been developed specifically for assessing stormwater programs.[1] Water quality indicators 1 through 16—physical, hydrological, and biological indicators—can be integrated into an overall assessment of the program and used as a basis for the long-term evaluation of program success. Indicators 17 through 26 correspond more closely to the administrative and programmatic indicators and practice-specific indicators.

Table 5.1. Environmental Indicators for Assessing Project Success

Category	#	Indicator Name
Chemical Indicators This group of indicators measures specific water quality or chemistry parameters.	1	Water quality pollutant constituent monitoring
	2	Toxicity testing
	3	Loadings
	4	Exceedance frequencies of water quality standards
	5	Sediment contamination
	6	Human health criteria
Physical and Hydrological Indicators This group of indicators measures changes to or impacts on the physical environment.	7	Stream widening/downcutting (Hydromorphology)
	8	Erosion Rates (BANCs), Bank Erosion Hazard Index (BEHI)
	9	Instream habitat monitoring
	10	Impacted dry weather flows (Flashiness Index)
	11	Increased flooding frequency
	12	Percent impervious surface of watershed area
	13	Stream temperature monitoring
Biological Indicators	14	Fish assemblage

This group of indicators uses biological communities to measure changes to or impacts on biological parameters.	15	Macroinvertebrate assemblage
	16	Single species indicator
	17	Composite indicator
	18	Other biological indicators
Social Indicators This group of indicators uses responses to surveys, questionnaires, and the like to assess various parameters.	19	Public attitude surveys
	20	Public involvement and monitoring
	21	User perception
Programmatic Indicators This group of indicators quantifies various non-aquatic parameters for measuring program activities.	22	Number of illicit connections identified/corrected
	23	Number of BMPs installed, inspected and maintained
	24	Permitting and compliance
	25	Growth and development
Site Indicators This group of indicators assesses specific conditions at the site level.	26	BMP performance monitoring
	27	Industrial site compliance monitoring

Measurement and evaluation are important parts of planning because they can indicate whether or not efforts are successful, and they also provide a feedback loop for improving project implementation as new information is gathered. If the watershed partners are able to show results, then the plan likely will gain more support from the partnering communities and agencies, as well as local decision makers, and increase the likelihood of project sustainability and success. Monitoring and measuring progress in the watershed necessarily will be conducted at the local level by individual agencies and communities, as well as at the watershed level, in order to assess the ecological effects of the collective entity actions on the health of the Huron River and its tributaries in the Middle Huron Watershed.

Monitoring and measuring progress in the Watershed will be two-tiered. First, individual agencies and communities will monitor certain projects and programs on the agency and community levels to establish effectiveness. For example, a community-based lawn fertilizer education workshop will be assessed and evaluated by that community. Also, with the implementation of a community project such as the retrofitting of detention ponds, the individual community responsible for the implementation of that task may monitor water quality/quantity parameters before and after the retrofit in order to measure the improvements.

Secondly, there will be a need to monitor progress and effectiveness on a regional – subwatershed or watershed – level in order to assess the ecological effects of the collective community and agency actions on the health of the river and its tributaries.

The watershed partners recognize the importance of a long-term water quality, water quantity, social, hydromorphology, and biological monitoring programs to determine where to focus resources as they progress toward meeting collective goals. These parameters will reflect improvements on a regional scale. The monitoring program should be established on a watershed scale since this approach is the most cost effective and consistent if sampling is done by one entity for an entire region.

5.2 Qualitative Evaluation Techniques

As seen in the Action Plan presented in Chapter 4, there are and will be a range of programs and projects implemented—ranging from stream bank stabilization projects to public education—to improve water quality, water quantity and habitat in the Middle Huron Watershed, Section 1. Finding creative ways to measure the effectiveness of each of these individual programs is a challenge.

A set of qualitative evaluation criteria can be used to determine whether pollutant loading reductions are being achieved over time and whether substantial progress is being made toward attaining water quality standards in the Watershed. Conversely, the criteria can be used for determining whether the Plan needs to be revised at a future time in order to meet standards. A summary of the methods provides an indication of how these programs might be measured and monitored to evaluate success in both the short and the long term (Table 5.2).

Some of these evaluations may be implemented on a watershed basis, such as a public awareness survey to evaluate public education efforts, but most of these activities will be measured at the local level. By evaluating the effectiveness of these programs, communities and agencies will be better informed about public response and success of the programs, how to improve the programs, and which programs to continue. Although many of these methods of measuring progress are not direct measures of environmental impact, it is fair to assume that successful implementation of these actions and programs, collectively and over time, will have a positive impact on in-stream conditions.

Table 5.2. Summary of qualitative evaluation techniques for the Middle Huron Watershed

Evaluation Method	Program/Project	What is Measured	Pros and Cons	Implementation
Public Surveys	Public education or involvement program/project	Awareness; Knowledge; Behaviors; Attitudes; Concerns	Pro: Moderate cost. Con: Low response rate.	Pre- and post- surveys recommended. By mail, telephone, online, or group setting. Repetition on regular basis can show trends. Appropriate for local or watershed basis.
Written Evaluations	Public meeting or group education or involvement project	Awareness; Knowledge	Pro: Good response rate. Low cost. Con: No measure of change in behavior or retention of knowledge	Post-event participants complete brief evaluations that ask what was learned, what was missing, what could be done better. Evaluations completed on-site.
Stream Surveys	Identify riparian and aquatic improvements.	Habitat; Flow; Erosion; Recreation potential; Impacts	Pro: Current and first-hand information. Con: Time-consuming. Expertise and some cost involved.	Identify parameters to evaluate. Use form, such as Stream Crossing Inventory, to record observations. Summarize findings to identify sites needing observation.
Visual Documentation	Structural and vegetative BMP installations, retrofits	Aesthetics. Pre- and post- conditions.	Pro: Easy to implement. Low cost. Con: Can be subjective.	Provides visual evidence. Photographs can be used in public communication materials.
Phone call/ Complaint records	Education efforts, advertising of contact number for complaints/ concerns	Number and types of concerns of public. Location of problem areas.	Con: Subjective information from limited number of people.	Answer phone, letter, emails and track nature of calls and concerns.
Participation Tracking	Public involvement and education projects	Number of people participating. Geographic distribution of participants. Amount of waste collected, e.g. hazardous waste collection	Pro: Low cost. Easy to track and understand.	Track participation by counting people, materials collected and having sign-in/evaluation sheets.

Focus Groups	Information and education programs	Awareness; Knowledge; Perceptions; Behaviors	Pro: Instant identification of motivators and barriers to behavior change. Con: Medium to high cost and expertise to do well.	Select random sample of population as participants. 6-8 people per group. Plan questions, facilitate. Record and transcribe discussion. Analyze results.

Adapted from: Lower One SWAG, 2001

5.3 Quantitative Evaluation Techniques

In addition to measuring the effectiveness of certain specific programs and projects within communities or agencies, it is beneficial to monitor the long-term progress and effectiveness of the cumulative watershed efforts in terms of water quality, water quantity and biological health. Watershed-wide long-term monitoring will address many objectives established for the Middle Huron Watershed, Section 1, and monitoring also can show localized, small-scale success which are important for proving incremental improvement and morale boosts of partnerships. A monitoring program at the watershed level will require a regional perspective and county or state support. Wet and dry weather water quality, stream flow, biological and other monitoring will afford communities and agencies better decision-making abilities as implementation of this plan continues.

Parameters and Establishing Targets for River Monitoring
Beyond the data collected for the original Watershed Management Plan and its updates, it was recognized that there is a need to augment the type of parameters monitored, the number of locations in the watershed, and the frequency of wet weather monitoring. A holistic monitoring program has been established to help communities and agencies to identify more accurately water quality and water quantity impairments and their sources, as well as how these impairments are impacting the biological communities that serve as indicators of improvements.

HRWC Monitoring
The long-term monitoring program has been established so that progress can be measured over time. The program includes the following components:

- Stream flow monitoring to determine baseflows and track preservation and restoration activities upstream. Additionally, physical and hydrological indicators such as stream widening/downcutting, physical habitat, stream temperature, and a variety of geomorphology measures are collected at HRWC Adopt-a-Stream sites throughout the Watershed. Adopt-A-Stream began in 1992 and the Chemistry and Flow Program began in 2002. The BANCs assessment was conducted in 2021 and could be repeated again when this plan needs to be updated again.

- Wet and dry weather water quality data are being collected in the watershed to identify specific pollution source areas within the watershed, and measure impacts of preservation and restoration activities upstream. Included as water quality indicators are water quality pollutant monitoring and loadings. However, due to limited funding, only limited collection of this data has been performed. More regular collection of these parameters along with exceedence frequencies of water quality standards, sediment contamination, and human health criteria need to be added to complete the program.

- Biological monitoring of macroinvertebrates is conducted regularly at sites throughout the watershed. Additional monitoring of fish and mussels would improve the scope of biological knowledge. These indicators are used as measures of the potential quality and health of the stream ecosystem. Include as biological indicators: fish assemblage; macroinvertebrate assemblage; single species indicators; composite indicators; and other biological indicators.

- Identification of major riparian corridors and other natural areas is being conducted via HRWC's Natural Areas Program in order to plan for recreational opportunities, restoration, preservation, and linkages. The Natural Areas Program began in 2000.

- The monitoring within the watershed maximizes the use of volunteers to encourage involvement and stewardship.

The HRWC monitoring program currently includes measurement of Dissolved Oxygen (DO), Bacteria (*E. coli*), Phosphorus (P), total suspended solids (TSS), Nitrate-Nitrite, stream flow, conductivity, aquatic macroinvertebrates, temperature, physical habitat, and channel structure.

Establishing Targets

Measuring parameters to evaluate progress toward a goal requires the establishment of targets against which observed measurements are compared. These targets are not necessarily goals themselves, because some of them may not be obtainable realistically. However, the targets do define either Water Quality Standards, as set forth by the State of Michigan, or scientifically-supported numbers that suggest measurements for achieving water quality, water quantity and biological parameters to support state designated uses such as partial or total body contact, and fisheries and wildlife. Using these scientifically-based numbers as targets for success will assist the advisory bodies in deciding how to improve programs to reach both restoration and preservation goals and know when these goals have been achieved. These targets are described below.

Dissolved Oxygen: The Michigan Department of Environment, Great Lakes and Energy (EGLE) has established state standards for Dissolved Oxygen (DO). The requirement is no less than 5.0 mg/l as a daily average for all warm water fisheries. The Administrative Rules state:

> . . . for waters of the state designated for use for warmwater fish and other aquatic life, except for inland lakes as prescribed in R 323.1065, the dissolved oxygen shall not be lowered below a minimum of 4 milligrams per liter, or below 5 milligrams per liter as a daily average, at the design flow during the warm weather season in accordance with R 323.1090(3) and (4). At the design flows during other seasonal periods as provided in R 323.1090(4), a minimum of 5 milligrams per liter shall be maintained. At flows greater than the design flows, dissolved oxygen shall be higher than the respective minimum values specified in this subdivision.
>
> (Michigan State Legislature. 1999)

Bacteria: State standards are established for Bacteria (*E. coli*) by EGLE. For the designated use of total body contact (swimming), the state requires measurements of no more than 130 *E. coli* per 100 milliliters as a 30-day geometric mean during 5 or more sampling events representatively spread over a 30-day period. For partial body contact (wading, fishing, and canoeing) the state requires measurements of no more than 1000 *E. coli* per 100 milliliters based on the geometric mean of 3 or more samples, taken during the same sampling event. These uses and standards will be appropriate for and applied to the creek and those tributaries with a base flow of at least 2 cubic feet per second.

Phosphorus: State water quality standards for phosphorus require that "phosphorus which is or may readily become available as a plant nutrient shall be controlled from point source discharges to achieve 1 mg/l of total phosphorus as a maximum monthly average effluent concentration unless other limits, either higher or lower, are deemed necessary and appropriate." In the case of the Middle Huron Watershed, the Ford and Belleville Lakes TMDL defines effluent standards for point sources and establishes an environmental standard of 30 µg/L at Ford Lake and Belleville Lake (Appendix A). The State also requires that "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the waters of the state." Monitoring frequency and number of sites for phosphorus and nitrogen needs to be increased to capture seasonal variation and dry and wet weather conditions, and effectively estimate changes in loading of these nutrients.

Total Suspended Solids/Sediment: No numerical standard has been set by the state for Total Suspended Solids (TSS) for surface waters. However, the state requires that "the addition of any dissolved solids shall not exceed concentrations which are or may become injurious to any designated use." To protect the designated uses of fisheries and wildlife habitat, as well as the desired recreational and aesthetic uses of the surface waters in the watershed, there are recommended targets established on a scientific basis. From an aesthetics standpoint, it is recommended that TSS less than 25 mg/l is "good", TSS 25-80 mg/l is "fair" and TSS greater than 80 mg/l is "poor."[2] The TSS target, therefore, will be to maintain TSS below 80 mg/l in dry weather conditions. Another measurement that can be used to determine the impacts of sediment loading is to determine the extent of embeddedness of the substrate (how much of the stream bottom is covered with fine silts) and the bottom deposition (what percentage of the bottom is covered with soft muck, indicating deposition of fine silts). These are measurements taken by the Surface Water Assessment Section (SWAS) protocol habitat assessment conducted by EGLE every five years, and by HRWC more frequently. Rating categories are from "poor" to "excellent." The target should be to maintain SWAS "excellent" and "good" designations at sites where they currently exist, and to improve "fair" and "poor" sites to "good."

Stream Discharge: Stream flow, or discharge, for surface waters do not have a numerical standard set by the state. Using the health of the fish and macroinvertebrate communities as the ultimate indicators of stream and river health is most useful in assessing appropriate flow. That being said, EGLE recommends using the Richard-Baker Flashiness Index as a way of understanding flow and interpreting other data, such as watershed development trends, stream bank erosion rates, or biological survey data.[3]

Conductivity: Conductivity measures the amount of dissolved ions in the water column and is considered an indicator for the relative amount of some types of suspended material in the stream. The scientifically-established standard for conductivity in a healthy Michigan stream is

800 microSiemens (μS), which should be the goal for the Huron River and its tributaries.[4] Levels higher than the standard may indicate the presence of suspended materials from stormwater runoff, failing septics, illicit connections, ground water seeps or other sources.

Fisheries: Numerical or fish community standards have not been set by the state. However, EGLE has developed a system to estimate the health of the predicted fish communities through the SWAS 51 sampling protocol. This method collects fish at various sites and is based on whether or not certain expected fish species are present, as well as other habitat parameters; fish communities are assessed as poor, fair, good, or excellent. The state conducts this protocol every five years in the Huron River Watershed. The target should be to maintain SWAS 51 scores of "excellent" and "good" at sites where they currently exist, and to improve "fair" and "poor" sites to "good." The SWAS 51 protocol also identifies whether or not there are sensitive species present in the Huron River and its tributaries, which would indicate a healthy ecosystem. Certain species are especially useful for demonstrating improving conditions. These species tend to be sensitive to turbidity, prefer cleaner, cooler water, and their distribution in the Huron Watershed is currently limited. The target is to continue to find species currently found in self-sustaining population numbers, at a minimum. Improvements in habitat and water quality should also result in the expansion or recruitment of additional species. In addition to EGLE, The DNR Fisheries Division also does fisheries assessments on both lakes and streams.

Benthic Macroinvertebrates: Similar to the assessment of fish communities, the state employs the SWAS protocol for assessing macroinvertebrate communities on a five-year cycle for the Huron River Watershed. HRWC monitors macroinvertebrate health and physical habitat at sites in the Watershed using a volunteer friendly adaptation of the SWAS procedure. The sites are monitored for macroinvertebrates two or three times each year and periodically for physical habitat health. The monitoring target for macroinvertebrate communities will be to increase scores of EGLE and HRWC monitoring to improve "poor" and "fair" communities to "good" while maintaining the "good" and "excellent" conditions at the remaining sites.

Temperature: The state lists temperature standards only for point source discharges and mixing zones – not ambient water temperatures in surface water. However, recommendations for water temperature can be generated by assessing fish species' tolerance to temperature change and these guidelines are found within the statute. Although some temperature data have been collected in the Middle Huron system by the HRWC program and as part of the monitoring for the Middle Huron Partnership Initiative, additional studies are needed to establish average monthly temperatures and whether increased temperatures are limiting biota habitat.

Wetlands: An annual review should be done of EGLE wetland permit information and local records in order to track wetland fills, mitigations, restoration and protection to establish net loss or gain in wetlands in the watershed. The Landscape Level Wetland Functional Assessment (LLWFA), which will hopefully be conducted per the recommendation 1B in Chapter 4, should assist with tracking. The target for this parameter is to track the net acres of wetland in the watershed to determine action for further protection or restoration activities. In addition, the Natural Areas Program evaluates small, non-regulated wetlands. Once identified, these should also be tracked as above.

Reporting: Details regarding responsible parties, monitoring standards, sampling sites, and frequency of monitoring for qualitative and quantitative evaluation techniques need to be periodically reviewed by the Middle Huron Partners and subwatershed groups. Results from monitoring and progress evaluation are reported through a variety of mechanisms. The Middle Huron Partnership Initiative reports on progress toward the Ford and Belleville Lakes TMDL every two years, on average. Many of the communities and other responsible agencies in the Middle Huron submit periodic reports (approximately every 2 years) as part of Phase II stormwater compliance. HRWC produces a summary of results on the Adopt-a-Stream and Chemistry/Flow program once per year.

5.4 Evaluation Monitoring for the Middle Huron Watershed

Based on an evaluation of the above information, the goals and objectives of this plan, and the causes and sources of water quality impairments in critical areas, the monitoring plan detailed in Table 5.3 has been established. This plan is contingent upon funding and participation of community partners and monitoring agencies.

The monitoring plan is based around programs administered by HRWC and EGLE.

First, through its Adopt-a-Stream/BioMonitoring program, HRWC collects data on benthic macroinvertebrates three times a year, including a special collection of winter stoneflies. HRWC also samples for water conductivity at each macroinvertebrate event. HRWC also does a complete stream habitat assessment of each site every 4-5 years, which includes a number of geomorphic characteristics along with general habitat characteristics. Summer temperatures are also documented every 5 years. HRWC uses volunteers to collect the vast majority of the data. Results from this program are included in section 2.4.

HRWC also administers the Chemistry/Flow Program on behalf of the Middle Huron Partnership. HRWC uses volunteers and staff to collect water samples and deliver to the Ann Arbor Water Treatment Plant for analysis. Analytes include total phosphorus, nitrates, nitrites, total suspended solids and *E. coli*. Volunteers also collect stream discharge data from all sites to allow for the calculation of pollutant loads. Currently, data is collected once or twice per month (depending on site) with additional storm event and high flow samples collected opportunistically during the April to September growing season.

EGLE conducts rotational watershed assessments every five years to collect benthic macroinvertebrates, habitat assessment data and, in some cases, a suite of water chemistry parameters. Site selection varies each year. EGLE most recently sampled in 2017 with the next rotation set for 2022. Specific locations and data can be found online: https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-32369--,00.html

EGLE welcomes suggestions for monitoring site outside of the basin year through our targeted monitoring process if there is a specific need identified.

Table 5.3 HRWC Middle Huron River (Section 1) Watershed Monitoring and Evaluation

See Figure 2.20, for locations

Monitoring Site[1]	Parameter Target	Type of Analysis	Protocol	Frequency	Test Agent
Huron River A62, A22, A26	*T, I, Bio, S* [2]	Stream Habitat Assessment	HRWC Protocol,	3- 5 yr interval	HRWC
		Temperature	Multi-Meter	3-5 yr interval	HRWC
Boyden Creek A2 *Honey Creek* A20, A18		Benthic Macroinvertebrates	HRWC Protocol	2-3x/year	HRWC
Mill Creek A31, A33, A34, A55, A57 A79, A80, A96		Conductivity	Multi-Meter	2-3x/year	HRWC

Monitoring Site	Parameter Target	Type of Analysis	Protocol	Frequency	Test Agent
Chem/Flow sites [1]					
Huron River MH01, HR05, HR12	S,N,DO,T,I, B [2]	Stream Habitat Assessment	HRWC Protocol	3- 5 yr interval	HRWC,
		Total Suspended Solids	SM20 2540 D[3]	2x/Mo Apr-Sept	HRWC
		Total Phosphorus, Nitrates, Nitrites	SM20 4500	2x/Mo Apr-Sept	HRWC;
Boyden Creek BC01, BC02, BC03, BC04, BC05		Temp, DO, pH, Conductivity	Multi-Meter	2x/Mo Apr-Sept	HRWC
Honey Creek MH03, HC01, HC14, HC15		E. coli	SM20 9213 D	2x/Mo Apr-Sept	HRWC
Mill Creek Mill01 – Mill14, MH02A, MH02B					

[1] A = HRWC Adopt-a-Stream; MHP = Middle Huron Partners tributary nutrient monitoring conducted by HRWC

[2] S= Sediment; N= Nutrients; DO= Dissolved Oxygen; T= Temperature; I= Ions; B= Bacteria; Bio= Biota

[3] Analytical protocols follow "Standard Methods for the Examination of Water and Wastewater", 20th edition, by the American Waterworks Association

5.5 Parting Words

The Middle Huron River Watershed Management Plan: Section 1 was created to provide a strong foundation and framework for improving water quality in the Middle Huron Watershed and protecting its valuable natural resources for future generations. The authors hope that choosing a consensus-based approach to developing the Plan will pay off in the form of a strong sense of ownership and unanimous support for the Plan in the years to come.

The task ahead—continued implementation of this watershed management plan—demands patience, persistence, determination, and cooperation of many partners and stakeholders at all levels. No matter how much effort and dedication was put into the Plan, it is of little value if the Plan itself remains the primary end-point. Fortunately, the partners who contributed to the Plan over the past nearly three decades have been implementing many of its remedial activities, started many ongoing programs, and plan to do much more. The partners have put in a great effort to date and progress is obvious.

For this 2022 update, the plan partners were invited to submit the accomplishments and strides they have taken to achieve better water quality throughout the Watershed since the writing of the 2009 Watershed Management Plan. The City of Dexter, Dexter Township, Webster Township, Scio Township, the Huron Clinton Metropark Authority, and the Washtenaw County Water Resources Commission each responded with an extensive though not exhaustive list of accomplishments (Appendix K). Each one of these accomplishments could itself be a long report or story and show the commitment of these municipalities to water quality and the environment.

Yet our concerted efforts can't slack or wane. This 2022 Watershed Management Plan provides plenty more possibilities to continue efforts toward water quality, reduced erosion, and better habitat. Each community in the watershed continues to have a choice. It can regard the Plan as merely another plan required for state funding or regulation and move on to the next requirement, or it can use the Plan as it is intended: to guide each community not only in fulfilling its own requirements, but also in partnering with other stakeholders throughout the watershed to protect the land and water that connects us all.

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