Norton Creek Watershed Management Plan

2018 — 2022

For the purpose of achieving the Total Maximum Daily Load (TMDL) and removing the dissolved oxygen and sedimentation/siltation impairment of Norton Creek

February 2018

Developed by the Huron River Watershed Council.

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Huron River Watershed Council

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Table of Contents

1. Introduction and Background

Norton Creek (HUC: 04090005-0103) is a small warm water creek located within Oakland County in southeast Michigan. As part of the Kent Lake sub-watershed, this creek is one of several tributaries to the Huron River. [1] The following document is intended to serve as a Watershed Management Plan for Norton Creek. It is designed, in part, in response to the 2009 Total Maximum Daily Load (TMDL) developed by the Michigan Department of Environmental Quality (MDEQ) in order to address persistent low dissolved oxygen concentrations, and high siltation levels. This plan meets the EPA's nine elements for a watershed management plan, as required for approval by the MDEQ.

Several studies throughout the last 20 years have found Norton Creek persistently low in dissolved oxygen (DO) and high in sediment and siltation, both of which lead to poor habitat quality for aquatic life. State water quality standards (WQS) mandate a minimum DO concentration of 5 mg/L for all state waters, but data reveals consistent non-attainment of this standard in Norton Creek. Consequently, the Michigan Department of Environmental Quality (MDEQ) listed Norton Creek as an impaired water body because it did not fulfill three of its designated uses as 1) a warm water fishery, 2) a viable habitat for other indigenous aquatic life and wildlife, and 3) a source of fish for human consumption.

Portions of the Clean Water Act (CWA) and United States Environmental Protection Agency (EPA) regulations require states to establish pollutant loading limits for waterbodies not meeting WQS, and so, in 2009, MDEQ published a Total Maximum Daily Load (TMDL) for Norton Creek, identifying sediment oxygen demand (SOD) as the primary cause for low DO and calling for an 84% reduction in sediment loads along a three mile segment of the creek (Figure 1). This reduction in sediment loads is expected to help the creek achieve DO WQS and improve habitat conditions for native aquatic life. The presence of polychlorinated biphenyls (PCBs) in the water column and high levels of total dissolved solids (TDS) were also both mentioned as possible causes of impairments to fish consumption, and other indigenous aquatic life respectively, but these conditions were not addressed by the 2009 TMDL and, consequently, await the development of their own TMDLs.[2]

Historically, the entire Upper Huron has struggled with high levels of sediment and nutrients. In 2000, the Huron River Watershed Council (HRWC) collaborated with partners and communities to publish the Kent Lake Sub-watershed Management Plan to address high phosphorous and siltation conditions. This earlier plan identified Norton Creekshed as a priority area requiring further attention. A more detailed watershed plan is needed to address impairments specific to Norton Creek. This document fills that need and sets the groundwork to rehabilitate the stream and the framework to establish future protections.

Figure 1: Three mile segment of Norton Creek with associated TMDL for sediment. Image courtesy of DEQ.

1.1 The Huron River and the Upper Huron

Flowing a total of 136 miles, the Huron River (HR) originates just north of Indian Springs Metropark. From these headwaters, the main stem meanders through a complex series of wetlands and lakes in a southwesterly fashion to the area of Portage Lake. Here, the river begins to flow south until reaching the Village of Dexter in Washtenaw County, where it redirects southeast through Ann Arbor and Ypsilanti and proceeds to its final destination of Lake Erie; its confluence just south of Detroit. En route, it provides drinking water for 150,000 residents throughout its 900 square mile watershed (Figure 2). [3]

The Huron River is a Michigan gem; a unique and valuable resource in southeast Michigan that contains ten Metroparks, two-thirds of all southeast Michigan's public recreational lands, and multiple county and city parks.[4] Indeed, much of the HR between Kent Lake, near Brighton, and Barton Pond, north of Ann Arbor, has enjoyed designation as a "Country Scenic Natural River" since 1979 thanks to the Michigan Natural Rivers Act. This protective designation helps the Huron to maintain not only its natural look, but also its ecological health, leading to a collection of community benefits including improved habitat for fisheries and wildlife, floodplain management, stream bank stabilization, erosion control, and enhanced recreation and aesthetic enjoyment. This 27-mile stretch of the Huron River (representing Southeast

Michigan's only such designation)[5] contributes to the "up north" feel of the Huron River and provides unique access to the wild beauty of southeast Michigan for anglers and paddlers alike.

The Huron River does not flow free, however. It is dammed 98 times, 17 of which are on the main stem. [6] Private citizens as well as local, state, and federal governments own these barriers which serve numerous purposes ranging from hydroelectric power generation to recreational and waterfront housing enhancement[7]

The Upper Huron (UH), a segment that includes the headwaters down through the Kent Lake impoundment in the Kensington Metropark, comprises a 556 square mile (100,000 acres) sub-watershed known as the Kent Lake sub-watershed. This portion contains nearly 700 individual lakes comprising approximately 9,000 acres, and numerous acres of wetlands providing water quality and aesthetic value. The vast majority of the sub-watershed lies within Oakland County and comprises all or portions of eight municipalities and five cities or villages which make up approximately 37,000 acres of built land. Included in the sub-watershed are two metroparks and four state recreation areas, along with numerous county, city, and village parks, totaling roughly 22,000 acres of publicly owned land. The exceptional ecological value of a portion of this area is such that The Nature Conservancy has deemed it "Globally Significant."[8]

In past years, the Kent Lake sub-watershed and the Huron River Watershed as a whole experienced amplified developmental pressures from a flourishing economy and urban flight. While the rapid population growth has since eased, Oakland County continues to experience some development pressures. According to the Southeast Michigan Council of Governments (SEMCOG), the population of Oakland County increased 11% from 1,083,592 to 1,202,362 individuals from 1990 to 2010. Projections to 2030 estimate a further 2% increase in population from 2010 levels, or an additional 28,393 individuals. The projected increase in development and corresponding hard (impervious) surfaces combined with the previous loss of intact natural spaces is of particular concern since these areas are significant contributors of nonpoint source pollution (NPS).[9] These concerns led to the development of the Kent Lake Sub-watershed Management Plan (KLSMP) in 2000 to address high phosphorous and sediment pollution in the lakeshed and to mitigate these development pressures.

Figure 2: Huron river watershed boundary and river course. Yellow shape denotes location of Norton Creekshed

1.2 The Kent Lake Sub-watershed Management Plan

1.2.1 Background

The Kent Lake Sub-watershed Management Plan (KLSMP) was originally drafted in 2000 by a working group and approved in August 2002 by the MDEQ. The main goal of the KLSMP was to set forth a comprehensive, long-term effort to restore and protect the water quality of the Upper Huron area with the goal of attaining the requirements of the Kent Lake Total Phosphorus TMDL written by MDEQ and approved by USEPA in March 2000.[10] Moreover, the sub-watershed contains numerous communities who were required to obtain a state or federal permit for stormwater runoff under the National Pollutant Discharge Elimination System (NPDES) Phase II program. The KLSMP established a protocol to help those communities meet the minimum requirements of the permit program.

1.2.2 Goals of Sub-watershed

The KLSMP prioritized goals for the region that would lead to improved water quality conditions. Those that are most pertinent to the Norton Creekshed include the following; [11]

- Promote community land use planning and design standards,
- Protect open spaces and intact natural areas,
- Reduce nonpoint source loading,
- Increase public awareness and involvement, and
- Continue monitoring and data collection for water quality.

Notably, Norton Creek was identified as a priority creekshed within the plan indicating it was recognized as either a site of significant pollutant loading or a site where deployment of restoration and protection techniques would theoretically achieve maximum benefits.[12]

1.2.3 Action Plan

The action plan for KLSMP highlighted both structural and non-structural best management practices (BMPs) that would prevent nutrients, pollutants, and other sediment from entering stormwater runoff or that would reduce the volume of stormwater requiring management. The recommended sequence of the implementation of structural or non-structural BMPs was based on several considerations including fiscal constraints, potential effectiveness, degree of difficulty or planning required, community acceptability, political realities, and ecological factors.

Since it was meant to be an umbrella plan for several creeksheds, the KLSMP presented a broad range of BMPs and general information about their application. The recommended actions most pertinent to Norton Creek fall under the following categories: [13]

- Stormwater BMP retrofitting and construction;
- Streambank and stream restoration techniques,
- Public information and education;
- Revision of community master plans; and
- Adoption of low impact design principles and local stormwater ordinances.

1.2.4 Implementation

The KLSMP called for the creation of a Huron Headwaters Steering Committee (Committee), and associated Task Force subgroups, to provide sustainability towards plan implementation, coordination, evaluation, and amendment. The Committee was to be coordinated and managed by the Huron River Watershed Council (HRWC). [14] Following a number of changes in Michigan's stormwater program, however, several municipalities withdrew from the watershed planning process and the Committee has since only met infrequently. The last meeting was March 12, 2013, and municipalities covered by stormwater regulations in the subwatershed are now mostly implementing stormwater management plans by individual jurisdiction.

The KLSMP employed comprehensive, long-term efforts geared towards control of stormwater runoff through BMPs, conservation planning and standards adoption, and education and stewardship. Such efforts were expected to be conducted within each creekshed of the Kent Lake drainage basin, including Norton Creek.[15] The development of this Norton Creek Watershed Management Plan, therefore, is in part an effort to update and implement recommendations from the KLSMP for one of its most critical catchments.

1.3 Intent and Organization of the Norton Creek Watershed Management Plan

This watershed management plan provides a comprehensive evaluation of Norton Creek and its watershed, with an emphasis on water quality and aquatic habitat. This first chapter provided an overview of the context in which Norton Creek is placed, and what has led up to this plan. Chapter 2 provides a comprehensive review and evaluation of the watershed characteristics and conditions from geography to government. Following the theme of the plan, the chapter focuses most of the discussion on factors contributing to water quality and aquatic habitat. It presents a summary of all data collected about the watershed. Chapter 3 outlines the critical problems in the watershed, with a focus on water quality and biological impairments. Each impairment is evaluated for its sources and causes. Chapter 4 outlines the overall five-year strategy and provides an action plan for remediating or addressing the impairments identified in the previous chapter. Specific recommendations are made, along with implementation characteristics. Finally, chapter 5 presents a plan for accountability, evaluation, and revision.

Chapter 1 References and Endnotes

[1] Kent Lake Watershed Management Plan (WMP) (vii)
[2] http://iaspub.epa.gov/tmdl_waters10/attains_waterbody.control?p_list_id=&p_au_id=MI040900050103-04&p_cycle=2010&p_state=MI
[3] Honey Creek WMP(5)
[4] Kent Lake WMP (7)
[5] Honey Creek WMP(5)
[6] Honey Creek WMP(5)
[7] Kent Lake WMP (7)
[8] Kent Lake WMP (vii)
[9] http://semcog.org/Data-and-Maps/Community-Profiles
[10] Norton Creek TMDL (17)
[11] Kent Lake WMP (59-60)
[12] Kent Lake WMP (54)
[13] Kent Lake WMP (90)
[14] Kent Lake WMP (87)
[15] Norton Creek TMDL (17)

2. Watershed Characterization and Conditions

2.1 Geography and History

As part of the Kent Lake sub-watershed, Norton Creek is one of several tributaries to the Huron River. Extending about 8 miles from its source just south of the city of Wixom, to its confluence with the Huron River, this creek drains 24.2 square miles of surface land and crosses portions of Commerce, Lyon and Milford Townships, the cities of Novi, Walled Lake, and Wixom, and the Village of Wolverine Lake.

Norton Creek originates just south of Interstate 96 in the town of Wixom, MI and travels northeast through Lyon Oaks County Park and past a retired Ford Motors assembly plant. Between W. Pontiac Trail and W. Maple Road, it shifts direction and generally flows northwest through Proud Lake State Recreation Area in Milford Township and into the Huron River (Figure 1).

The creek has 110 miles of branching stream channels, and it drains just over 24 square miles of land. From the highest headwater to the mouth, the creek's elevation drops 115 feet. The average slope is 17.5 feet per mile, which is on par for the Huron River as a whole. Portions of the creek range in flow, but there are few if any notable rapids and it is predominantly a slow flowing creek that hosts a number of branching channels traveling through swamp wetlands with deep silt. Additionally, to accommodate rapid urbanization, much of Norton Creek underwent significant channelization in the 1980s and thus appears unnaturally straight in several segments; most notably the reach from Wixom Habitat to Proud Lake.[1]

The creekshed holds 61 ponds (those with a surface area less than 10 acres), and 8 lakes (those with a surface area greater than 10 acres). The biggest, Wolverine Lake, is 286 acres, and was artificially constructed in the 1920s through a private damming and inundation project that raised the water level eight feet and united six small lakes and several marshes.[2] This damming project had a significant impact on the natural hydrology of the creekshed and raised the ground water table around the lake.[3] It also created a malleable creekshed boundary in which Wolverine Lake only flows into Norton Creek under particular lake level and wind conditions.[4] As a representative from the Oakland County Water Resources Board explains;

> "Under normal conditions when both Twin Suns and Wolverine Lake are at the same level, Twin Suns and [the] wetlands west of Benstein Rd. flow [west] to Loon Lake and Norton Creek, and Wolverine Lake east of Benstein Rd. flows [northeast] over the spillway at Glengary Rd. to South Commerce Lake in the mainstem of the Huron River. However, if the conditions are right, flow can go in both directions from Wolverine Lake to Twin Suns and from Twin Suns to Wolverine Lake. Particularly after a large rain event, when Wolverine levels are high and Twin Suns Lake levels are low, flow from Wolverine Lake can go west [into] Twin Suns. Since Wolverine Lake has 3 augmentation wells, they installed a weir on the east side of Bentsein Rd. to try and prevent this westward flow

from happening when the augmentation wells were running. Also, both Wolverine and Twin Suns are affected by wind patterns. Depending on the direction and intensity, flow can be directed into or out of the culverts under Benstein Rd."[5]

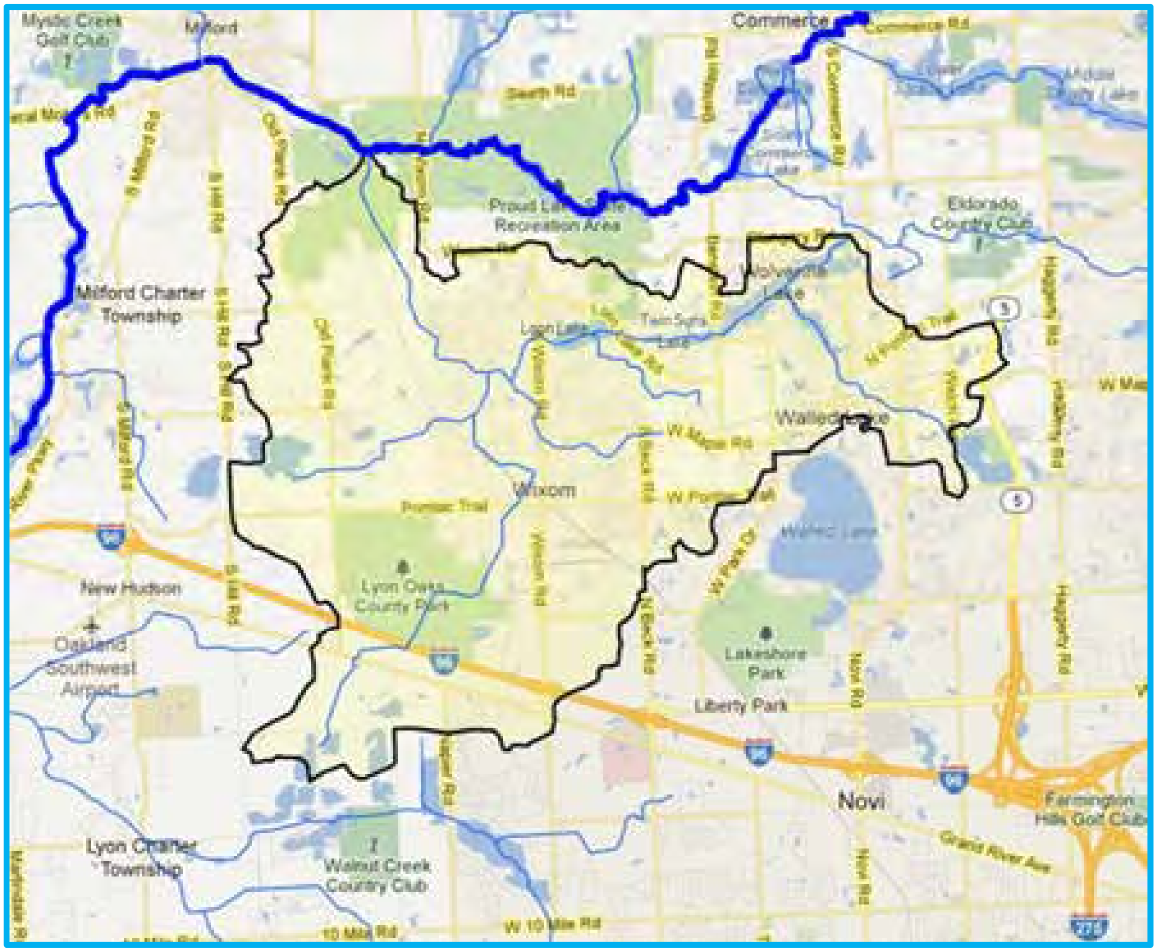

Figure 1: Norton Creekshed boundary. Note that creek flows north and converges with the mainstem of the Huron River in Proud Lake State Recreation Area.

2.2 Climate Summary

An analysis of the historical climatic record for the area reveals how climate change is already impacting the watershed. The past 30 years are characterized by more intense and frequent storms, changing precipitation patterns and rising air temperatures[6,7].

2.2.1 Historical

Annual rainfall has increased by 15% with the largest increases in fall and spring rainfall. A recent revision of precipitation frequency estimates by NOAA revealed that more precipitation is falling during a given storm event for much of the Great Lakes region. For example, the 1% chance, 24-hour storm event in Milford, a city near the project location, increased from 4.36" to 4.87"; a 10 % increase (Table 1). Air temperatures have also increased. Historical records show an average annual increase of 2.3 degrees Fahrenheit in southeast Michigan. The greatest increases have been in winter and spring temperatures[8].

Table 1. A comparison of precipitation volumes in inches between Bulletin 71[9] and Atlas 14[10] (Bulletin 71/Atlas 14) along with percent change between the two in brackets.

	1-Yr	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
1-hr	0.88/0.98 [11%]	1.06/1.16 [9%]	1.29/1.46 [12%]	1.47/1.73 [15%]	1.69/2.12 [20%]	1.87/2.43 [23%]	2.05/2.76 [9%]
12-hr	1.63/1.86 [12%]	1.97/2.11 [7%]	2.39/2.57 [7%]	2.72/3.0 [9%]	3.13/3.66 [14%]	3.46/4.24 [18%]	3.79/4.87 [22%]
24-hr	1.87/2.12 [12%]	2.26/2.39 [5%]	2.75/2.89 [8%]	3.13/3.35 [7%]	3.60/4.06 [11%]	3.98/4.67 [15%]	4.36/4.87 [10%]

Bulletin 71 is the resource used to design existing infrastructure and reflect an analysis of rainfall data collected through 1986. NOAA Atlas 14 is a re-analysis of precipitation data that incorporates an additional 24 years of data (1987-2011). This data shows how typical "design" storms have changed over time. Atlas 14 data drawn from the GM Proving Grounds data station in Milford, MI. Please note: this table does not show projections for how the design storm may change in the future due to climate change rather reflects what has changed already.

2.2.2 Future Projections[a]

Climate models are used to make projections about how climate is likely to change in the future. Average temperatures in the area are projected to increase 3.0 to 7.0°F by mid-century under a business as usual (i.e., high emissions) scenario and 5 – 11°F by end of the century. The area may experience up to 12 to 36 more days over 90°F by mid-century and fewer cold days. Average precipitation in the area is projected to increase by 2 to 4 inches by mid-century compared to current trends. 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. 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.

[a] All climate data shared in this section was provided by Great Lakes Integrated Sciences and Assessment (GLISA) team at the University of Michigan.

Table 2. Historical and future projected temperature and precipitation for southeast Michigan. Data provided in this table comes from CMIP[b], GHCN[c] and Dynamical Downscaling for the Midwest and Great Lakes basin[d].

	Historic (1951-2014)	Mid-Century Projections (High Emissions)	End of Century Projections (High Emissions)	Change Mid-century/End of century	Percent Change* Mid-century/End of century
Average Temperature	49.8°F	52.8 to 56.8°F	54.8 to 60.8°F	3 to 7°F / 5 to 11°F	6 to 14% / 10 to 22%
Winter (1981-2010)	27.1°F	28.1 to 32.1°F	30.1 to 36.1°F	1 to 5°F / 3 to 9°F	4 to 19% / 11 to 33%
Spring (1981-2010)	48.4°F	49.4 to 55.4°F	51.4 to 59.4°F	1 to 7°F / 3 to 11°F	2 to15% / 6 to 23%
Summer (1981-2010)	71°F	74 to 78°F	78 to 82°F	3 to 7°F / 7 to 11°F	4 to 10% / 10 to 16%
Fall (1981-2010)	52.2°F	55.2 to 59.2°F	59.2 to 63.2°F	3 to 7°F / 7 to 11°F	6 to 13% / 13 to 21%
Average Low Temperature	40.4°F	41.4 to 47.4°F	45.4 to 51.4°F	1 to 7ºF / 5 to 11°F	3 to 17% / 12 to 27%
Average High Temperature	59.1°F	62.1 to 66.1°F	64.1 to 70.1°F	3 to 7°F / 5 to 11°F	5 to 12% / 9 to 19%
Days/Year Greater than 90°F	8 Days	20 to 44 Days	44 to 50 Days	12 to 36 Days/ 36 to 42 Days	150 to 450% / 450 to 525%
Days/Year Greater than 95°F	2 to 4 Days	6 to 20 Days	Not Available	4 to 16	200 to 400%
Days/Year Less than 32°F	122 Days	95 to 99 Days	Not Available	-27 to -23	-22 to -19%
Total Annual Precipitation	36.7 in.	38.7 to 40.7 in.	35.7 to 33.7 in.	2 to 4 in. / -1 to 7 in.	5 to 11% / -3 to 19%
Winter (1981-2010)	7.9 in.	6.9 to 10.9 in.	5.9 to 10.9 in.	-1 to 3 in. / -2 to 3 in.	-13 to 38% / -25 to 38%
Spring (1981-2010)	9.3 in.	8.3 to 12.3 in.	8.3 to 13.1 in	-1 to 3 in. / -1 to 4 in.	-11 to 32% / -11 to 43%
Summer (1981-2010)	11 in.	9 to 16 in.	8 to 14 in.	-2 to 5 in. / -3 to 3 in.	-18 to 46% / -27 to 27%
Fall (1981-2010)	9.4 in.	9.4 to 10.4 in.	8.4 to 12.4 in.	+0 to 1 in. / -1 to 3 in.	0 to 11%/ -11 to 32%

[b] Coupled Model Intercomparison Project (CMIP) Version 3. The future (mid-century) climate projections for Ann Arbor are based on the Coupled Model Intercomparison Project Version 3 (CMIP3) A2 emissions scenario, representing "business as usual" high emissions scenario. These data were selected because they were used in the Third National Climate Assessment (Melillo et. al., 2014).
[c] National Oceanic and Atmospheric Administration National Centers for Environmental Information Global Historical Climatology Network Station Observations (GHCN). More information about this station located in Ann Arbor, MI from 1981-2010 is available at: https://glisa.umich.edu/station/c00200230
[d] Future projections are based on the dynamically downscaled data set for the Great Lakes region developed by experts at the University of Wisconsin-Madison. There are a total of six downscaled models that represent how a variety of different variables are projected to change (mid-century, 2040-2059, compared to the recent past, 1980-1999). The ranges are comprised of the lowest and highest values from all six dynamically downscaled data sets.

Heavy Precipitation Days(>1.25")	3.7 Days/Year	4.1 to 6.5 Days/Year	6.1 to 6.5 Days/Year	0.4 to 2.8 Day/Year / 2.4 to 2.8 Days/Year	11 to 76%/ 65 to 76%

*Percent change is calculated as the difference between the projected values and the historic average, divided by the observation and multiplied by 100.

2.2.3 Climate impacts on aquatic systems

Changing thermal and precipitation regimes will push aquatic ecosystems to extremes outside of those in which they evolved. The hydrologic regime is a master variable defining river systems and the biological community that inhabits the system[11]. The timing, duration, frequency and magnitude of channel defining flows are subject to change as storms become more extreme and rainfall patterns experience seasonal shifts[12]. Increasing air temperature result in warmer water temperature which will tax native species[13]. Also, the rate of change and the interactions between temperature and precipitation have implications for river ecosystems. For example, fewer days below freezing, less precipitation falling as snow[14], and an earlier onset of spring streamflows[15] lead to deviations from the natural hydrology of the river with potential consequences for aquatic organisms and ecosystem function[16].

In an urban setting, these climate impacts are exacerbated as runoff and air temperatures are likely already influenced by impervious cover and the clearing of forest canopy that leads to heat islands. For Norton Creek to function as a healthy urban river in a changing climate, stormwater runoff must be managed to promote infiltration to groundwater, filter pollutants associated with urban runoff, and slow water movement to the channel in a way that maintains the hydrology of the system within the natural range of variation. The channel in turn must be able to attenuate flood floods, provide refugia to species during extreme events and promote natural physical and chemical processes essential to maintain a healthy ecosystem.

2.2.4 Climate Vulnerability

In a climate justice analysis of the Huron River watershed[17], a Flood Hazard Index was developed to explore the sensitivity of creeksheds within the Huron River watershed to flooding. Across scenarios of increasing temperature and precipitation, Norton Creek consistently ranked highly sensitive to climate change. Figure 2 shows the results of the analysis within the Huron River watershed for two of the six different temperature/ precipitation scenarios examined. The Flood Hazard Index increased from baseline conditions even when precipitation increases were smaller and temperature increases were greater (2 degree Celsius increase in temperature, 10% increase in precipitation) indicating that Norton Creek is highly sensitive to climate change-induced flooding hazards. While global models vary for this area, this scenario most closely reflects predictions for a number of global climate models[18].

Further, Norton Creek ranked high across all vulnerability and risk indices (Figure 3). The communities within Norton Creek are expected to experience more frequent flooding and exposure to polluted runoff. Many of these communities are considered socially vulnerable.

Supporting adaptation work in this catchment will not only build resilience in the river system but also among citizens that may be the least able to recover from climate impacts.

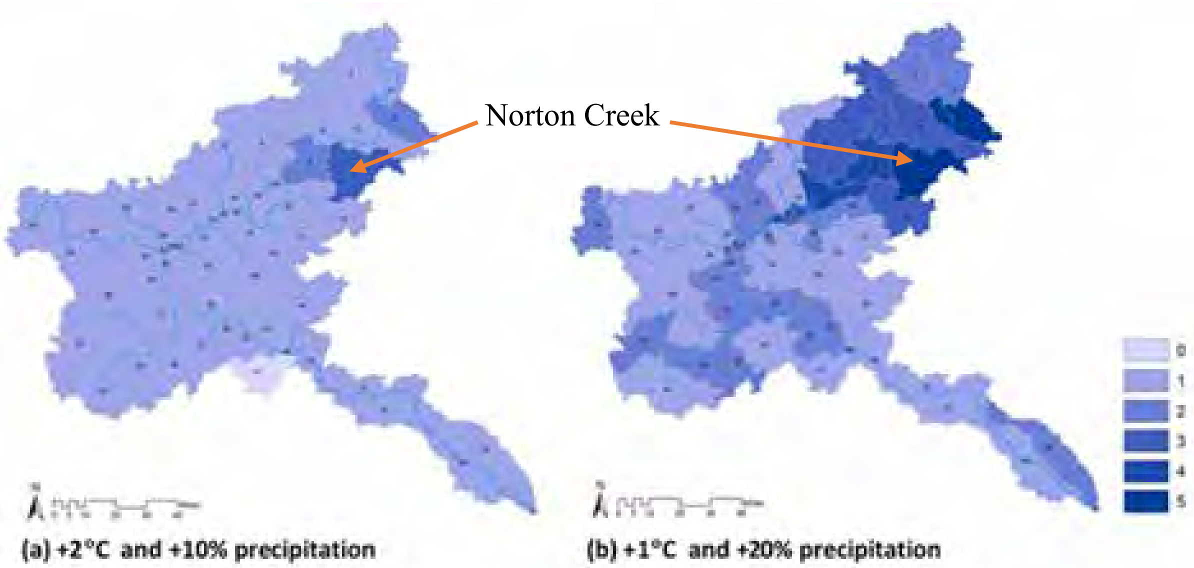

Figure 2. Norton creek ranked high for risk of flooding various climate change scenarios. This Climate change Induced Flooding Hazard Index show the increased differences from baseline in a five-point scale (0: zero increase, 1: +0-1-2%, 2: +1-2%, 3: +2-3%, 4: +3-4%, 5: > +4%) for (a) lower climate change impacts and (b) higher climate change impact[19].

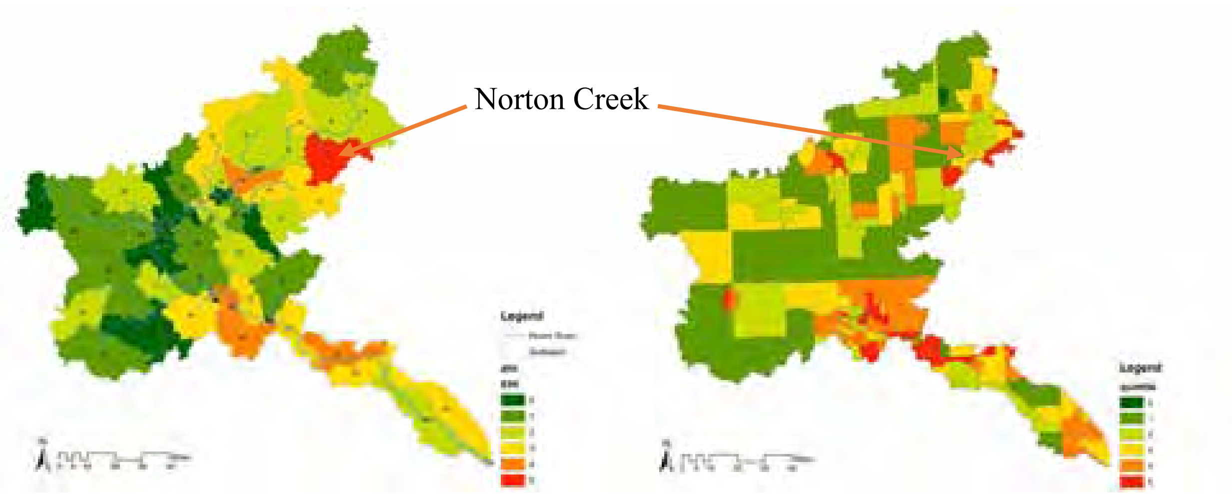

Figure 3. Norton creek also ranked high for the environmental hazard index and social vulnerability index. The Environmental Hazard Index (left) is the synthesized density of environmental hazard sites and Risk Screening Environmental Indicators polluted reach data at the subbasin with a five-point scale, 5 being the highest potential of water pollution, 0 being no environmental hazards present. The Social Vulnerability Index (right) illustrated at census tract unit with a five-point scale, 5 being the highest social vulnerability, 0 being no data present[20].

2.3 Geology and soils

It is valuable to consider soil types and conditions in a watershed analysis because these soils impact ground water flow and vegetative land cover characteristics. Glacial outwash and post-glacial alluvium plains, as well as end moraines of coarse textured till are the two dominant glacial landscapes of the creekshed.

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. End moraines, by contrast, are areas where glacial processes stopped abruptly and 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. Consequently, the course-textured end moraines that dominate the soil around the west and main branch of Norton Creek tend to have moderate permeability while the sand and gravel outwash plains that dominate the eastern creekshed facilitate rapid infiltration of water (Figure 4).

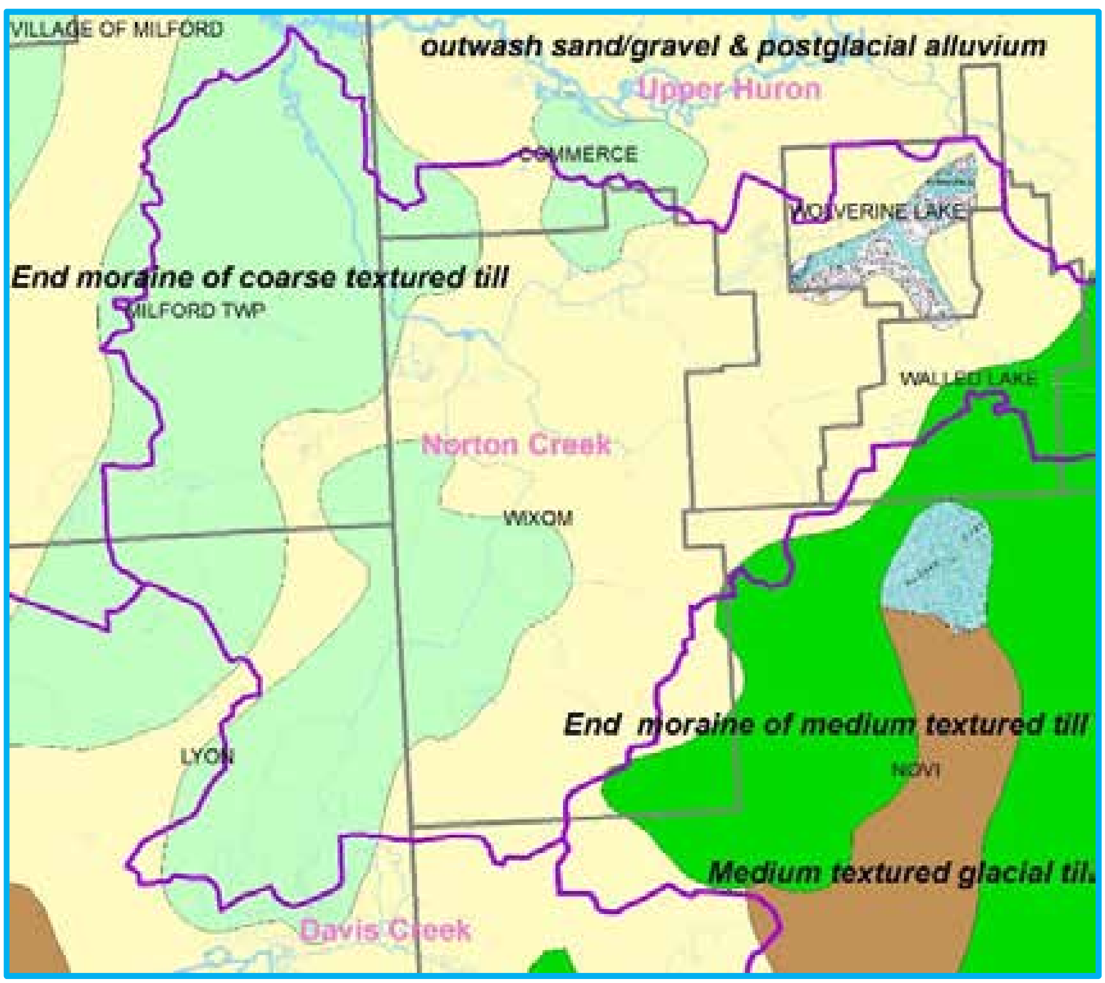

Figure 4: Glacial landscapes of Norton Creekshed. Beige coverage indicates glacial outwash and postglacial alluvium plains (higher filtration), while the pea green represents end moraines of coarse textured till (lower filtration)

Hydrologic soil groups closely follow the glacial history and reveal a range of soil composition structures throughout the creekshed (Figure 5). Around the waterways, the soils tend to be either sandy loam or silty-clay loam, while higher upland the soils are a good mix of either loam or sandy-clay loam.

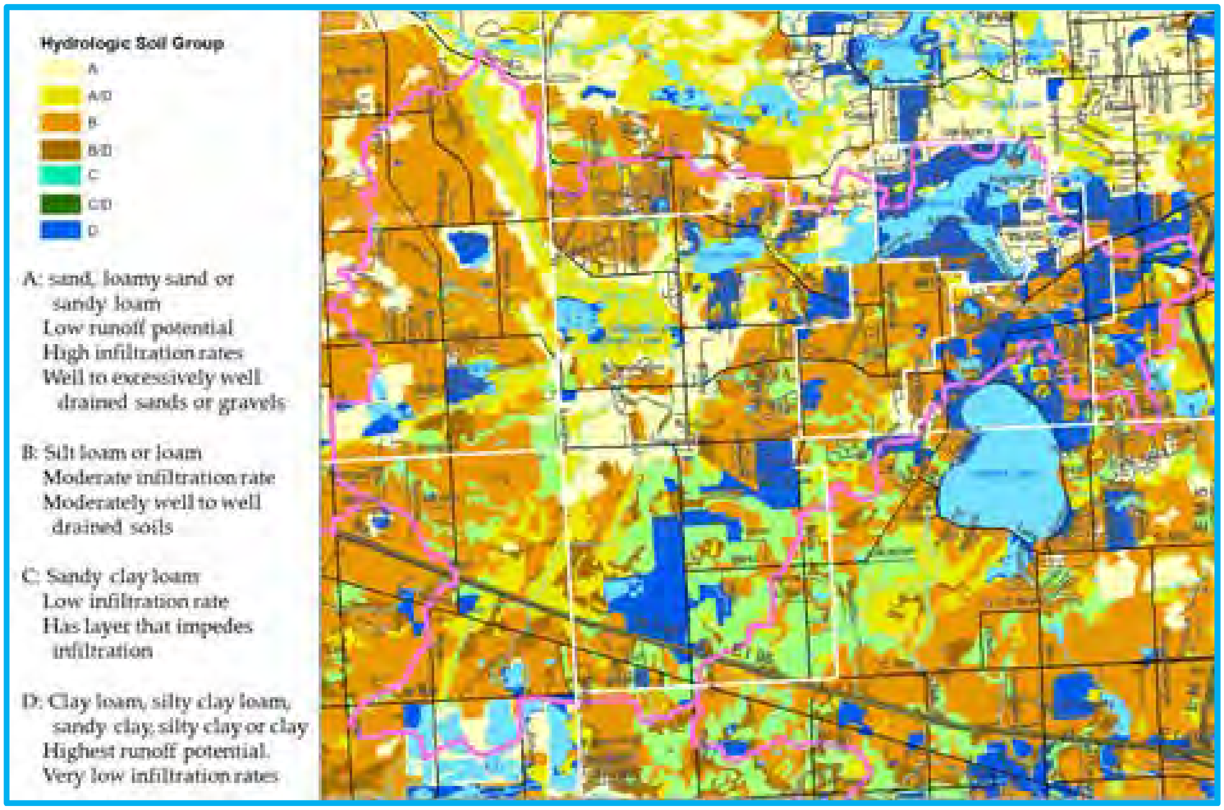

Figure 5: Hydologic soil groups and their relative infiltration rates and run-off potential for Norton creekshed.

2.4 Topography and Geomorphology

The Norton Creek watershed can generally be characterized as a relatively flat watershed with a complex of historically interconnected wetlands and natural inland lakes that has been altered and into a moderately developed, urban watershed. This general physical description leads to much of the current chemical and biological condition of the watershed.

All major Norton Creek stream segments were delineated into individual stream reaches for geomorphic analysis (see Figure 6). A multi-level evaluation of stream reach geomorphology was conducted to compare the Norton Creek drainage structure to reference conditions developed for natural stream reaches across southern Michigan[21]. First, a desktop analysis was conducted to calculate basic statistics like reach length, gradient (elevation change), and drainage area. Reach sinuosity was also calculated by delineating stream valleys and comparing reach length to valley length. This included an evaluation of the current location of stream reach channels and their location in 1949 from archived air photos.

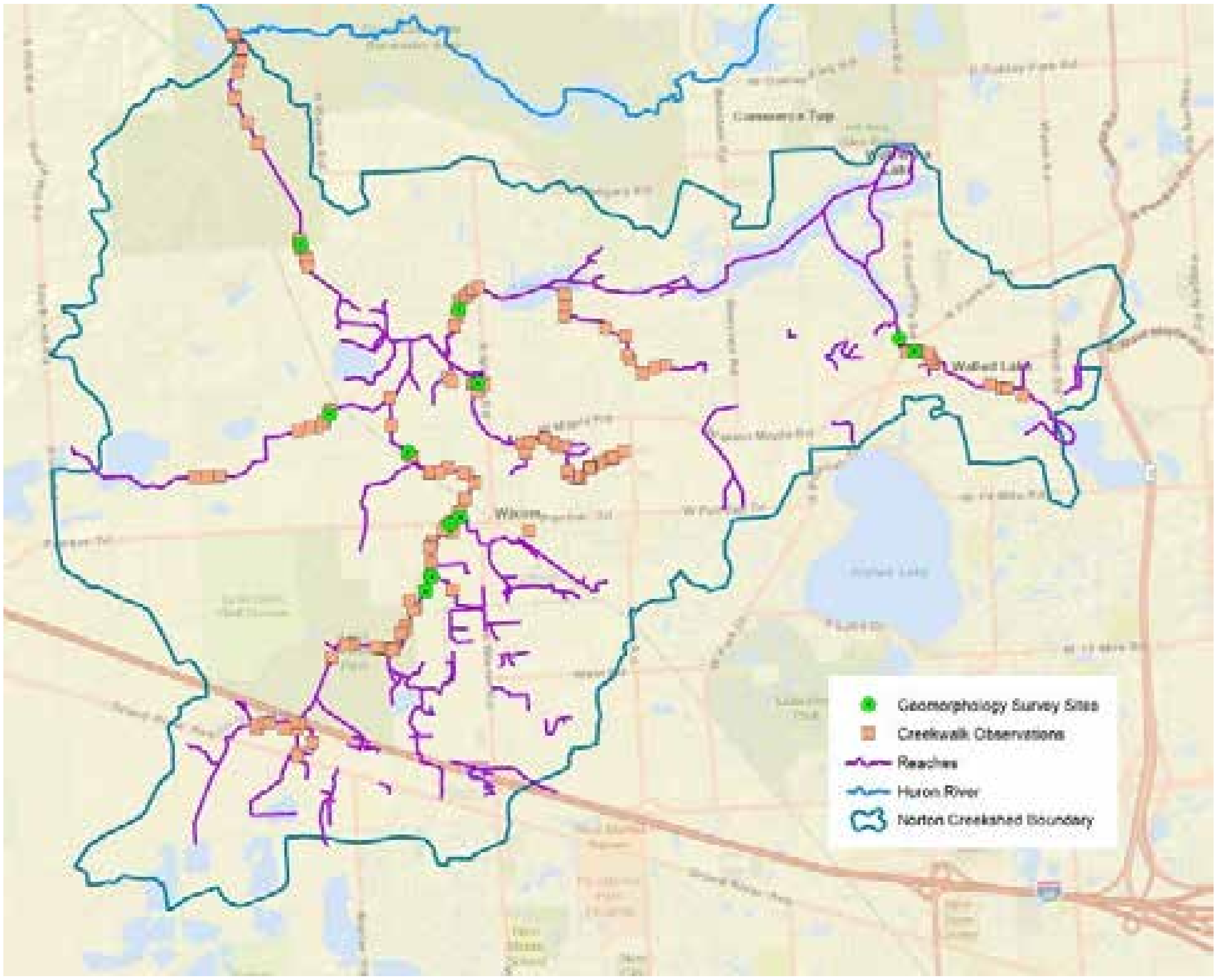

Figure 6: Norton Creek stream reaches with locations of creekwalking team observations and geomorphological cross-section survey sites.

Field surveys were conducted to provide critical information about reach width, depth and signs of stream degradation. Field work consisted of extensive "creekwalking" surveys, road-stream crossing surveys and targeted cross-sectional channel surveys. Methods for each field program are included in Appendices E and F. Creekwalking surveys (see figure 6 for observation locations) provided rough measures of stream width and depth (later estimated to bankfull width and depth), photographic evidence of degradation and stream impact and general stream conditions. Road-stream crossing surveys provided an inventory of crossing condition and identified potential erosion sources from problematic culverts and other crossings. The cross-sectional channel surveys were conducted at representative locations (see figure 6) on major reaches to identify bankfull width, depth and area, and to generate bankfull discharge estimates. Cross-sectional survey results were used with estimates from creekwalking surveys at other locations along a reach to generate a best estimate of geomorphological statistics. These key statistics (bankfull width, depth, area, discharge, gradient, and sinuousity) were compared to regional reference conditions to determine how Norton Creek stream reaches compare to expected natural conditions.

Table 3. Geomorphic statistics of Norton Creek reaches

Reach ID	Drain Area (Mi^2)	Compared to Reference*				Sinuosity
		Width	Depth	Area	Discharge	
010001	24.7	-14.7%	+161.1%	+44.4%	+6%	1.01
010002	23.1	-11.9%	+111.3%	+22.9%	-10%	1.01
020101	8.9	-31.0%	-31.6%	-68.9%	-68%	1.08
020105	2.0	+10.2%	-28.2%	-42.7%	+77%	1.07
020202	2.4	+70.4%	-14.6%	-100.0%	-100%	1.01
020301	1.1	+44.9%	-3.1%	-25.7%	+126%	1.03
020302	0.38	+61.8%	-15.1%			1.02
030002	2.5	-17.1%	-23.1%	-47.1%	-3%	1.04
030101	8.1	-28.1%	+57.7%	-18.4%	+127%	1.05
030201	7.4	-32.2%	+28.3%	-22.3%	+143%	1.09
030202	0.92	+82.5%	+55.2%	+22.3%	+94%	1.01
030301	6.1	-41.4%	+39.1%	-50.9%	-83%	1.01
030401	5.4	-7.0%	-32.4%	-65.8%	-70%	1.01
030402	1.5	+36.1%	-16.3%			1.12
030501	3.6	+13.3%	+9.0%			1.01
030502	0.79	+86.1%	-6.3%			1.01
030601	1.1	+131.3%	+10.5%			1.03

* References refer to projections from drainage area-dimension curves compiled from reference stream reaches from across southern Michigan.

Figure 7 illustrates the combined dimensions of width and depth, and how they have been altered compared to reference reaches. Compared to regional reference conditions, only one of the 17 Norton Creek reaches evaluated had width and depth dimensions that were within 20% of reference projections. However, the reaches have not been altered in consistent ways either. Two reaches are overly narrow and shallow (including 020101 – the outflow from the Loon-Wolverine Lake chain). Two reaches are overly shallow. One long combination of three reaches is overly narrow and deep (incising). Five reaches, including the final three reaches are overly deep. Four reaches are overly wide, and one reach, which is mostly piped underground, is overly wide and deep. Of the 16 altered stream reaches, 13 are oversized for at least one of the two dimensions, meaning that they likely have excess capacity over the expected bankfull discharge.

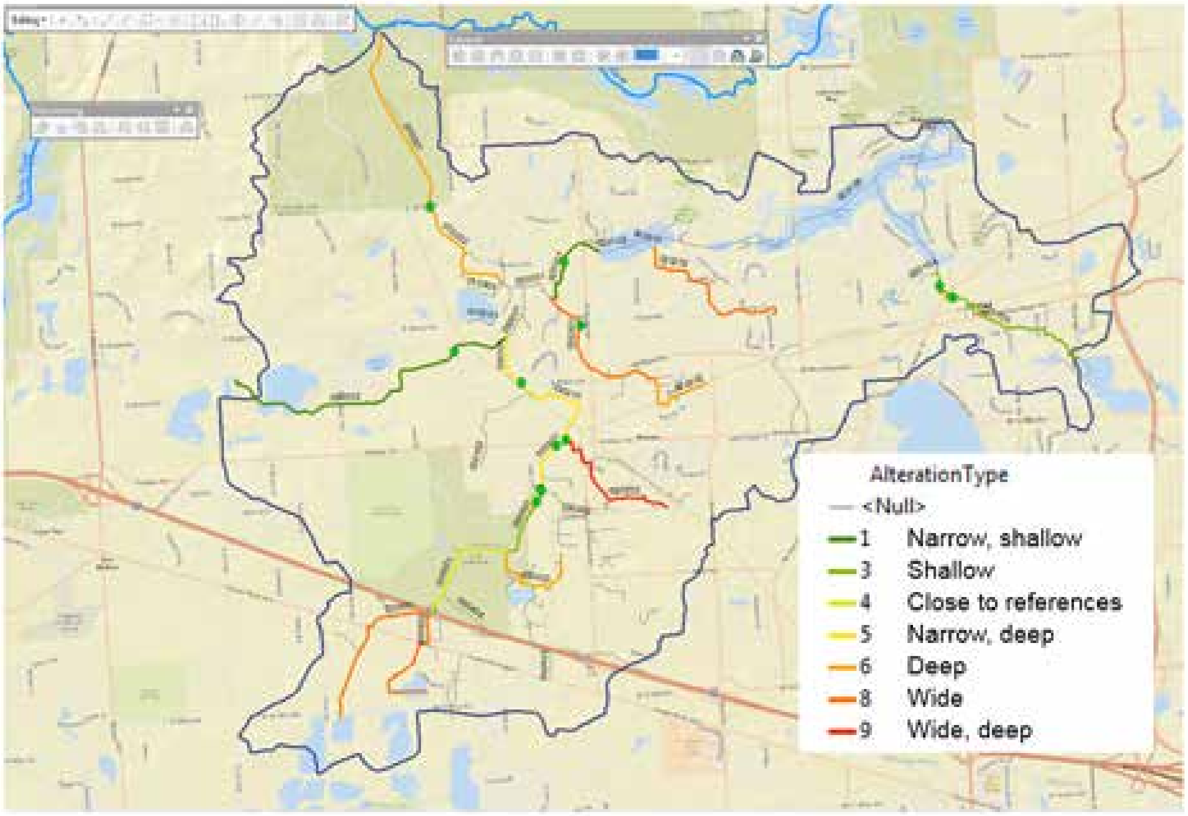

Figure7: Norton Creek reaches showing combined width and depth measures against reference conditions.

Bankfull area was only calculated for reaches that had cross-sectional surveys conducted on them. Of these, three yielded excess area, eight had areas below reference predictions and one was within 20% of reference.

Mostly, the reaches in this watershed have good connection to their floodplain. Only one reach (030002) was even somewhat entrenched with a ratio of 2.1. All others had connection to the floodplain on at least one side, with entrenchment ratios all over 2.2.

The majority of stream channels in the Norton Creek system are relatively trapezoidal. Only one reach (020202) has a width-to-depth ratio over 12. That channel runs through suburban residential neighborhoods and may have been widened by flashier hydrology. All other channels have ratios of 10 or less. These ratios are almost all lower than the theoretical reference reach based on drainage area.

The gradient or slope of stream channels in the Norton Creek watershed is low. The average gradient of all 30 measured reaches is 0.0032 or 0.32%, with a range of essentially 0 slope to 0.019 (one small reach).

Given this low slope, it would be expected that Norton Creek reaches would have highly sinuous form. This is not the case. Figure 8 shows how the form (as sinuosity) of stream reaches in Norton Creekshed have been altered as compared to reference conditions. The stream channels throughout the Norton Creek watershed adhere closely to their valley lines. Natural sinuosity for streams in this drainage range would be expected to 1.2. None of the Norton Creek reaches exceed this standard. In fact, only two small reaches have sinuosities above 1.1.

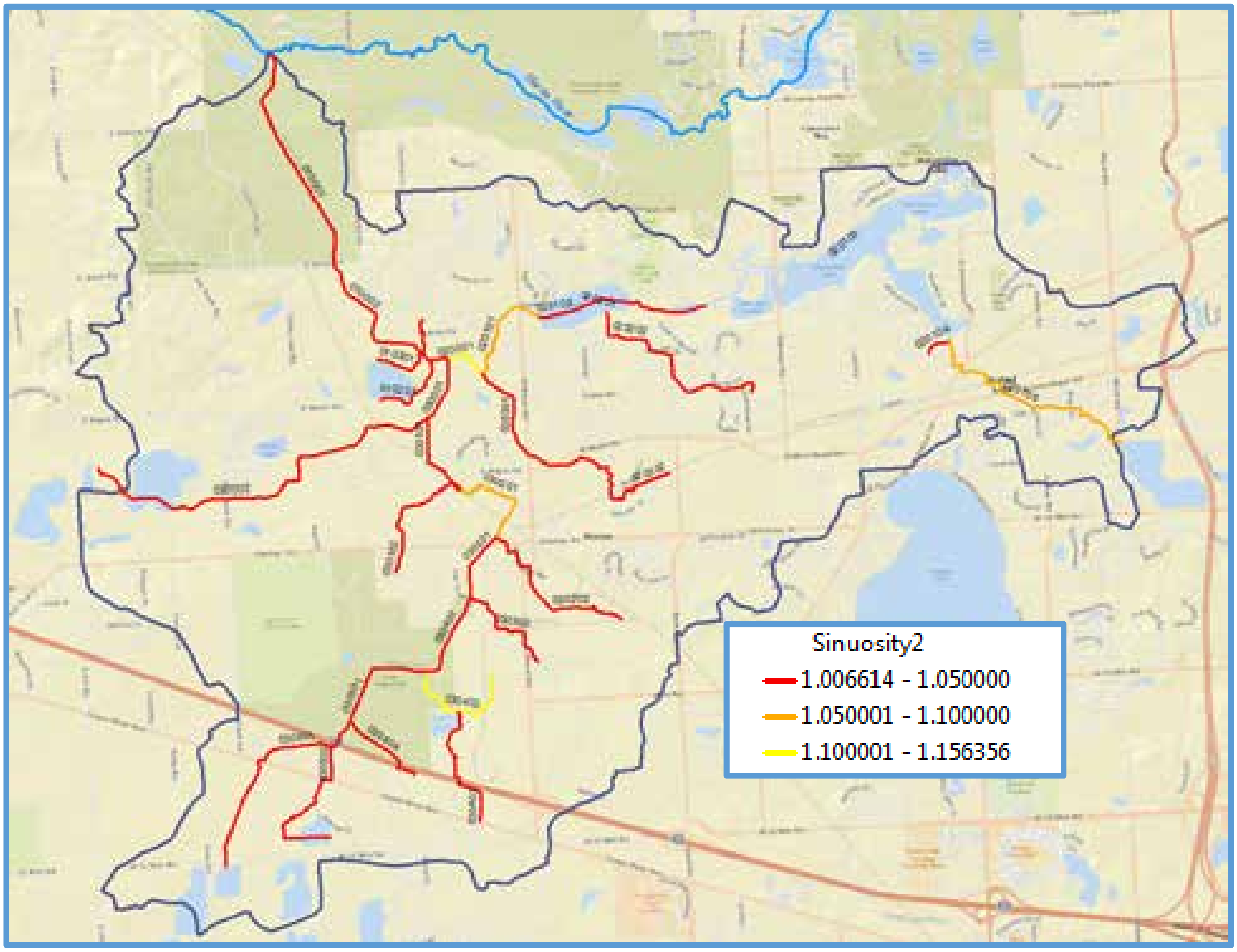

Figure 8: Norton Creek reaches showing combined width and depth measures against reference conditions.

Given the findings that 1) the Norton Creek watershed has low gradient throughout, 2) its reaches have unnaturally low sinuosity, 3) and most channels have lower width-depth ratios than expected compared to reference conditions, a search was made for historical photo reference. The oldest digitized photos obtainable were obtained from SEMCOG and were dated 1949[22]. As shown in figure 9, the signature sharp, unnatural, angular creek bends that suggest channel alteration, were also present in 1949. In the past, and sometimes currently, the county drain commissioner would be responsible for altering streams to reduce flooding or “reclaim” land for agriculture. Indeed, the Oakland County Water Resources Office indicates that most of the county drains in Norton Creek were established prior to 1920. It appears from the photo that the channel shape has changed little since 1949.

Figure 9: Section of current Norton Creek stream network (between Pontiac Trail and Maple Road) shown on an aerial photo from 1949. Note that the photo is not orthorectified, so the channels do not exactly match. However, current channel shape matches almost identically to 1949.

2.5 Hydrology

HRWC staff and volunteers installed a water level sensor at the Buno Road site and transduced stream flow with a series of discharge measures using a rating curve (see methods in Appendix C). Discharge was estimated at 10-minute intervals seasonally in 2015 and 2016 (see Figure 10).

Stream flow data generated a number of useful statistics to use in determining the health of Norton Creek flow dynamics (see Table 4). MDEQ originally estimated summer flow for portions of the creek to average 2.5 cfs[23]. However, in two seasons of continuous measurement, HRWC estimated median flows that were considerably higher. In fact, flows from the two seasons had an overall daily median flow of 8.73 cfs.

The 2015 season produced a large rain storm (2.31" over 28 hours (2)) that fell near the 50% return internal for a 24-hour storm (3), which resulted in a peak flow of 36 cfs. Such a storm is a bit below a bankfull event, or, a storm large enough to result in flow that rises to or above the stream banks. The Regional Reference Curves for southern Michigan suggest that a watershed the size of Norton Creek (23 sq. mi. @ Buno Road) should generate a bankfull event around 154 cfs, over five times larger than the largest event observed.

Table 4. Stream discharge statistics for Norton Creek at Buno Road.

Data Period	Discharge statistics (cfs)			24-hour Precipitation (in)	Flashiness Index
	Median	10th Percentile (baseflow)	Peak		
May-Sep, 2015	7.32	4.56	36.0	2.07	0.21
April-Sep, 2016	9.60	4.90	34.1	0.98	0.19
Total	8.73	4.71	36.0	2.07	0.20

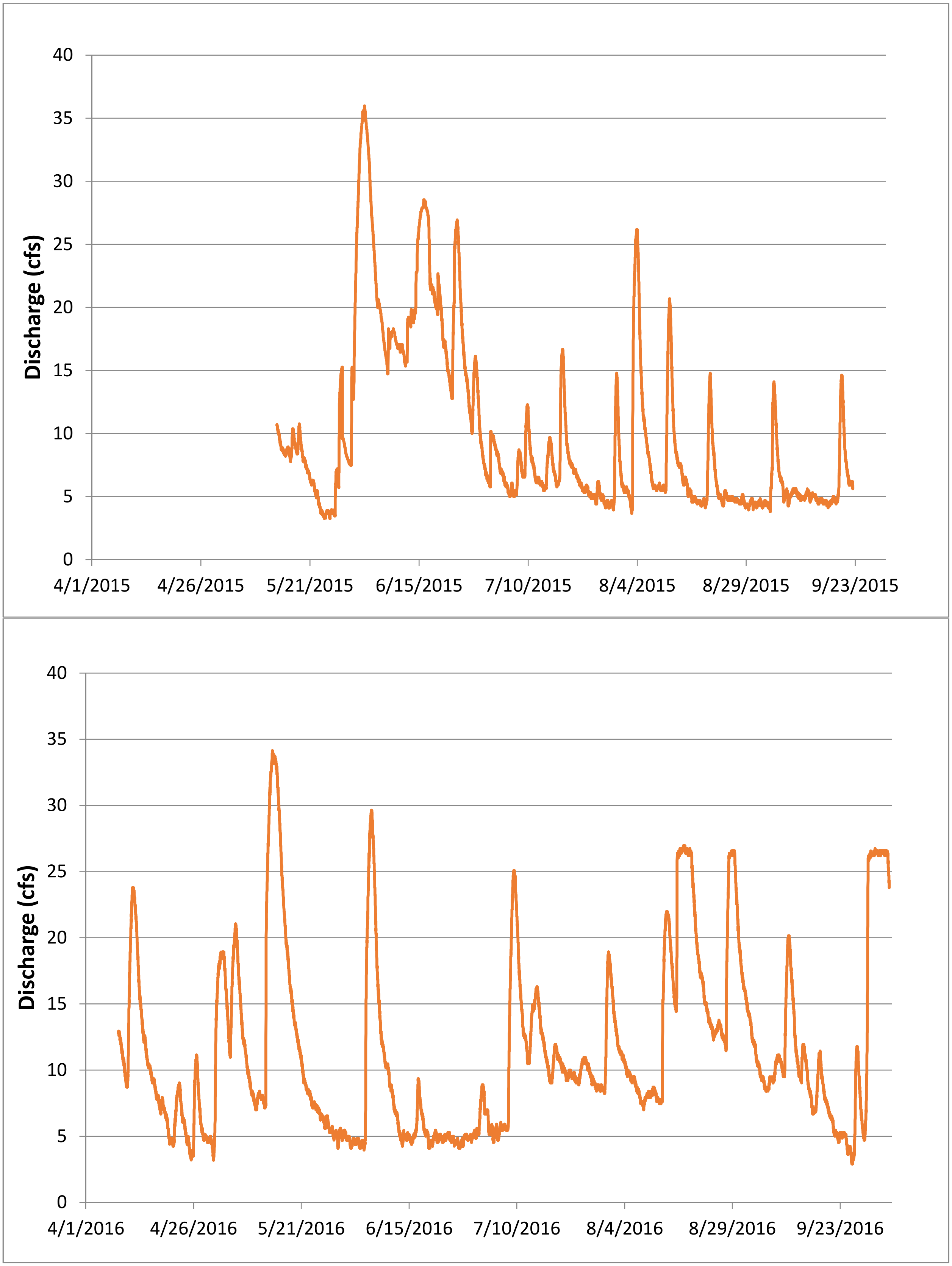

Figure 10. Stream discharge for Norton Creek at Buno Rd. for 2015 and 2016 gage periods.

2.5.1 Baseflow

In the Tennant method (Tennant, 1976), streamflow requirements are based on the observation that aquatic habitat conditions are similar in streams carrying the same proportion of the mean annual flow (QMA). The Tennant method applies different criteria for winter (October-March) and summer (April-September) flow periods. During summer low-flow periods, minimum streamflows are defined as 40, 30, and 10 percent of the mean annual discharge (QMA); these streamflows create good, fair, and poor habitat conditions, respectively, according to Tennant (1976).

A study by USGS examined 5 gaged stream flows across a variety of methods with fairly consistent results matching Tennant's stream health range from 0.71 cfs/mi^2 (good habitat) to 0.18 cfs/mi^2 (poor habitat). With a drainage area at the Buno Road station of 23 mi^2, poor to good baseflow for Norton Creek should be between 4.1 and 16.3 cfs. Norton Creek's minimum and 10th percentile flows were in the poor range in 2015 and in the good range in 2016 (see table 4).

2.6 Water Quality

Throughout the summer of 2015, HRWC launched an intensive data collection process incorporating 10 standard sampling locations, and weekly creekwalks throughout the watershed. Measurements across the two forms of assessment included concentrations of total phosphorus, total suspended solids, conductivity, pH, temperature, dissolved oxygen, flow rate, creek depth, and presence of *E. coli.* In developing the TMDL for Norton Creek, the Michigan Department of Environmental Quality (DEQ) also performed several water quality assessments for the creek in 2007 and 2008.[24] Finally, there were studies performed in both 1980 and 2002 that analyzed DO concentrations in Norton Creek. The water quality indicators as measured by all of these data collection efforts are outlined below.

2.6.1 Nutrients and Sediments

The Michigan Department of Environmental Quality (MDEQ) has primarily used biological assessments to analyze siltation and sediment levels. As of 2009 they had 5 reports dating back to 1972 that indicated poor habitat quality due to high siltation and/or nutrient levels. During the development of the TMDL, MDEQ researchers collected habitat metrics including one specific to "Epifaunal Substrate/Available Cover." A high habitat score with this metric indicates little to no siltation, but all habitats in Norton Creek exhibited some form of siltation and rarely showed more than 40% stable habitat conditions.

Suspended Sediments

HRWC conducted extensive water quality sampling and analysis at sites across the Norton Creek watershed. See Appendix C for details on methods and sampling results. Suspended sediments in the water column were determined using total suspended solids measures. MDEQ generally uses a standard of 80 mg/l, above which stream habitat will start becoming impaired. None of the sampling locations exceeded this threshold. However, that concentration is typically related to storm flows. HRWC took regularly scheduled samples in wet and dry weather. The highest mean TSS concentration was just under 42 mg/l. Figure 11 shows mean TSS concentrations above and below a 25 mg/l concentration, to set a reasonable target to examine potential erosive reaches. Only two reaches exceed that mean concentration. The reach with station NC09 has the highest gradient in the Norton Creek watershed. The reach that includes station NC08 drains through a number of residential subdivisions and into the Wixom Habitat.

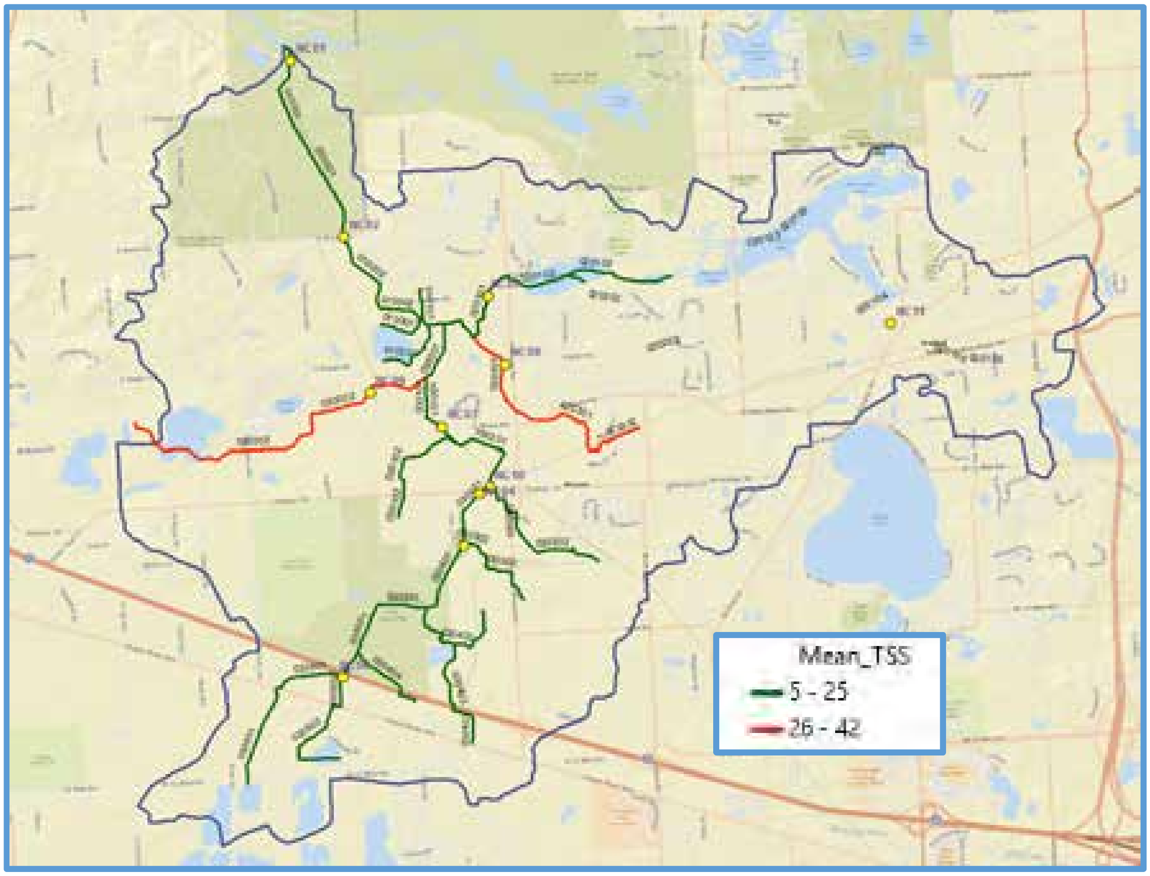

Figure 11: Norton Creek watershed showing stream reaches with corresponding total suspended solids concentrations in mean mg/l.

Road Crossings

In addition to sampling for TSS concentration, HRWC staff and volunteers assessed the majority of road-stream crossings in the watershed – over 50 crossings (see Figure 12). The purpose of this exercise was to determine if any bridges, culverts or other structures were altering stream flow in such a way as to create excessive erosion downstream or aggradation upstream. Out of all 54 crossings, only two minor erosion/siltation issues were observed. These findings were reported back to the Oakland County Road Commission for prioritization and repair. Given the development that has occurred in the Norton Creek watershed, altered hydrology and erosion were expected. The lack of observational evidence of erosion furthers a conclusion that current sediment loading of Norton Creek reaches is not a significant concern, and is not likely a long-term source of sediment loading or high sediment oxygen demand.

Figure 12: Locations of surveyed road-stream crossings in Norton Creek watershed.

Phosphorus

The typical growth-controlling nutrient in southeast Michigan lakes and streams is phosphorus. MDEQ does not have a numeric standard for phosphorus in surface waters. Nutrient impairments in the Huron River watershed have been based on lake models that predict eutrophication levels. Limits have been set as low as 0.025 mg/l and as high as 0.05 mg/l. HRWC experience has shown that stream concentrations are typically considerably higher than lake levels, but a 0.05 mg/l has been used as a general indicator of eutrophic potential.

All sampling sites in Norton Creek had mean total phosphorus levels that exceeded the 0.05 mg/l target. Figure 13 illustrates the range of results. Reach NC08, in particular, had a mean TP of over 5 times the target. Visual inspection revealed active algae growth and blooms in areas.

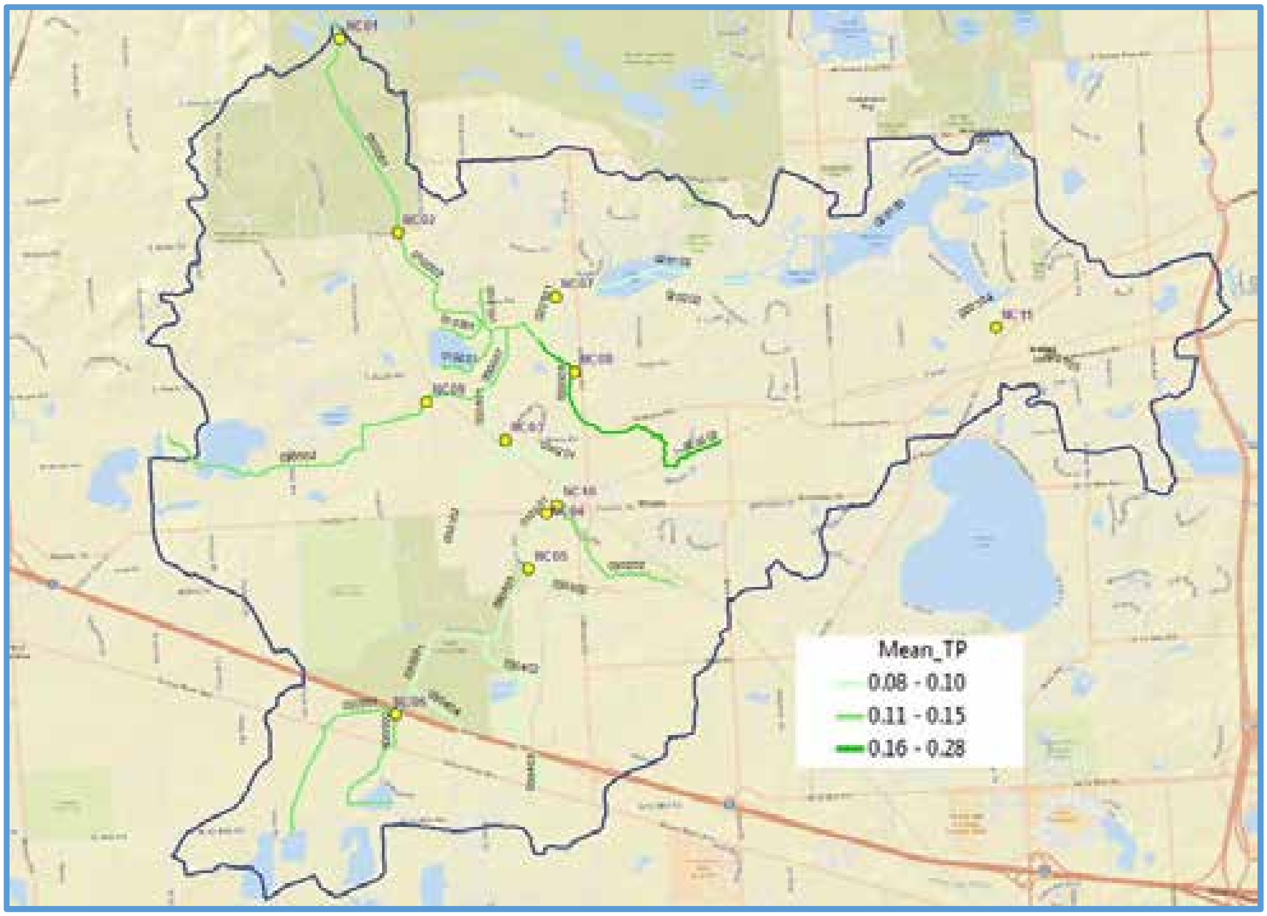

Figure 13: Norton Creek watershed showing stream reaches with corresponding total phosphorus concentrations in mean mg/l.

2.6.2 Dissolved Oxygen

Low Dissolved Oxygen is one of the two main concerns for Norton Creek. Indeed the 2009 TMDL developed by MDEQ identified an 18.8 mile stretch of the creek as impaired for certain designated uses due specifically to low dissolved oxygen (DO) and high sediment/siltation. The 1980 Norton Creek study found that DO levels dipped below the current minimum standard of 5 mg/l in more than one location. The creek also presented with extreme diurnal swings in DO concentration, possibly due to the abundant plant life feeding from the combined effluent of both the Ford Assembly plant and the Wixom WWTP.

The 2002 study found smaller diurnal fluctuations than the 1980 study, but researchers still measured DO concentrations below the minimum of 5 mg/l more than 61% of the time. This standard "non-attainment" persisted in both wet and dry weather but was site specific to monitoring just downstream of the WWTP on what is now called ATS Drive.

HRWC staff installed dissolved oxygen loggers (model Hobo U26-001) at 8 monitoring stations on Norton Creek in the summer of 2015 (see Figure 14). Only two loggers were available, so the loggers were rotated every two weeks so that two weeks of data were collected at each monitoring station in June/July and in August/September. Therefore at the end of the summer, 4 weeks of DO measurements were taken at 8 sites.

The loggers were placed in enclosed PVC tubes for protection, drilled with numerous holes to allow for free flow of water, and placed in stilling wells that were attached to fence posts pounded into the stream bed. The loggers were positioned so that they were not placed into fine sediment or sand. They were set to take DO measurements every 10 minutes.

The data from one of the sites (NC04) was rejected because the DO measurements show a continual decline over the two week deployment that indicates the meter was silted in over time. The data from the other monitoring sites did not show this pattern.

Surface waters protected for warmwater fish and aquatic life must meet a minimum dissolved oxygen standard of 5 mg/l. Only one of the sites monitored (East Branch) was regularly able to meet this standard, although about 5% of the logged time it did not meet this. Still, this site was significantly better than all of the other sites, which had less than 5 ppm for the majority of the logged time. The poorest site was at the upper Main Branch (NC06), which was less than 5 ppm 100% of the recorded time in the water. Table 5 and Figure 14 illustrate these results in detail.

In fact, not only did Norton fail to meet State standards at these monitoring locations, but often the creek was not even achieving a DO level of 2 ppm. Exposure to 2 ppm or less for one to four days will kill most of the aquatic life in a system.

Table 5. Logging results for dissolved oxygen at Norton Creek sites

	% of logged time less than:		
Site	5 ppm DO	2 ppm DO	Average ppm DO
Lower Main Branch (NC02)	62	33	3.5
Lower Middle Main Branch (NC03)	82	44	2.8
Upper Middle Main Branch (NC05)	67	17	3.7
Upper Main Branch (NC06)	100	100	0.0
East Branch (NC08)	99	89	0.6
Loon Lake Outlet (NC07)	91	86	0.6
West Branch (NC09)	5	0	6.1

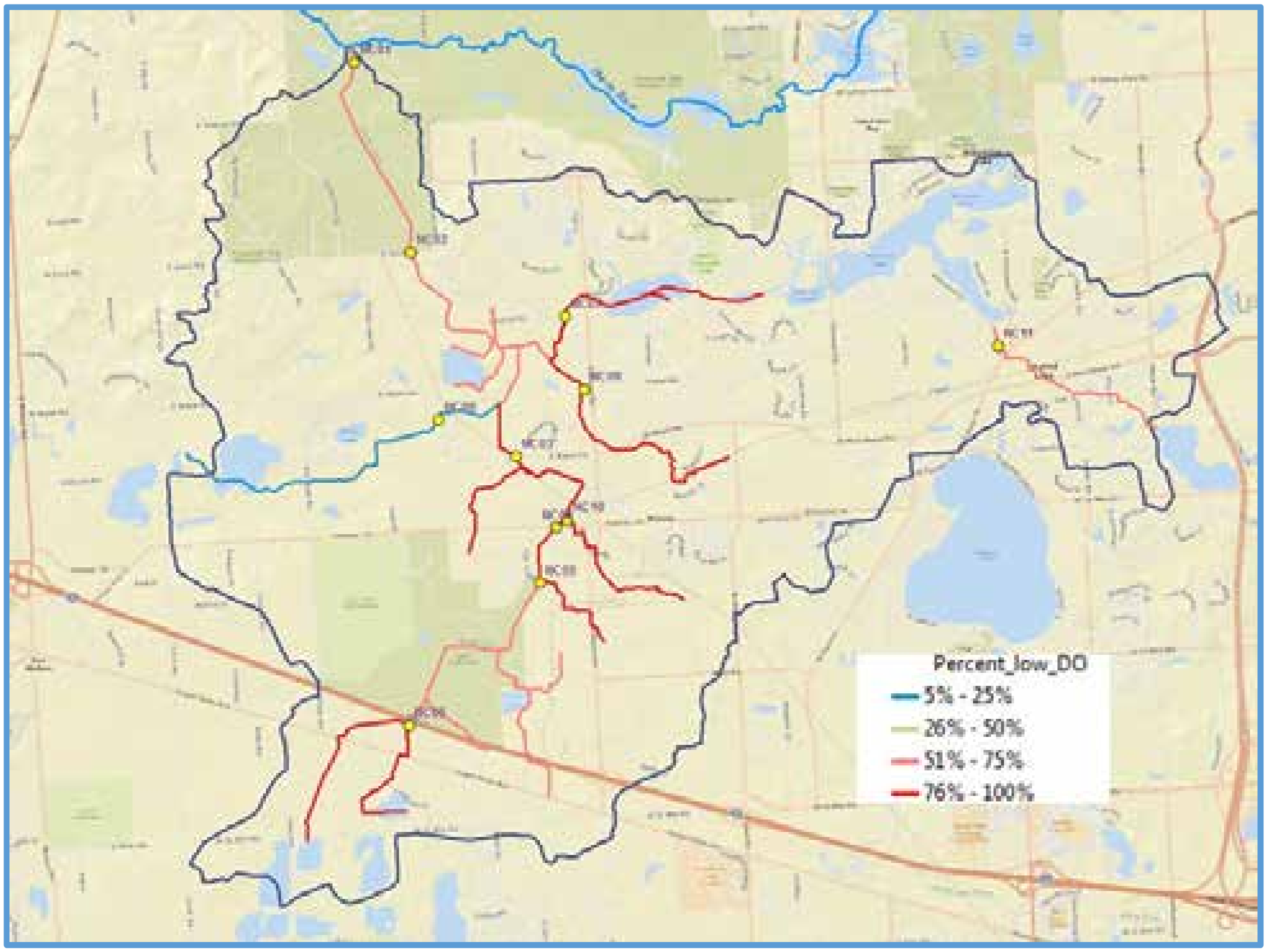

Figure 14: Norton Creek watershed showing stream reaches with corresponding dissolved oxygen levels. Levels are expressed in percent of continuous sampling time below the 5 ppm standard.

2.6.3 Conductivity & pH

In June, 2008, across nine sample sites, conductivity readings total for Norton creekshed averaged around 1038 µmhos/com. Conductivity was highest at the intersection of ATS Drive and W. Pontiac Trial, by the current Gibson Park in Wixom, MI and just downstream of the retired Ford assembly plant.

Total Dissolved Solids and polychlorinated biphenyls have also been reported as above official water quality standards, but the focus of this plan remains on mitigating for low DO and high sedimentation. The TDS impairment was determined to be from a direct source which was subsequently addressed.

HRWC measured conductivity, TDS and pH levels during water quality sampling at sites throughout the watershed.

<u>*Conductivity*</u>

Conductivity is a measure of the ability of water to pass an electrical current, and is a general measure of water quality. Conductivity is affected by temperature: the warmer the water, the higher the conductivity. As such, conductivity is reported as conductivity at 25ºC. Conductivity in surface waters is affected primarily by the geology of the area through which the water flows. In Michigan, values for a healthy river or stream habitat range between 100 and 800 µS/cm. Low values are characteristic of oligotrophic (low nutrient) lake waters, while values above 800 µS/cm are characteristic of eutrophic (high nutrient) lake waters where plants are in abundance. High values are also indicative of high mineral concentrations. There are a number of potential sources of minerals and some natural variation, but consistent results above 800 µS would be unexpected from natural sources. Anthropogenic sources can include winter road salts, fertilizers, and drinking water softeners.

Conductivity measurements were taken at select sites on Norton Creek over the 2015-2016 monitoring seasons. The median values for conductivity exceeded the upper limit for healthy waters (800 µS) for all of the sites measured. It cannot be determined from these results which ions are driving the elevated conductivity values in these streams, so further investigation is warranted to determine the nature and potential sources of dissolved ions.

Total Dissolved Solids

Total dissolved solids (TDS) is a measurement of inorganic salts and is listed by EPA as a secondary standard. The secondary standards are established for aesthetic considerations, such as odor, taste, and color. The guidelines are to assist public water systems in managing their drinking water. Total dissolved solids are not considered to present a risk to human health. The secondary maximum contaminant level (MCL) for total dissolved solids according to the EPA is 500 mg/L. According to MDEQ, surface waters should not have concentrations that exceed 500 mg/L as a monthly average or 750 mg/L at any time as a result of controllable point sources. TDS measurements were taken at select sites on Norton Creek over the 2015-2016 monitoring seasons and the median values exceeded the upper limit (500 mg/L), with a majority of the measurements taken over 750 mg/L. Further monitoring is warranted to determine the nature and potential sources of total dissolved solids.

pH

Measuring pH provides information about the hydrogen ion 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. Michigan Water Quality Standards require pH values to be within the range of 6.5 to 9.0 for all waters of the state. In Michigan surface waters, most pH values range between 7.6 and 8.0. The pH of rivers and streams may fluctuate due to natural events, but inputs due to human activities can also cause ‘unnatural’ fluctuations in pH. Median values for all sites measured in Norton Creek ranged between 7.38 and 8.14, with little variability in individual samples.

2.6.4 Bacteria (E. coli)

The final water quality metric to consider is human pathogens. The MDEQ uses the bacterium *Eschericia coli* as a surrogate for human pathogens in surface water that could lead to human health impacts if ingested. HRWC assessed Norton Creek water samples for E. coli levels (see Figure 15). The state water quality standard for full body contact is 300 colony forming units (cfu) for a single sampling event, and a geometric mean of 130 cfu for a 30-day sampling period.

All Norton Creek sites sampled exceeded the 30-day standard. However, two reaches were generally below the single sample threshold. All other reaches regularly exceeded the single event standard. Based on these results, surface water in the Norton creekshed should be considered unsafe for full contact exposure.

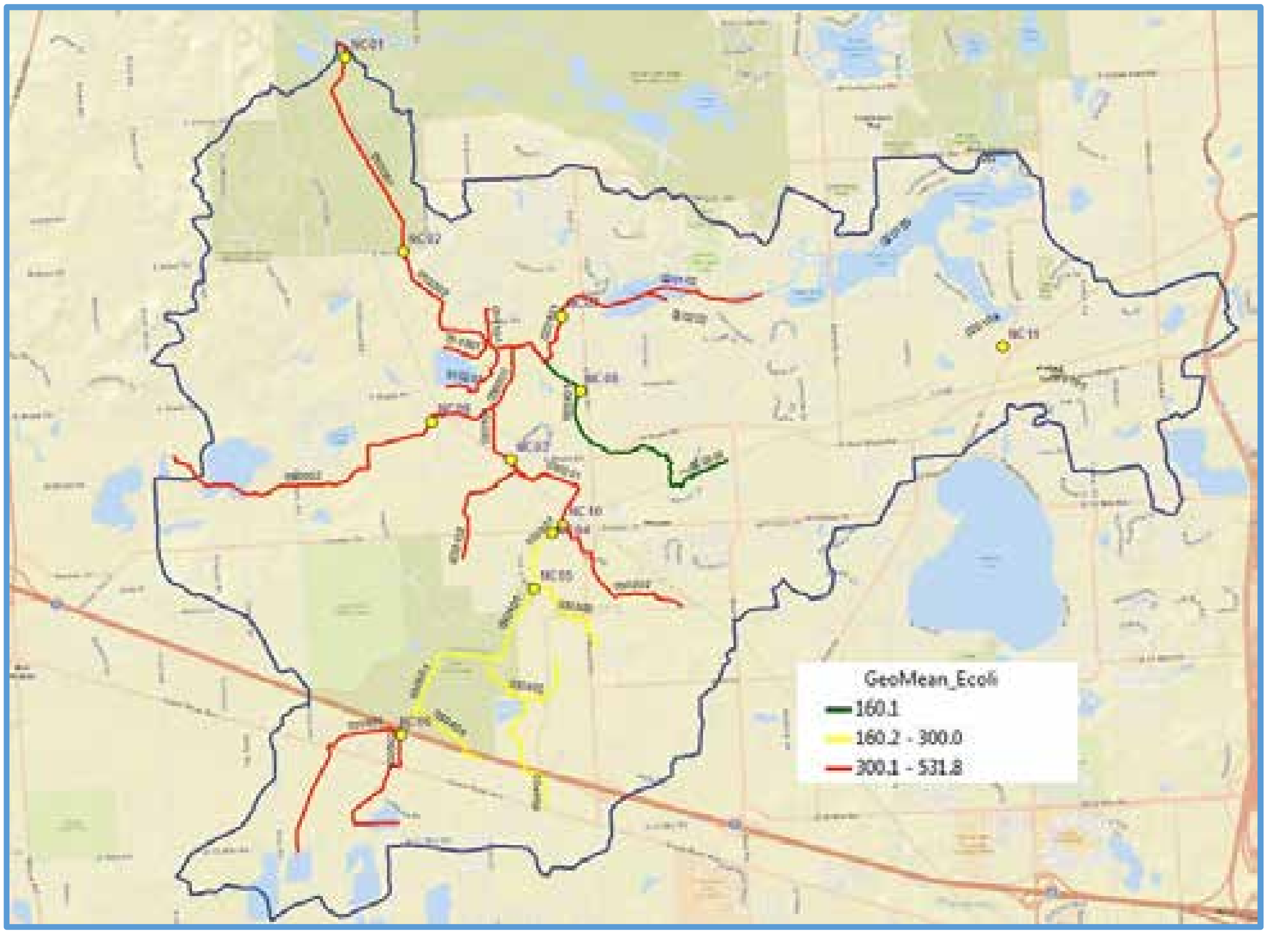

Figure 15: Norton Creek watershed showing stream reaches with corresponding E. coli levels in geometric mean counts of colony forming units.

2.7 Ecology

In their original study to develop the TMDL, MDEQ researchers collected some information on conductivity and total dissolved solids (TDS). However, the research to develop Norton Creek's TMDL focused heavily on macroinvertebrate communities, and habitat and fish community assessments. Across four assessment sites in the creekshed, MDEQ rated stream habitat as good. Researchers found extensive collections of large woody debris, and some macrophyte stands near wetland locations. Bottom sediment ranged across the creekshed from sand and gravel to soft organic material. Macroinvertebrate community scores ranged from poor to just barely acceptable and MDEQ staff concluded that a macroinvertebrate TMDL would be justified. Fish community scores faired a little better and fell within the acceptable range.

HRWC did not specifically investigate fish or macroinvertebrates as part of the Watershed Management Plan development study, but HRWC has collected data on macroinvertebrates and habitat and documented past fish surveys.

2.7.1 Macroinvertebrates

HRWC has collected benthic macroinvertebrates at Norton Creek near the intersection of West Maple Road since the fall of 2000. This sampling occurred about twice a year from 2000-2013, and has since declined to about once a year since a new sampling site was added to Norton Creek at Gibson Park in 2015.

Norton Creek at West Maple Road regularly has one of the worst macroinvertebrate populations of all 70 sites that HRWC regularly monitors across the Huron River watershed. Since 2014, the average number of insects families collected is 3.5, with an average of 0.5 these being a member of Ephermeroptera-Trichoptera-Plecoptera (EPT), the insect families that are known to be more sensitive to disturbance. The total number of insect families and EPT families has statistically significantly decreased since 2000.

The new sampling site at Gibson Park was selected because the access and stream substrate are better at this location. Since 2015, insect families found have averaged 9.5, with an average EPT of 1 family. There are not enough data to assess trends.

Physical stream habitat is assessed at each site approximately every five years and is based on a slightly modified version of DEQ's Procedure 51 Habitat Assessment.

The site at West Maple Road has an average depth of 1.2 feet, a maximum depth of 2.1 feet, and is an average of 14 feet wide. Twenty percent of the banks are bare and subject to erosion. Sixty percent of the stream is shaded. The creek substrate is 47% sand and 38% clay and silt, with the remainder small percentages of gravel and larger rock. Fifty percent of the stream banks are at a hard right angle to the surface of the water, and the other 50% are undercut. The stream is surrounded by a wide vegetated riparian buffer. Overall, the stream habitat scores a 52 out of 100 for overall quality. The average habitat score for the 70 sites regularly monitored across the Huron River Watershed is 64, so the habitat at West Maple can be considered slightly below average.

The site at Gibson Park has an average depth of 0.9 feet, a maximum depth of 1.7 feet, and is an average of 13 feet wide. Zero percent of the banks are bare and subject to erosion. Thirty percent of the stream is shaded. The creek substrate is 13% sand and 21% clay and silt, with 42% of the substrate made of gravel and larger rocks. Thirty five percent of the stream banks are at a hard right angle to the surface of the water, and the other 65% are obtuse angles (sloped away from the water). The stream has a very narrow vegetated riparian buffer on one side, and mowed grass on the other. Overall, the stream habitat scores a 42 out of 100 for overall quality. While the substrate is better than the stream at West Maple Road and as a result the insect population is much better here, the very poor riparian buffer heavily lowers the overall habitat score. Together, the West Maple and Gibson Park sites can be considered representative of upper Norton Creek habitat. Lower Norton Creek channels traverse wetland habitat, and are much deeper and difficult to assess.

2.7.2 Fish

No known fish surveys, other than those collected by MDEQ for the TMDL study, have been conducted in Norton Creek. Based on the habitat, stream size, and water temperature, the creek most likely holds cool and warm water fish. These would include small fish like bluntnose minnows, central stonerollers, blacknose dace, as well as small populations of centrarchids like green sunfish, bluegill, and smallmouth bass.

2.7.3 Natural Area Assessment

Staff used HRWC's Bioreserve Map and aerial photos to select properties of potentially the highest ecological quality and sent letters to those properties offering field assessments. The field assessments involve a team of trained volunteers walking the property and filling out worksheets about wetland and forest characteristics, the flora and fauna observed, invasive species, levels of human disturbance, and other ecological observations. Reports created from the field assessments are useful to planners when determining where best to target conservations and restoration efforts. HRWC staff recruited trained volunteers to help asses 5 properties in the watershed.

Wixom Habitat: The site's GIS score places it among the highest scoring bioreserve sites in the Huron watershed. The wetland on this site received a significantly higher than average score for the field assessment. The wetland lies in what was historically inland wet prairie, oak barrens, and tamarack swamp, ecosystem types that have undergone drastic reductions as the area has been settled and are considered endangered ecosystems.

This is a very diverse wetland with invasive species still isolated. There is a patch of Japanese Knotweed near the fire station (south) that should be eradicated before it spreads. The only sign in the park is down an overgrown side path; consider clearing a bit and/or adding signs at the entrance and overlook. A team of creekwalkers from HRWC found a Blanding's Turtle in the creek at the entrance south of the boardwalk. This turtle is listed as Species of Special Concern in Michigan.

Finnish Co-operative Property: The wetland and forest on this site received a significantly higher than average score for the field assessment. The wetland and forest lie in what was historically oak barrens and tamarack swamp, ecosystem types that have undergone drastic reductions as the area has been settled and are considered endangered ecosystems. Volunteers found little or no invasive plants in the wetland.

The property has a forest with pockets of hydrologically connected wetland. The team suggested that the property owner get involved with the Oakland County CISMA and the Stewardship Network to get help with controlling invasive species. There is a little stand of black gum on the wetland pocket next to the wetland. The forest has much oriental bittersweet invading. Under the pine trees in the old plantation, oak seedlings are coming up. With removal of invasive plants and with fire management, the forest could be restored to a high quality ecosystem.

Southeast Michigan Land Conservancy Preserve: The wetland lies in what was historically lowland hardwood swamp, an ecosystem type that has undergone drastic reductions as the area has been settled and is considered endangered. However, at this point, it is dominated by cattails.

Lyon Oaks County Park: The site's GIS score places it among the highest scoring bioreserve sites in the Huron watershed. The wetland, the forest, and grassland on this site received a significantly higher than average score for the field assessment. The wetland, forest, and grassland lie in what was historically inland wet prairie, lowland hardwood swamp, and oak barrens, ecosystem types that have undergone drastic reductions as the area has been settled and are considered endangered ecosystems.

The park contains diverse forest, especially on the west portion. The restored grassland looks great, and it includes White Gentian, a species listed as endangered in the state of Michigan. The stream is mostly channelized, but a small portion of the stream is showing a return of small meanders.

Collins Property: The site's GIS score places it among the highest scoring bioreserve sites in the Huron watershed. The wetlands on this site received a significantly higher than average score for the field assessment. The wetlands lie in what was historically inland wet prairie, an ecosystem type that has undergone drastic reductions as the area has been settled and is considered endangered.

Wetland A appears to be a wet meadow with shrubby patches strongly covered closer to the creek, with larger, denser cattail stands to the north. In its interior is wetland B: a fen. From a distance, forest A appeared to be a drier island with tall oaks. It appears the creek has been channelized in the past. Both wetlands appear of high quality. Volunteers found little or no invasive plants in wetland B. In addition wetland B is a fen, a unique and endangered wetland type known for its biodiversity. The team found bog valerian, a species found in high quality wetlands. The team did not have a chance to survey wetland C or forest A.

2.8 Land Use and Development

2.8.1 Land Cover

Pre-settlement land cover reflected the underlying soil types. Norton Creekshed was predominantly white oak/hickory forest, but oak barrens and mixed wood forests of beach, sugar maple, basswood, and red oak also speckled the landscape (Figure 16). Oakland County, in which Norton Creekshed is based, was named for its abundance of oak trees but rich soils in the area proved more attractive to agriculturalists than lumbermen.

Near the creek and around the soils with slow filtration rates that dominate the eastern and main branch of Norton Creek, tamarack, inland wet prairie, and emergent marsh habitats thrived. Indeed Norton Creekshed harbored plenty of wetlands and marshlands that have since been drained to allow for development. [25]

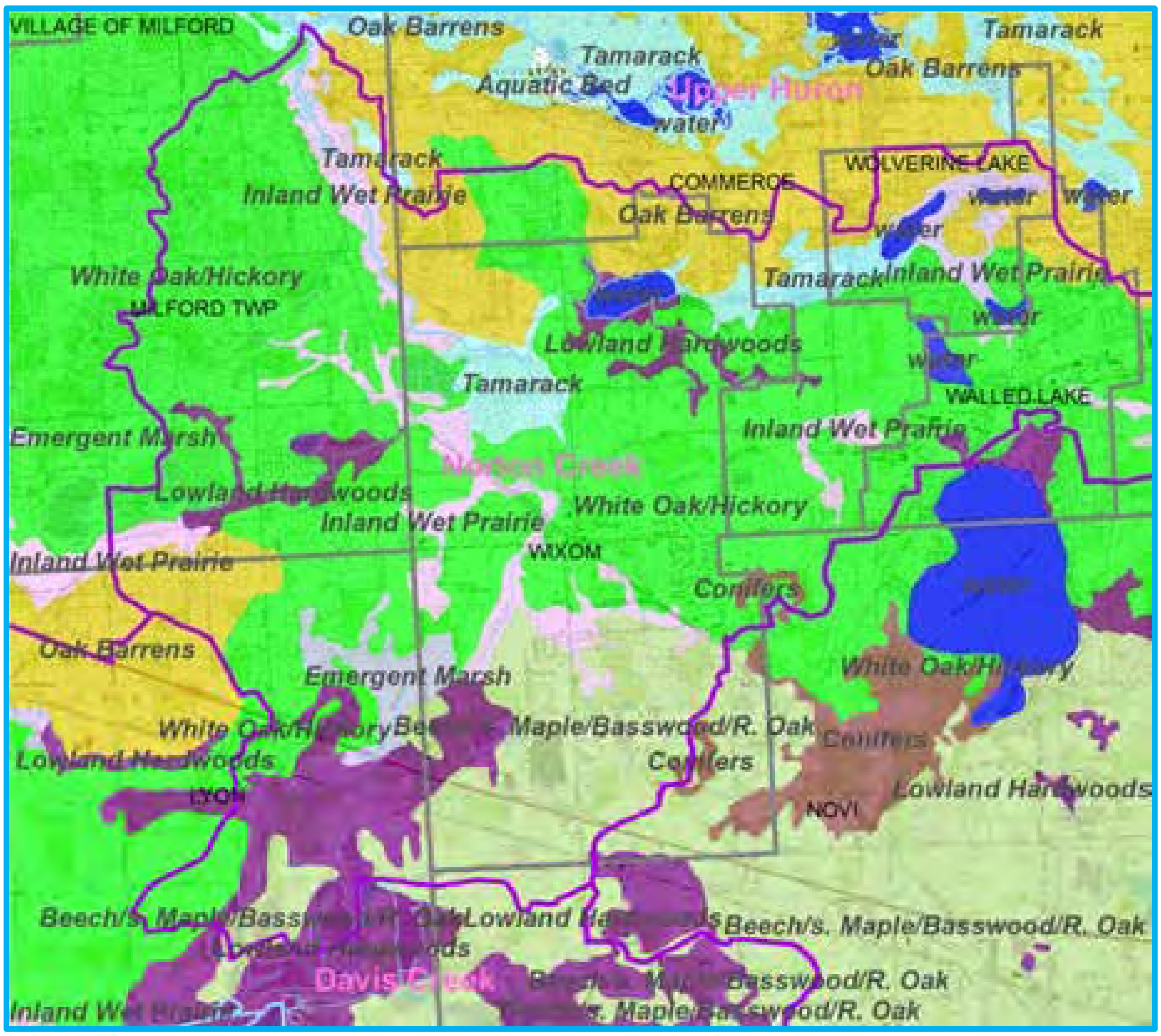

Figure 16: Pre-settlement natural land cover for Norton Creekshed.

The creekshed's forests, wetlands, and grasslands soak up rainwater and runoff, filter pollutants from runoff, and provide wildlife habitat and beautiful places for all to enjoy. As of this writing, only 25% of the creekshed remains as intact natural areas, and less than half of these areas are protected from future development (Figure 17). Those areas that enjoy protections from development include a portion of Proud Lake State Recreation Area, Lyon

Oaks County Park, and Wixom Habitat Park, and collectively these account for about 10% of the modern creekshed land cover. Moving forward, it is critical that communities keep these lands natural, so that the creek does not degrade further.

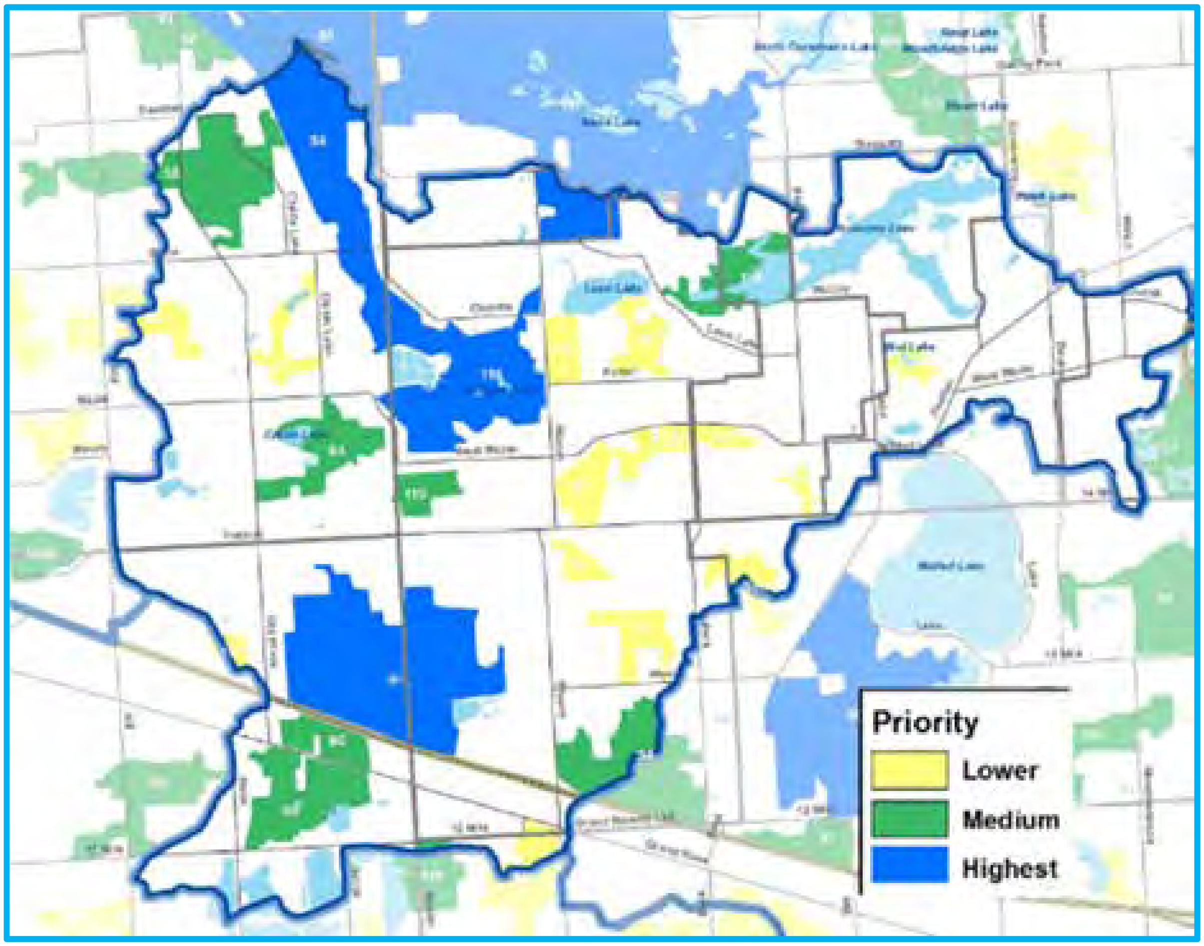

Figure 17: Remaining intact natural expanses coded yellow, green, and blue by order of priority for future preservation.

2.8.2 Wetlands

Wetlands provide many important functions in a watershed from flood storage, critical habitat for numerous plant and animal species (many of which are threatened or endangered), and carbon sequestration, to serving in water quality treatment, flow mitigation and bacteria removal capacities. Notably, wetlands also naturally exhibit low levels of dissolved oxygen, our impairment of concern for Norton Creek.

The Michigan DEQ conducted a Wetlands Functional Assessment for Norton Creek as part of this plan development process (see Appendix A for details). The summary conclusion is that, as of 2005, 54% of the original wetlands in the watershed remain, meaning that 46% (or 1,703 acres) were lost. While this is indeed a large amount of wetland, it is a lower loss rate than for most of Southeast Michigan. Several large intact wetlands remain, notably at the mouth of Norton Creek in the Proud Lake State Recreational Area, in the Wixom Habitat, and in Lyon

Oaks County Park. These large core habitats are identified in green in figure 18 below as high priority conservation targets.

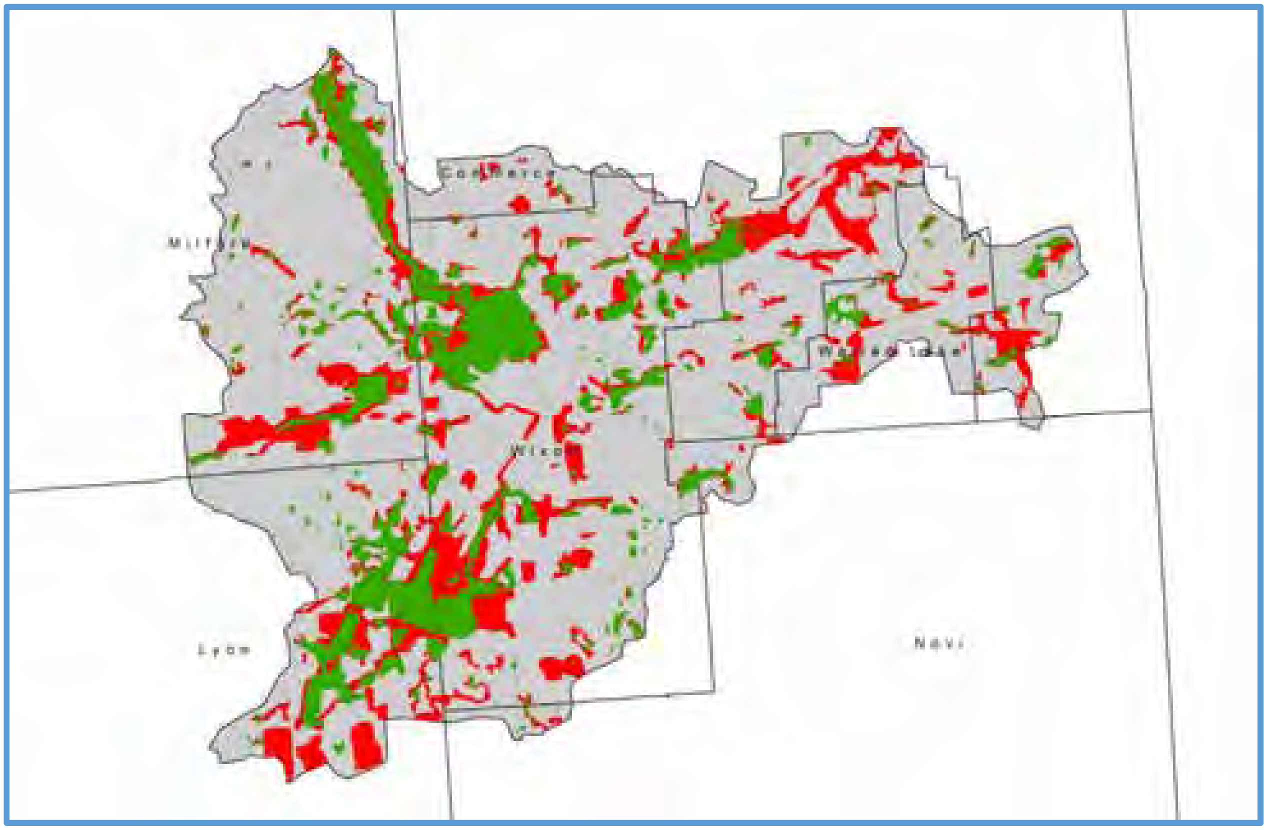

Figure 18: Norton Creek watershed showing remaining wetlands (as of 2005) in green and lost wetlands in red..

2.8.3 Land Use

Land use in Norton Creek watershed ranges from public parks and open wetlands to residential and industrialized sprawl. Residential and urban uses dominate about 62% of the landscape as the primary land use. Open space and wetlands collectively account for about 24%, forests and agriculture each individually cover 5%, and open surface water accounts for the remaining 4% (Figure 19).

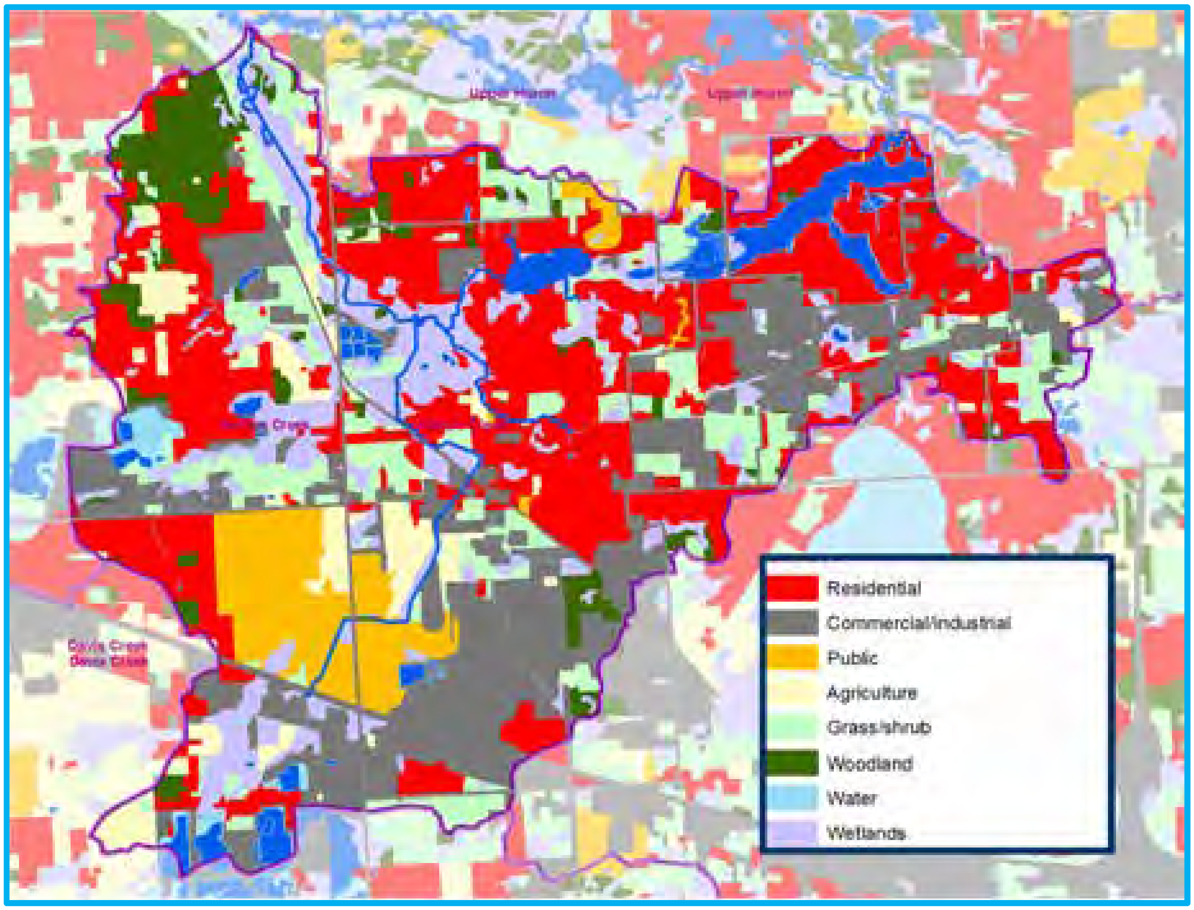

Figure 19: Land uses in the Norton creekshed, as of 2008. Note the cluster of industrial users in the southwest section and the spread of residential uses across the north end of the creekshed.

While land use heavily correlates with impervious surface (as in, more urban uses are typically located in areas with more impervious surfaces), it is valuable to highlight distinctions when considering how storm water runoff is currently regulated across these uses. For example, industrial sites are required to hold individual permits from the MDEQ for storm water runoff, and to develop their own stormwater management plans. Stormwater runoff from residential areas, conversely, is assumed to be covered under municipal stormwater permits held by local authorities (MS4s) and so local governments draft their own stormwater management plans to be reviewed and approved by the MDEQ. Furthermore, agricultural land and forests enjoy exemptions entirely from the National Pollutant Discharge Elimination System (NPDES). Consequently, stormwater mitigation strategies and responsibilities are spread out across the permit holders.

2.8.4 Development

Rapid population growth and urbanization of the creekshed has been a major contributor to the decline of intact natural areas. Although population growth has recently steadied (the city of Wixom only grew about 2% from 2000 to 2010), Norton Creekshed experienced heavy and rapid growth throughout the 1990s which added acres of impervious surface that remains today. Indeed, the City of Wixom's population grew by 58% from 1990 to 2010[26], and SEMCOG

estimates the City of Wixom will grow another 4% over the next 20 years. Notably, Wixom authorities are preparing for an even greater population expansion, indicating in their master plan for the city that they expect the population to be about 16,456 by 2035 (a growth of almost 22% from 2010 population levels).[27]
The result of this rapid growth has been an increase in development and the conversion of open natural areas and wetlands to surface materials like concrete and pavement that prevent water infiltration into the soil. Currently, the total impervious area is estimated to be about 27% or 5.5 square miles (Figure 20).[28]

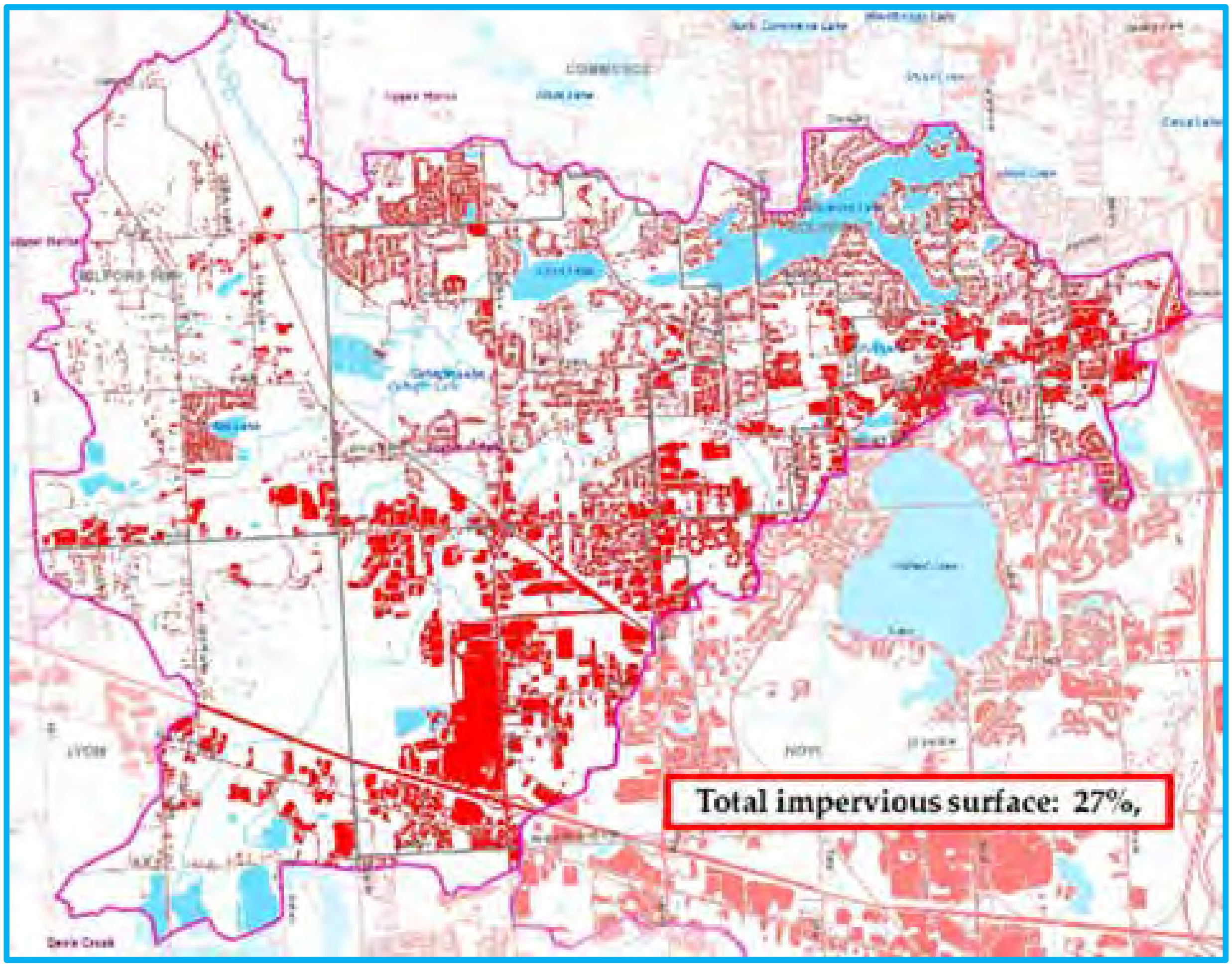

Figure 20: Impervious cover from 2010 aerial image analysis. Red indicates impervious surface coverage across the creekshed. Impervious surfaces can include, among other things, roof tops, sidewalks, roadways, and parking lots.

Extensive impervious surface coverage leads to high storm water runoff when it rains because the water is not allowed to seep slowly into underlying soils, but rather, is directed straight into the nearest creek or drain. Stormwater runoff from parking lots, roof tops, and roads harm the stream by introducing pollutants like E. coli and phosphorus and by creating unstable water flow. Flashy flows erode the stream banks leading to muddy, mucky water conditions unsuitable for supporting diverse aquatic life.

Research indicates that once the impervious cover in a watershed exceeds 10%, surface waters begin to show signs of impairment. Impervious cover over 25% generally results in significant impairment. Furthermore, fish and insect communities are less diverse when the amount of impervious surface exceeds 10-12%. As Norton Creekshed is at 27%, this means that high amounts of rain and pollutants are running off directly into the creek.

2.8.5 Future Projections

Communities are often set on a particular development trajectory based on current land use patterns and future planning objectives. The following sections describe work performed by HRWC staff and partners to predict conditions within the creekshed if no action is taken to rehabilitate and protect the area.

Build Out Analysis

After developing a background on the natural and sociopolitical conditions of the Norton creekshed, staff at HRWC performed a build out analysis to predict the degree of future stressors on the creek's health. Specifically this reveals the percent of impervious surfaces within the creekshed if all development as currently zoned and planned is allowed to proceed. It also is used to predict sediment and nutrient loading (discussed further in Chapter 3). HRWC's buildout analysis revealed that overall impervious surface is only expected to grow by 4%, from 27% to 31% (Figure 21). Most of the developable land in the creekshed has already been built on. However, important riparian areas south of West Maple Road and adjacent to wetland areas west of Childs Lake Road are unprotected from development. These areas should be considered for rezoning or setback provisions to protect important water resources. Further, the rail corridor south of West Maple through Wixom and Walled Lake is likely to eventually build out.

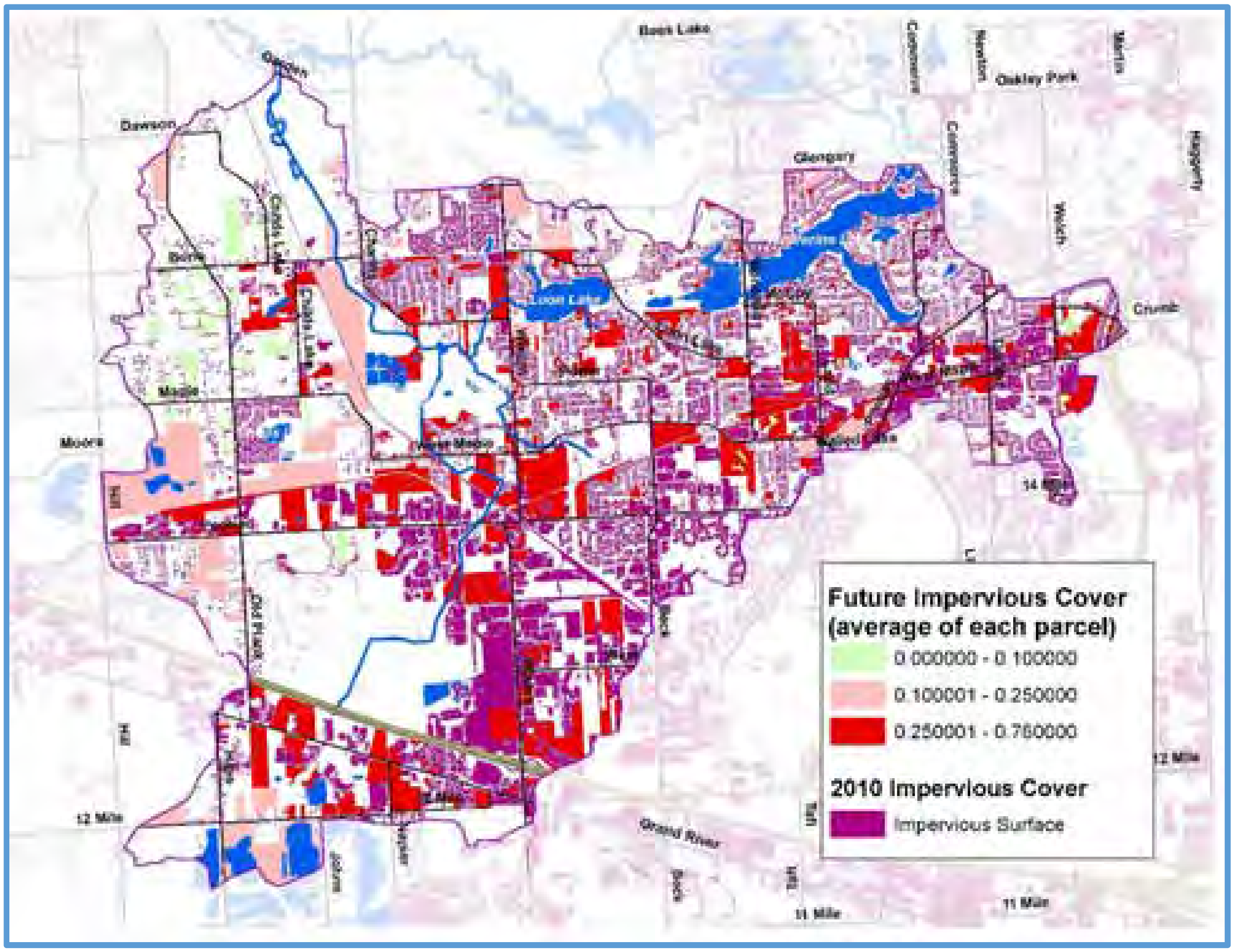

Figure 21: Norton Creek watershed 2010 impervious cover with future additions by percent of parcel cover. Future impervious cover = 31%. Based on local master plans and 2015 Oakland County parcel data.

<u>Point Sources and Stormwater Pollution Permits</u>

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 United States Environmental Protection Agency (U.S. EPA) and MDEQ. Major activities regulated by the state, through the MDEQ, are the alteration/loss of wetlands, pollutant discharges (NPDES permits), control of stormwater, and dredging/filling of surface waters.
In 2008 there were 40 active National Discharge Elimination System (NPDES) permits within the creekshed.[29] As of January 2015, there were 26 NPDES permitted discharges into Norton Creek, representing 25 facilities as one carries more than one permit (Hallite Seals Americas). This list of permits includes one individual permit (IP), three No Exposure certifications (NECs), and 22 general (COCs) industrial stormwater permits (Figure 22).[30]

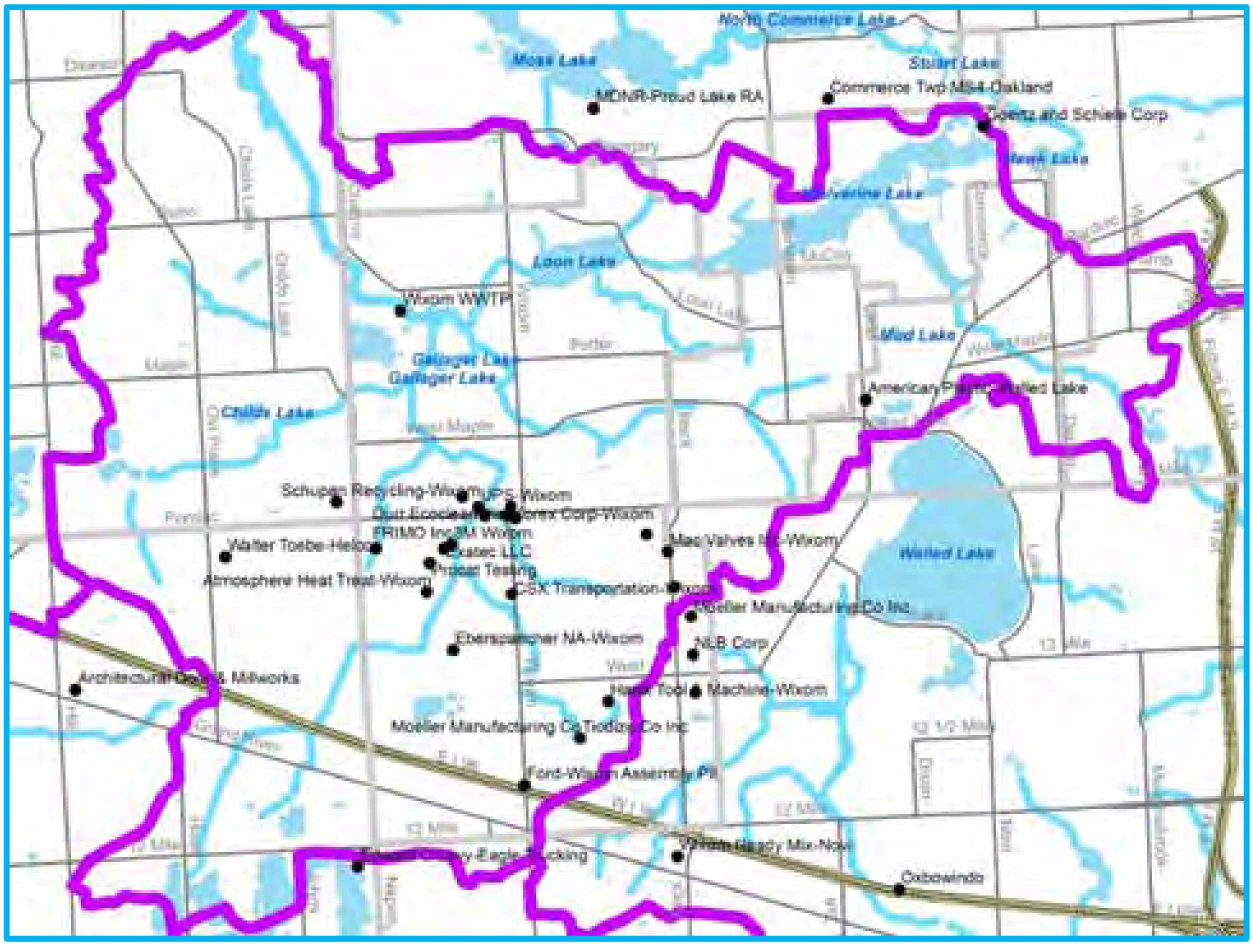

Figure 22: Location of NPDES permit holders in creekshed. Note cluster around the intersection of Wixom and Pontiac roads.

One of the main development features that alters stream structure and function is stormwater conveyance. Cities, road agencies and private developers have devised a number of strategies to convey, store and treat water that runs off the land and into streams. As natural features get developed into human land uses with hard, impervious surfaces, the storm runoff volumes increase and need to be managed in more complicated ways. Under the NPDES program, the Michigan DEQ regulates stormwater management through a permitting system.

Eight municipal separate storm sewer systems (MS4) general permits that were active in 2008 have since expired but communities continue to operate under the conditions of permits granted in 2003. [31] This includes Oakland County, Lyon and Commerce Townships, the cities of Walled Lake, Wixom, and Novi, and the Village of Wolverine Lake. Under these MS4 permits, communities are still expected to develop and implement stormwater management activities that are periodically audited by the MDEQ. HRWC evaluated areas of the watershed that could be targeted for improved stormwater capture and treatment using Green Infrastructure techniques. This analysis is discussed further in Chapter 4.

Within this collection of permits, there are two significant dischargers of note. The first is the defunct Ford Motors plant which still carries a general industrialized stormwater permit. It is notable due to its size and area of soil disturbance. A full one percent of the entire creekshed consists of either impervious concrete, or disturbed and exposed soil located at the site of this retired plant.

The second discharger of note is the Wixom Waste Water Treatment Plant (WWTP) which holds the only individual point-source permit in the creekshed (MI0024384)[32], and which is authorized to process up to 2.89 Million Gallons a Day (MGD) of wastewater. It services both the City of Wixom and parts of Milford Township, and discharges into Norton Creek occur 24 hours a day, 365 days a year.[33 34] The WWTP staff are currently developing plans to expand this facility to meet growing load demands and so the newest permit, granted in 2014, allows for a change in maximum monthly concentrations for certain pollutants if and when the facility commences its upgrades.[35] The WWTP is in good standing with the MDEQ and has had only one permit violation in 2015 which was for excess cyanide in the effluent. (Table 4).[36]

Table 6: Effluent limits and reports for select pollutants for the Wixom WWTP in 2015. Data combined from EPA reporting database and the Wixom 2014 NPDES permit.

	Monthly Average					
Pollutant	December 2014 - March 2015		April 2015		May 2015	
	Max Permitted	Reported	Max Permitted	Reported	Max Permitted	Reported
CBOD5 Load (lbs/day)	440	18.75	350	17	90	16
CBOD5 Concentration (mg/l)	19	1.25	15	1	4	1.13
TSS Load (lbs/day)	700 lbs/day	25.75	700 lbs/day	27	470 lbs/day	32
TSS Concentration (mg/l)	30 mg/l	2	30 mg/l	2	20 mg/l	2.17
TP Load (lbs/year)	1800 lbs/**year**	1372	1800 lbs/**year**	1343	1800 lbs/**year**	1354
TP Concentration (mg/l)	0.4mg/l	0.29	0.4mg/l	0.35	0.4mg/l	0.34
Available Cyanide Load	0.13 lbs/day	0.14	0.13 lbs/day	0.025	0.13 lbs/day	0
Available Cyanide Concentration (µg/l)	5.4 µg/l	11.33	5.4 µg/l	2	5.4 µg/l	0
	Daily Minimum Permitted	Reported	Daily Minimum Permitted	Reported	Daily Minimum Permitted	Reported
DO	6 mg/l	8.53	6 mg/l	8.1	6 mg/l	7.1
pH	6.5 S.U.	7.38	6.5 S.U.	7.3	6.5 S.U.	7.26

Note only the cyanide level violates permit limits for noteworthy pollutants.

Notably, these 26 permits collectively amount to, on average, more than one permit per square mile of drainage area. Indeed, within the entire Huron River watershed, Norton Creek, is among the top three creeksheds for density of environmental hazards, coupled with two, far more urbanized regions further downstream (Figure 23).

"There are two sites within the City that are listed as Part 201 sites in the City of Wixom, as of January 7, 2002. The Kibner Trucking site has been redeveloped as Cut N Care and is located within the southern portion of the City, near the intersection of Wixom Road and West Road. The site is contaminated with lead diesel fuel and cadmium. It is a Category One site, meaning there has not been remedial action, evaluation or interim response taken that has been approved and recorded by the MDEQ. The second site is the Ford Plant on Wixom Road. Because of years of auto manufacturing, portions of the site are contaminated with lead zinc, chromium and cadmium. This site is a Category 3. A category 3 designation means that MDEQ is actively working with the responsible parties to develop a remedial action plan."[37]

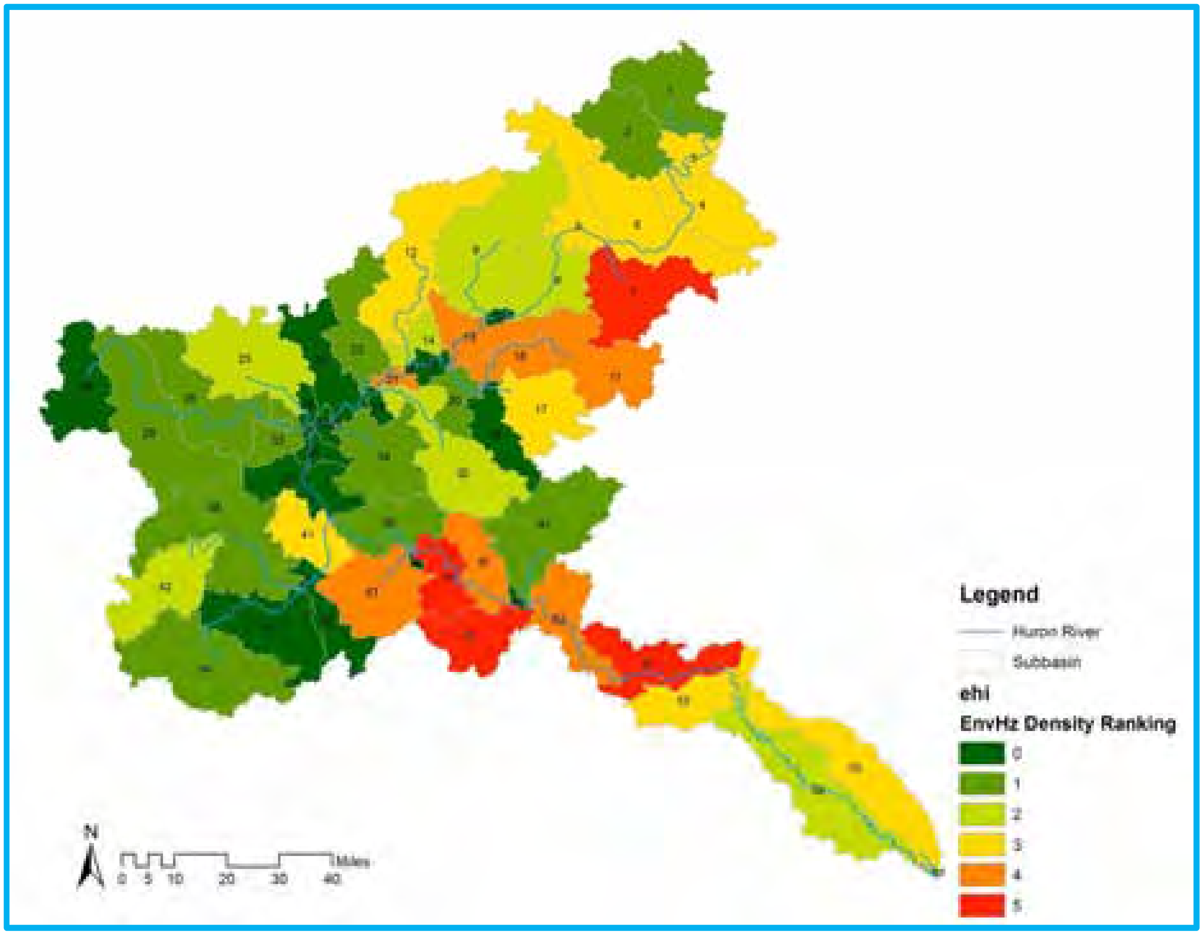

Figure 23: Environmental Hazards density map for Huron River Watershed. Note that Norton creekshed is on par with more urban areas downstream.

Water, Sewer, and Soil Management

Detroit Water and Sewerage Department (DWSD) supplies drinking water to Commerce Township, and the cities of Novi, Walled Lake, and Wixom, and receives sewage water for treatment from Novi and Walled Lake.[38],[39],[40] The Oakland County Water Resources Commission (OCWRC) oversees these DWSD water supply and sewage systems, and also maintains both county-owned sewers, and those under contract with certain cities, villages and townships. [41] This includes Lyon Township's well water drinking supply infrastructure, and the Village of Wolverine Lake water and sewer.[42] The Wixom WWTP manages sewage for the City of Wixom and a small portion of Milford, discharging treated effluent directly into Norton Creek.[43],[44]

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 a great impact on water quality 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). Sanitary sewer systems are superior to individual septic systems, however, because they are more effective in managing contaminants and nutrient effluent. While the majority of Norton creekshed is covered by sewer service, some pockets of private septic use remain (Figure 24).

Improperly functioning privately owned septic systems can also have a detrimental impact on water quality. By leaching 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).

The Oakland County Health Department regulates the design, installation, and repair of privately owned septic systems.[45] In count, this is about 80,000 individual septic systems across the county that require permits for any repair process.[46] Within the Norton Creekshed, both Commerce Township and Lyon Township also have local ordinances that require onsite inspections of private waste systems at time of property sale or transfer. [47] This provides an additional opportunity for structure assessment and maintenance.

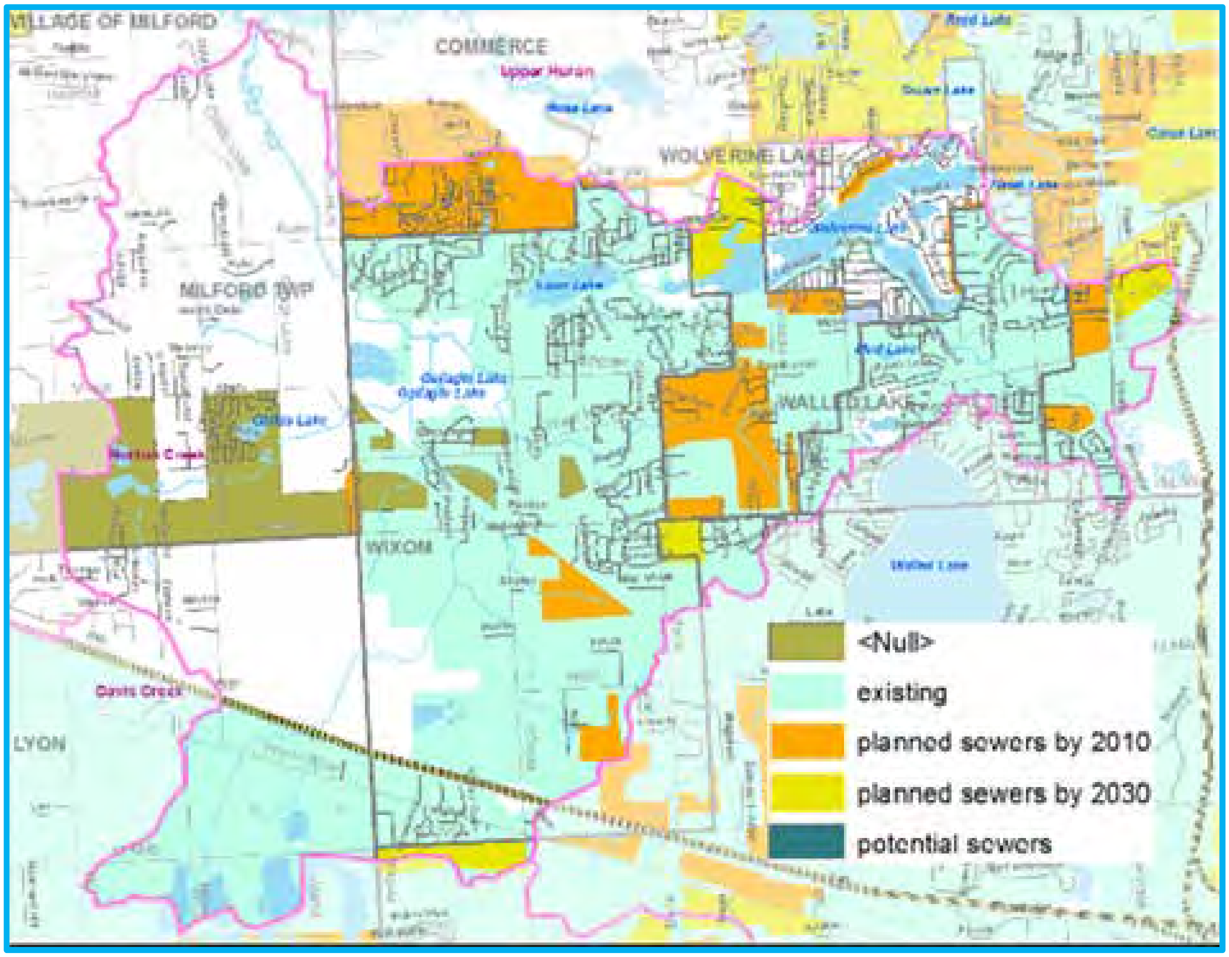

Figure 24: Sewer coverage for Norton creekshed. Null indicates no known information. White areas and those planned for development indicate currently assumed to be serviced by private septic tanks

Portions of Norton Creek are designated as a county drain. County drain systems are designed to provide storm water management, drainage, flood prevention, and stream protection for urban and agricultural lands. The 1956 State of Michigan Drain Code gives the county Water Resources Commissioners authority for construction or maintenance of drains, creeks, rivers and watercourses and their branches for flood control and water management. These water systems become designated as County Drains through a local petitioning process. There are also other “drains” in Oakland County, such as roadside ditches and culverts, that clear water from roadways but these are maintained by the Oakland County Road Commission and/or local public works departments.[48]

OCWRC maintains all county drains in Oakland County. The OCWRC Environmental Team further facilitates and coordinates with the Kent Lake/Upper Huron Sub-watershed Advisory Group to ensure high water quality and compliance with Federal Phase II Stormwater Regulations.[49] This group is also primarily responsible for implementing the KLSMP. As stated earlier, it rarely meets and is not actively coordinating stormwater management.
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, although local governments may also administer this program, and county road commissions typically self-regulate their erosion control. OCWRC, therefore, also oversees soil and sediment erosion control for Lyon and Milford Townships, and the City of Wixom, while Commerce Township administers its own soil erosion permit system but requires applicants also to comply with standards outlined by the OCDC.[50], [51] The Cities of Novi, Walled Lake, and Village of Wolverine Lake also administer their own soil and erosion control programs.[52]

2.9 Economy and Government

2.9.1 Political Boundaries and Structure

Norton Creek drains 24.2 square miles and crosses portions of Commerce, Lyon and Milford Townships, and the cities of Novi, Walled Lake, Wixom, and Wolverine Lake Village (Figure 25).[53] All of the Norton Creekshed is located within Oakland County. The City of Wixom accounts for the largest surface area of the creekshed at 35%, and most of the population within the Norton Creekshed is also concentrated in this city. The US Census calculated the 2010 population of Wixom to be about 13,498.

Figure 25: Political boundaries within Norton Creekshed. Percentages indicate relative surface areas such that, for example, 15% of the watershed lies in Lyon Township while 11% of Lyon Township lies in the watershed

Each local government in the watershed has a unique set of zoning codes, and their own master plans for future development. Working with the guidance of statewide and county procedures, townships and other local governments have the authority to formulate land use and development policy, among other important activities.

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.

Successful implementation of this watershed management plan will require proactive coordination across these separate zoning ordinances and planning departments so that all communities look at the watershed as a cohesive unit worthy of restoration and protection.

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[45] Honey Creek (15)
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[53] TMDL actual (1)

3. Problem Definition

In 2014, HRWC embarked on a 2-year watershed management planning project. HRWC conducted extensive monitoring to identify problem areas and sources, brought together stakeholders to establish an action plan for restoration, and began public outreach and education.

Below you will find a summary description of each of the impairments or water resource problems identified in the Norton Creek watershed. In addition, the critical area of focus for each problem is identified. Following these sections, potential problem sources are described and evaluated.

3.1 Low Biotic Diversity

While MDEQ researchers collected some information on conductivity and total dissolved solids (TDS), the research to develop Norton Creek's TMDL focused heavily on macroinvertebrate communities, and habitat and fish community assessments.[1] Across four assessment sites in the creekshed, MDEQ rated stream habitat as good. Researchers found extensive collections of large woody debris, and some macrophyte stands near wetland locations. Bottom sediment ranges across the creekshed from sand and gravel to soft organic material.[2] Macroinvertebrate community scores ranged from poor to just barely acceptable and MDEQ staff concluded that a macroinvertebrate TMDL would be justified.[3] Fish community scores faired a little better and fell within the acceptable range.

As discussed in section 2.7.1, HRWC monitors aquatic macroinvertebrates at 2 sites in the Norton Creek watershed. The site at Maple Road produces a very low diversity of macroinvertebrates and has below average habitat. The newer site at Gibson Park has a better population of macroinvertebrates, but still below average diversity. The substrate is better at Gibson Park, but riparian cover is poor.

Conclusion: Overall, given the poor biological measures and other contributing factors outlined below, Norton Creek, throughout its western section (i.e. west of the lake chain) should be considered biologically impaired. This is considered the most important impairment as it reflects that the combination of conditions in Norton Creek are not sufficient to support a variety of aquatic life.

3.2 Low Dissolved Oxygen

Low dissolved oxygen is one of the top two concerns for Norton Creek. Indeed, the 2009 TMDL developed by MDEQ identified an 18.8 mile stretch of the creek as impaired for certain designated uses due specifically to low dissolved oxygen (DO) and high sediment/siltation.[4] The 1980 Norton Creek study found that DO levels dipped below the current minimum standard of 5 mg/l in more than one location. The creek also presented with extreme diurnal swings in DO concentration, possibly due to the abundant plant life feeding from the combined effluent of both the Ford Assembly plant and the Wixom WWTP. [5] The 2002 study found smaller diurnal fluctuations than the 1980 study, but researchers still measured DO concentrations below the minimum of 5 mg/l more than 61% of the time. This standard "non-attainment" persisted in both wet and dry weather but was site specific to monitoring just downstream of the WWTP on what is now called ATS Drive. [6]

HRWC monitoring efforts established that, in fact, most of the stream reaches in the Norton Creek watershed fall below DO standards most of the time (see Chapter 2). Based on continuous sampling results, and assuming that those results are representing of conditions in other stream reaches upstream and downstream, all but one reach studied was impaired for low DO greater than 50% of the time (see figure 2-12).

Conclusion: Overall, continuous dissolved oxygen monitoring indicates that all but one stream reach (030002) is impaired for low or absent dissolved oxygen. Since oxygen is necessary for aquatic life, low DO must be considered the next most important impairment as it is likely the proximate cause of low biological diversity.

3.3 High Nutrient Levels

HRWC monitoring efforts established that all sampled Norton Creek reaches appear to be exporting a significant load of phosphorus downstream to the Huron River. However, this phosphorus load is not accompanied by a large suspended solids load, so the phosphorus appears to be mostly dissolved into solution. Total phosphorus levels were extremely high, with mean concentrations ranging between 80 and 283 µg/l. Total Maximum Daily Load (TMDL) limits for phosphorus in regional lakes range between 25 and 50 µg/l.

Conclusion: Norton Creek continues to be a source of phosphorus loading for the Huron River and lakes downstream (like Kent Lake). Some creek reaches may also be impaired by algae growth in summer months as well. The entire watershed (see Chapter 2) should be considered a critical area for reducing nutrient levels, though a primary focus should be on residential areas.

3.4 High Pathogen Levels

HRWC monitoring showed high *E. coli* bacteria colony counts at most of the sites sampled (see section 2.6.4). Mean bacteria levels at some of the monitoring stations exceed the single sample standard of 300 cfu. Such waters present a human health risk to exposure from recreational contact.

Conclusion: The drainage areas to all but three reaches (those coded green or yellow in chapter 2, figure 13) of the watershed should be considered impaired for high pathogen levels. These waters should be included in Michigan's statewide bacteria TMDL. E. coli colony counts at sample sites regularly exceeded the single sample threshold and many sites had average counts above that standard. Norton Creek waters should not be considered safe for full body exposure due to this contamination. Remedial efforts should focus on drainage areas to the impaired reaches.

3.5 High Conductivity and Total Dissolved Solids

As with nutrients and pathogen levels, most of Norton Creek reaches exceeded targets for conductivity and total dissolved solids. In June, 2008, across nine MDEQ sample sites, conductivity readings total for Norton creekshed averaged around 1038 µmhos/com. [7] Conductivity was highest at the intersection of ATS Drive and W. Pontiac Trial, by the current Gibson Park in Wixom, MI and just downstream of the retired Ford assembly plant. [8] Total Dissolved Solids and polychlorinated biphenyls have also been reported as above official water quality standards[9]

HRWC took conductivity and TDS measurements at a subset of sites across the watershed. All samples exceeded 1200 µS/cm for conductivity and 760 mg/L for TDS. These values exceed target desired levels. HRWC did not sample for conductivity and TDS during all sampling visits due to conflicting scheduled use of the measurement sonde. Therefore, much of the watershed is unsampled and cannot be evaluated.

Conclusion: All waters should be considered impaired for conductivity and TDS, however, further sampling is needed to confirm levels at many stream reach sites. Critical areas cannot accurately be defined until sampling is complete.

3.6 Potential Sources of the Problems

In developing the 2009 TMDL, the MDEQ used a DO modeling process that identified sediment oxygen demand (SOD) as the leading cause of DO depletion in Norton Creek. Plant respiration and biochemical oxygen demand (BOD) from the Wixom WWTP and non-point sources were thought to play smaller roles. As the MDEQ staff explained, "any solids settling from such a highly treated effluent [from the WWTP] are expected to contribute significantly less SOD than more readily degraded, untreated settled solids from NPS such as pet waste, detritus, or rich organic soils."

In its investigation, HRWC identified the five significant impairments listed above. Given the weight of all the sampling data evidence, it is difficult to conclude that all the impairments can be connected to just one source. It is unlikely that *any* of the impairments have been caused by any one source.

In order to evaluate the impairments, the range of potential impairment sources will be identified, and then each impairment will be considered sequentially from the top of the pyramid of stream function (biology) to the bottom (geology and climate).

3.6.1 Anthropogenic Sources

Increased impervious surfaces due to regional development is a clear anthropogenic source for the problem of high stormwater runoff into Norton Creek and erosion of stream bank and bed materials. This can indeed lead to accumulation of sediments and high SOD, which consumes oxygen. However, there are many other potential human sources of dissolved oxygen loss, as well as additional sources for the other listed impairments.

Anthropogenic sources of impairments can include (but are not limited to) the following:

- Stream alteration
- Hydrologic alteration
- Direct pollutant/nutrient applications
- Improper disposal of waste
- Pet waste pathogen sources
- Point-source discharges
- Chemicals and pollutants in runoff
- Illicit discharges or dumping
- Failing septic systems or waste water treatment
- Agricultural runoff

3.6.2 Natural Sources

Aside from run-off conditions, the natural state of the creek can provide challenges to improving DO concentrations. Riffles and rapids are valuable features that provide the turbulence necessary to re-introduce atmospheric oxygen into water systems. Additionally, faster flowing streams prevent algae, and dead biomass from accumulating as a feast for aerobic bacteria to decompose.[10], [11] Since rapids are one of the primary sources of dissolved oxygen capture for streams, a low-gradient, slow-flowing stream like Norton Creek is naturally challenged to maintain concentrations of dissolved oxygen suitable for aquatic wildlife. Indeed, hypoxia is typical in low gradient streams or areas with high concentrations of wetlands.[12] Similarly, wetland areas (something pervasive across the Norton Creekshed) are naturally low in DO.

There are also natural sources of pollutants. Wildlife accessing streams and even inhabiting storm drains can contribute nutrients and bacteria contamination. Frequent access to streams by wildlife can also contribute to erosion. Finally, high-mineral soils can lead to higher conductivity and TDS, though typically natural conditions do not exceed state standards.

3.6.3 Source Assessment

Table 1 below lists each impairment identified in sections 3.1-3.5 along with potential sources and causes in order of likelihood or priority. Each section is followed by a summary of findings and analysis of most likely or highest priority sources and causes.

Table 1. Assessment of Sources and Causes of Norton Creek Impairments

Impairment 1: Low biota diversity	
Sources	**Causes**
1. Low dissolved oxygen	See impairment 2.
2. Poor substrate quality	Sedimentation Lack of sediment transport Low-gradient, wetland context Channel maintenance
3. Lack of habitat diversity	Channelization and maintenance Low-gradient wetland context
4. Lack of perennial flow	Low-gradient stagnation Disconnection from groundwater input Flow alterations Flashy runoff from urban land
5. Excessive algae growth	Excessive nutrients, especially phosphorus (see impairment 3) Poor riparian cover Low flow
6. Excessive pollutants	Lack of runoff controls Illicit discharges or dumping Road salt runoff and groundwater transport

Low diversity in aquatic macroinvertebrates at Norton Creek sites is likely due to a number of factors. Primarily, without oxygen, living things cannot survive long. If oxygen can be returned, the next focus should be to restore habitat quality and diversity in reaches where it is naturally appropriate. There are a number of reaches, however, that run through wetland complexes. These areas are unlikely to sustain habitat and flow to promote diverse biota, but areas for refuge could be located. Once oxygen and habitat are addressed, the other sources should be further investigated if aquatic biota do not recover.

Impairment 2: Low dissolved oxygen	
Sources	**Causes**
1. Oversized channels (no aeration)	Channel alteration (widening or deepening) Low-gradient, low energy context Altered hydrology
2. Low channel diversity (no aeration)	Channel alteration (straightening) Low-gradient, low energy context
2. Low flow	Channel alteration Altered hydrology Groundwater disconnection Low-gradient, low energy context
3. Sediment oxygen demand	Sediment deposition Lack of sediment transport Past or current erosion
4. Biological oxygen demand	Excessive algae growth Excessive nutrient runoff Wetland macrophyte consumption Excessive bacteria

Based on the data gathered, it appears that the lack of oxygen in most of the Norton Creek reaches is caused by one of two processes. First, in the upper and western part of the watershed, and in reaches leading to the lake chain, the stream channels have been altered to become overwide, overdeep or simply too straight. In places, they do not have a small enough channel to transport sediment (leading to high SOD) or aerate. In other places, the diversity is lacking to provide turnover and aeration. Flow alteration alone is not the likely culprit in these places as the hydrology is not flashy. The second process may be occurring in the lower part of the watershed, especially through the Wixom habitat through to the mouth of the system. Here, sedimentation from past flow alteration, erosion and deposition into a low-gradient wetland context is likely leading to high SOD and stagnation. Finally, flow has been artificially limited out of the chain of lakes (exiting via Loon Lake), and instead directed out of Wolverine Lake, robbing the system of additional flow that could create aeration in the current channel dimensions. Those channels likely formed in response to larger flows from the complete watershed.

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

Given that there was little evidence found for erosion at the current time, the excessive phosphorus levels are likely entering the system in dissolved form, rather than bound to sediment or from stream banks or bottoms. The most likely culprit is excessive fertilizer use and runoff. The highest phosphorus concentrations were downstream of residential areas. Pet concentrations are also higher there. Failing septics may contribute in the far western portion of the watershed. There is little evidence of excessive contributions from the WWTP, as the highest phosphorus concentrations occur upstream of the facility.

Impairment 4: Pathogens	
Sources	**Causes**
1. Pet and wildlife waste	Wildlife in storm drains Improper disposal of pet waste (runoff from paved areas) Ponds increase habitat for waterfowl, wildlife
2. 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
3. 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
4. Illegal/improper septage application	Lack of adequate septage disposal facilities

Norton Creek is not different than other urban or urbanizing areas across Michigan with regards to high bacteria levels. At this point in time, it has been determined that the stream reaches receiving waters from urban or suburban areas are consistently high in *E. coli* bacteria concentrations. There has not been a source investigation, so source identification must be limited to extrapolation from findings in other similar watersheds. If Norton Creek is typical, the main sources of bacteria will be pet and wildlife waste. A portion of the watershed remains on septic systems, and those could be sources, as could illicit discharges.

Impairment 5: High Conductivity and TDS (i.e. Salts, Organic Compounds and Metals)	
Sources	**Causes**
1. Roads	Salt application Auto emissions Poor road maintenance
2. Legacy pollution	PCBs and contaminants from the former Ford plant Illegal dumping
3. Developed areas	Lack of stormwater BMPs Waste incineration (atmospheric deposition) Illegal dumping Illicit connections
4. Turfgrass chemicals from residential, commercial lawns	Improper lawn care Illegal disposal
5. Legacy agriculture applications	Chemical applications from former farm operations

Only a limited amount of conductivity and TDS data has been collected thus far. There has not been a source investigation, so source identification must be limited to extrapolation from findings in other similar watersheds. If Norton Creek is typical, the main source of high conductivity levels are road salt applications for de-icing. Studies in other parts of the Huron River Watershed link high conductivity to road salts. Some national studies suggest that road salt may be migrating through ground water, leading to high levels in summer as well as winter. The former Ford plant was investigated and a remedial plan to clean up pollution sources was implemented. Other potential sources would require further investigation.

3.7 What is a TMDL?

When a water body is not attaining Water Quality Standards (WQS) for designated uses, it is put on the EPA's 303(d) List, according to the Clean Water Act, and is required to have a Total Maximum Daily Load (TMDL) developed. The TMDL is a policy document that requires the MDEQ to establish controls to reduce pollution and restore the quality of the resource. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. It is a document which presents available information to determine potential sources of contaminants.

As of the 2016 303(d) List of Nonattaining Waterbodies, Norton Creek remains listed for a water quality impairment for a lack of sufficient dissolved oxygen. The Norton Creek TMDL, which specifically targets sediment loading, was completed by the MDEQ in 2009 (see Appendix B).

3.7.1 Designated Uses and the TMDL

Following requirements in the federal Clean Water Act, the State of Michigan established designated uses for all state waterways, as listed below. The designated uses that apply to the Norton Creek are in boldface[13]:

- **Agriculture**
- **Industrial water supply**
- **Navigation**
- **Warmwater fishery**
- **Other indigenous aquatic life and wildlife**
- **Fish Consumption**
- Partial body contact recreation
- Total body contact recreation between May 1 and October 31
- Coldwater fishery (natural temperatures are too high)
- Public water supply at the point of intake

3.7.2 A TMDL for Dissolved Oxygen

Several studies throughout the last 20 years have found Norton Creek persistently low in dissolved oxygen (DO) and high in sediment and siltation, both of which lead to poor habitat quality for aquatic wildlife. State water quality standards (WQS) mandate a minimum DO concentration of 5 mg/L for Norton Creek but data reveals consistent non-attainment of this standard. Consequently, the Michigan Department of Environmental Quality (MDEQ) listed Norton Creek as an impaired water body because it did not fulfill three of its designated uses as 1) a warm water fishery, 2) a viable habitat for other indigenous aquatic life and wildlife, and 3) fish consumption.

Portions of the Clean Water Act (CWA) and United States Environmental Protection Agency (EPA) regulations require states to establish pollutant loading limits for waterbodies not meeting WQS, and so, in 2009, MDEQ published a Total Maximum Daily Load (TMDL) for Norton Creek, identifying sediment oxygen demand (SOD) as the primary cause for low DO and calling for an 84% reduction in sediment loads along a three mile segment of the creek. Reduction in sediment loads, therefore, is expected to help the creek achieve DO WQS and improve habitat conditions for native aquatic wildlife. The presence of Polychlorinated Biphenyls (PCBs) in the water column and high levels of total dissolved solids (TDS) were also both mentioned as possible causes of impairments to fish consumption, and other indigenous aquatic life respectively but these conditions were not addressed by the 2009 TMDL and, consequently, await the development of their own TMDLs.[14]

3.7.3 Other TMDLs

The DO TMDL is the only currently active TMDL covering Norton Creek. The other impairments identified in this plan may also require a TMDL to provide a regulatory framework to ensure the impairment is addressed.

A TMDL for biota impairment may or may not be necessary. The primary sources of biota impairment identified in this plan would be addressed by implementation to address the DO TMDL. Namely, if channel flow and diversity can be restored, thereby re-aerating the stream reaches and restoring oxygen, stream habitat would be improved at the same time. That would alleviative the top three sources of biota impairment. If after that, biota diversity does not improve, a TMDL to address the proximate source may be needed.

A TMDL may be needed to address the phosphorus impairment. The DEQ has never developed a TMDL for a river or creek end-point and there is not a numeric water quality standard for phosphorus in streams. TMDLs have generally been developed for lakes or impoundments with nutrient impairments, as, ultimately, lakes will suffer more severe consequences such as massive fish kills following large-scale algae blooms. It may be more appropriate to revisit the Kent Lake TMDL. If that body is deemed impaired again, recommendations in this plan could be applied to deal with phosphorus loading from Norton Creek.

The pathogen impairment should be addressed by adding Norton Creek to the statewide bacteria TMDL. That policy makes broad prescriptions for assessing and reducing bacteria sources that are carried through in this plan.

Similarly, the DEQ should consider drafting a statewide TMDL for total dissolved solids. Norton Creek is not unique as an urbanizing watershed with high conductivity and TDS levels. The effects of road salt accumulation are just now getting more thoroughly investigated nationally. A statewide TMDL could assure that these areas engage better management and control of that emerging pollutant.

Chapter 3 References and Endnotes

[1] TMDL 2007/2008 assessment (2)
[2] TMDL 2007/2008 assessment (4)
[3] TMDL 2007/2008 assessment (4)
[4] TMDL actual (2)
[5] TMDL actual (3)
[6] TMDL actual (3)
[7] TMDL 2007/2008 assessment (10)
[8] TMDL 2007/2008 assessment (10)
[9] TMDL actual (2)
[10] Ohio Storm Water Training Council. *Recommended Best Management Practices for Dissolved Oxygen and Organic Enrichment: Total Maximum Daily Load Fact Sheet*. N.d. Web. 11 June 2015. <http://www.neohiostormwater.com/uploads/3/0/9/8/3098302/fact_sheet_do_oe_-_final.pdf>.
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[12] Kerr, Janice, Darren Baldwin, and Kerry Whitworth. "Options for managing hypoxic blackwater events in river systems: A review." *Journal of Environmental Management* 114 (2013): 139-147. Web. 11 June 2015. < http://ac.els-cdn.com.proxy.lib.umich.edu/S0301479712005178/1-s2.0-S0301479712005178-main.pdf?_tid=ccacaf72-009b-11e5-896f-00000aab0f6b&acdnat=1432310665_3472ac133849fe07564c962b38269b87>.
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4. Strategy and Action Plan

4.1 Plan Development Process

HRWC developed this Management Plan for Norton Creek by undertaking a massive data collection effort and then engaging watershed stakeholders in a variety of ways to discuss watershed impairments, their likely sources, possible actions and solutions, and cost-effective short and long-term strategies.

4.1.1 Stakeholders

To ensure that recommended actions and strategies from the final plan would be implemented, HRWC invited representatives from all stakeholder institutions within the Norton Creek watershed that it was aware of. These institutions and organizations included the following:

Commerce Charter Township
Milford Charter Township
Michigan Department of Environmental Quality
Oakland County Parks
Oakland County Planning
Road Commission of Oakland County
Oakland County Water Resources Commissioner
City of Walled Lake
City of Wixom
Village of Wolverine Lake
Huron River Watershed Council

4.1.2 Stakeholder Engagement

Over the course of plan development, the HRWC team invited and recruited stakeholders to contribute to the watershed plan development at two important points. First, stakeholders were invited to provide their observations about the watershed after the HRWC presented initial findings from sampling and information collection. The team sought observations on strengths (things they liked), weaknesses (problems and issues), opportunities (goals for use and projects), and threats (future development and potential problems).

Second, stakeholders were invited back to review the HRWC plan team's development of summary conclusions and action recommendations. The stakeholders were invited to provide feedback on the feasibility of specific recommendations and suggest others that would fit within the overall strategy.

These stakeholder meetings included representation from all the stakeholder organizations listed in section 4.1.1, and also included general public participants. Building off communication around the public survey (see below), a marketing effort was engaged to recruit broad participation from residents across the watershed.

The team also formed a smaller Advisory Team that was asked to meet several times in between stakeholder meetings to provide feedback, and then were also asked to review the draft plan. Members of the Advisory Team are included in the acknowledgements and in chapter 1.

4.1.3 Public Survey

A public survey was developed and sent to 1000 inhabitants of the Norton Creek watershed. The purpose of the survey is to discover how residents of Norton Creek perceive the quality of water in their area, how they make decisions for their property, and if they are willing to change their behavior to protect their local water. The questionnaire is designed to measure five leading indicators:

1. The level of concern about pollution
2. Individual characteristics and barriers to behavior change
3. Understanding of the role between stewardship and water quality
4. Trusted sources of information
5. Preferred method(s) for receiving information

A stratified random approach was used for selecting addresses. Respondents mailed surveys to HRWC, and the survey data were entered into the Social Indicator Planning and Evaluation System (SIPES), an online platform for nonpoint source management. Respondents also had the option to enter their results directly into the SIPES platform instead of mailing the survey back. The overall response rate for the survey was 29%. Details on the survey methodology and extensive results can be found in the survey report in Appendix D. Key findings from the report are included below.

- Most respondents indicate that the quality of their local water is good even though it is listed by the State of Michigan as impaired. Most do not recognize stormwater run-off or channelization as being a problem in their area even though water quality studies show these two issues as being the primary sources of this area's water problems.
- While most respondents connect their behavior to water quality and recognize the importance of maintaining clean water, and even express willingness to change behavior, fewer than half would be willing to pay more (fees/taxes) to improve the local water. However, most did not highlight cost as a constraint to adopting their own practices.
- Most respondents indicate that they would be willing to do activities to protect their water yet many are unaware of the actual the problems with their local water or the solutions they can take to help solve them.
- Home owners knew more about where water run-off goes but their other responses about their knowledge of water quality and appreciation for water were comparable to renters.
- In comparing the sample (respondents) demographics to US Census data, more men, more educated, and more homeowners participated in the survey.
- Overall, respondents have a low awareness level of water quality issues yet they care about their local water. Their willingness to take actions to improve water quality is

moderate and their constraints to adopting various water protection practices are low. Current behaviors for using the practices are also low.

4.2 Goals and Objectives

4.2.1 Beneficial Uses

Ultimately, the goal for all watershed plans should be to restore all surface water functions and beneficial uses. Following requirements in the federal Clean Water Act, the State of Michigan established designated uses for all state waterways, as listed below. The designated uses that apply to the Norton Creek are in boldface[1]:

- **Agriculture**
- **Industrial water supply**
- **Navigation**
- **Warmwater fishery**
- **Other indigenous aquatic life and wildlife**
- **Fish Consumption**
- **Partial body contact recreation**
- **Total body contact recreation between May 1 and October 31**
- Coldwater fishery (natural temperatures are too high)
- Public water supply at the point of intake

4.2.2 Specific Goals for Norton Creek

The overall goal for management of the Norton Creek watershed is to achieve all state water quality standards and allow Norton Creek to be fishable, drinkable (with standard treatment) and swimmable. The primary objective of this watershed management plan is to address stream morphology constraints and stormwater runoff to achieve the WQS for dissolved oxygen by maintaining levels above 5 ppm in all perennial streams. Data show that Norton Creek has been significantly altered to such a degree that it no longer is able to achieve turbulent flow that would mix and re-oxygenate the water. Also, in some reaches, current stormwater treatment is returning insufficient flow to groundwater for stream recharge. Source-related goals include the following:

- Opportunistically develop and implement designs to restore critical morphological dimensions to stream channels that can increase downstream oxygen levels; and
- Pilot the design and installation of Green Infrastructure practices in developed areas of the watershed to infiltrate stormwater and increase groundwater flow.

Ultimately, restoring dissolved oxygen to the Norton Creek watershed is a transitional step needed to restore the biological diversity. Data suggest that quality habitat is present to allow for the repopulation of macroinvertebrates and fish if oxygen is restored to life-sustaining levels.

Secondary objectives include the reduction and eventual elimination of other potential impairments in the watershed. These objectives include the following:

- Reduce nutrient (phosphorus) loading across the watershed;
- Reduce or eliminate the sources of bacteria and other human pathogens; and
- Reduce or eliminate the sources of road salt or other contributors to high conductivity and total dissolved solids levels.

Secondary objectives will be met by first understanding the direct sources of these pollutants. Then, recommended actions can be set to reduce nonpoint source loading of nutrients, increase public awareness and involvement in watershed planning and management, gain broad implementation of watershed plan strategies, and continue monitoring and data collection for water quality, water quantity and biological indicators.

Measures to improve dissolved oxygen levels and reduce nutrients and *E. coli* will include some activities that, are already required of the National Pollutant Discharge Elimination System (NPDES) municipal storm water permittees within the watershed under Michigan's municipal storm water permitting program. Currently, the City of Wixom, and most of the other municipalities in the watershed hold NPDES Phase II municipal storm water permits. Oakland County holds a separate NPDES Phase II municipal storm water permit, as well. With the City of Wixom acting as the local government agency with jurisdiction over the majority of land in the watershed, some of the lessons learned about stormwater management practices will need to be transferred to and adopted by Wixom.

Municipal storm water permits for county agencies like the Water Resource Commissioner and the Road Commission provide mechanisms for controlling runoff loads to Norton Creek and its tributaries. Storm water permits require that a plan for effective elimination of illicit discharges and prohibition of illicit discharges be developed, that all catch basins be mapped and regularly cleaned, that effective storm water management in areas of redevelopment and new development occur, and that a public education program regarding storm water management and impacts of storm water pollution be implemented. Further, the Water Resources Commissioner controls many reaches of Norton Creek as designated county drains. That agency can help facilitate restoration and alter management practices to improve conditions.

4.3 Watershed Improvement Strategy

After conducting 1) extensive background research, 2) a watershed-wide environmental study, 3) morphological desktop and field surveys, 4) road-stream crossing and upland neighborhood surveys, 5) MDEQ wetlands assessment, and 6) extensive stakeholder outreach and input gathering, the HRWC planning team was fully informed about the watershed and in a strong position to recommend a strategy of actions to address the dissolved oxygen impairment, as well as the other problems identified in chapter 3.

The team looked at a range of possible activities with the goal of establishing a strategy that could be reasonably expected to be accomplished within 5 years and result in the elimination of the dissolved oxygen impairment or significant improvement towards such elimination and also make progress on other identified problems. The team evaluated the feasibility and likely effectiveness of activities of the following types:

- Structural and other physical improvement projects
- Policy changes
- Education
- Additional planning
- Monitoring and other information collection to fill gaps

Finally, the team prioritized activities that would 1) have a good likelihood of improving dissolved oxygen levels in Norton Creek, 2) reduce nutrient, pathogen or pollutant levels, or 3) provide information on pollutant sources that could be eliminated. The table on the following page outlines the five-year (short-term) strategy with highest priority activities followed by secondary priorities, as well as a ten-year or beyond (long-term) strategy with longer-term, more difficult to implement, or more expensive activities.

The short-term (5-year) strategy was developed in detail and includes all primary and secondary priority activities. The cost of this strategy is estimated at $655,000 to $2,865,000. The expectation is that, by completely employing this short-term strategy, dissolved oxygen will be restored to most stream reaches, nutrients will be significantly reduced, bacteria from human, pet and agricultural sources will be significantly reduced or eliminated, and sources of charged ions (conductivity and TDS) will be identified for remediation. These reductions should be sufficient to improve water quality to meet state standards, and improve habitat to allow the return of biota diversity. If monitoring shows this not to be the case, tertiary priority activities are proposed to reduce other sources.

Table 1. Summary of the initial 5-Year Watershed Improvement Strategy, 2018-23

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2018-2023	Lead Agency*	Success Measures
1A. Develop restoration and Green Infrastructure Opportunities Assessment	All/ multiple	2017*-2018	$8,000	HRWC	Opportunities identified that lead to projects in 1B and 1C
1B. Targeted stream channel restoration	DO, biota/ channel alteration	2018-23	$250k - $1,500k	HRWC, Wixom, Oakland County	Increased DO levels; improved channel morphology; biota monitoring
1C. Targeted Green Infrastructure Development and Retrofit Program	All/ Runoff	2018-23	$200k - $1,000k	HRWC, Municipalities, Oakland County	Increased baseflow; reduced nutrient and bacteria concentrations; monitoring
1D. Rules and Ordinances for Storm Water Management	All/ Stormwater	Update in 2018	Not tracked	OCWRC	Reduced runoff and nutrient/bacteria concentrations; monitoring
2A. Information and Education Strategy	All/ Multiple	2018-21	$64,000	HRWC, municipalities, Oakland County	Impairment knowledge from survey; participation rates, monitoring
2B. Buffer Enhancement Program	Runoff/ Multiple	2019-23	$40k - $200k	HRWC, Oakland County, municipalities	Linear feet established; % streams properly buffered; monitoring
2C. Canine source detection	Bacteria/ Human	2019-20	$10,000	HRWC, Wixom, OCWRC	Linear feet inspected; sources identified
2D. Investigate sources of high conductivity and TDS	TDS/ point sources	2020-21	$8,000	HRWC, Wixom, OCWRC	Identification of source constituents and potential point sources
2D. Illicit discharge elimination program	Nutrients, Pathogens/ Human	Ongoing	$30,000^	Oakland County, municipalities	% sources eliminated; bacteria cfu reduced

Activity	Impairment/ Source Reduced	Implementation Timeframe	Cost Estimate 2018-2023	Lead Agency*	Success Measures
2E. Storm Drain Marking Project	Stormwater	2019-20	$21,000	HRWC, OCWRC, municipalities	% drains marked; call volume; monitoring
2F. Targeted enforcement of phosphorus fertilizer law	Nutrients/ runoff	2018-20	$10,000	MDEQ, Wixom	Violations eliminated; lbs TP removed; TP monitoring
2G. Pooper Scooper Ordinance and education	Pathogens/ Pet waste	2020-22	$18,000	Wixom, other municipalities	Ordinance passed; call volume; violation #
2H. Doggie Bags at target locations	Pathogens/ Pet waste	2020-23	$15,000	OC Parks, municipalities	Stations established; use rate; pounds removed; monitoring
Short-term, Primary & Secondary Projects	**Total**	**2018-23**	**$674,000 - $2,884,000**		
3A. Septic Inspection, Education and Remediation Program	Pathogens/ Human	2020-25	$27,000	OC Environmental Health	Inspection call rate; annual septic remediations
3B. Wetlands Restoration and Protection Program	All/ Stormwater	2018-30	$2,200/ac + $15,000	Wixom, other municipalities	Reduced runoff and bacteria concentrations; monitoring
3C. Protect Priority Conservation Areas	All/multiple	2018-2025	TBD	All partners, land conservancy	Protect terrestrial and aquatic habitat; improved filtration
3D. Goose Control Program	Pathogens/ Wildlife	2018-25	TBD	Municipalities, OC Parks	Goose population estimates; bacteria monitoring
3E. Native Landscaping Ordinance Development	Nutrients, pathogens/ stormwater	2020-25	$5,000	Municipalities	Ordinance developed; natives planted; monitoring

*Activity underway by HRWC funded by a separate grant award. Some results included in this Watershed Management Plan

^ Part of required Stormwater Phase II program

4.4 Five-year Strategy

4.4.1 High Priority Projects

The below projects have the greatest likelihood of successfully restoring dissolved oxygen and improving biota diversity in Norton Creek

1A. Develop restoration and Green Infrastructure Opportunities Assessment

The first recommendation is an activity that has already been completed. It is included as part of the strategy to acknowledge its importance. HRWC developed a process to incorporate available geographic, aerial and other remotely collected information to identify opportunities for Green Infrastructure projects for stormwater treatment and conservation of natural areas. A final report detailing this GI analysis and assessment is included in Appendix F. Figure 1 below shows the map of stormwater opportunities.

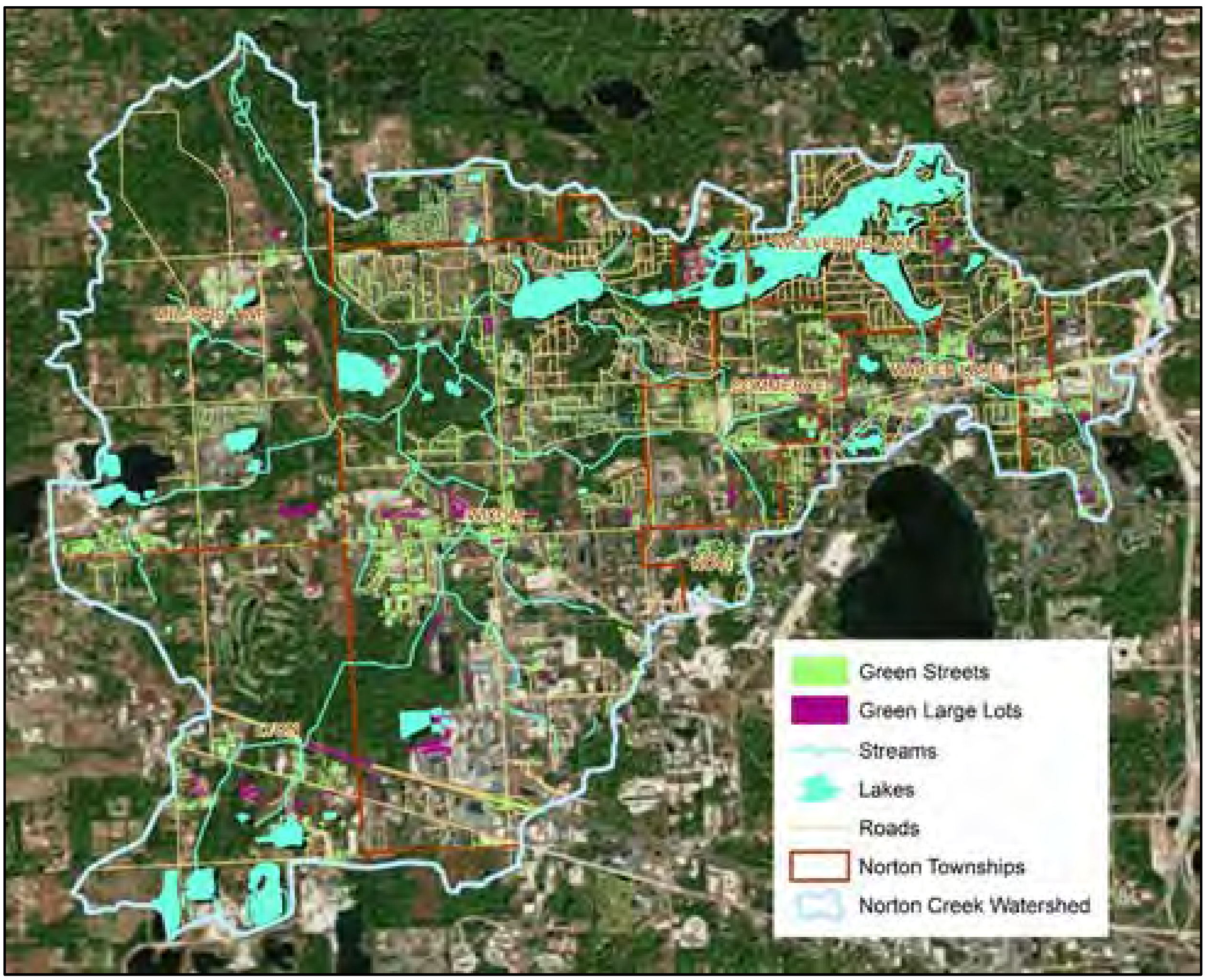


Figure 1. Norton Creek Green Infrastructure Opportunities Map for stormwater, showing locations that offer reasonable opportunities for projects to capture runoff from streets and large parking lots.

Timeframe: 2017

Cost: $8,000 for staff time to conduct analysis and develop report.

Potential funding sources: Michigan SAW grant, Wildlife Conservation Society grant
Success Measures: Implementation of projects in recommendations 1B and 1C.

1B. Targeted stream channel restoration
The second step towards remediation and climate resilience is stream channel restoration. A restored channel, with a more moderated delivery of stormwater to the river provided by GI efforts, will provide the river itself with the ability handle climate-related impacts. Green Infrastructure planning and implementation is proposed for the more developed areas in the middle and headwater sections of 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 GI practices will increase groundwater flow and even out flows during the longer dry periods expected.

The stream channel restoration is proposed along the flatter downstream channels. Here, low flow channels with increased sinuosity and substrate diversity will provide aeration as the creek moves toward its confluence with the Huron River. A more natural channel shape provides the template for restored ecosystem function that will support the return of a healthy biological community. The existing floodplain will be connected to allow for flooding from smaller as well as larger storms to better establish floodplain communities and provide better riparian habitat.

An restoration potential analysis was conducted to identify Norton Creek reaches with the highest potential for successful restoration to improve dissolved oxygen (see Figure 2 below). Opportunities within high potential reaches should be identified.

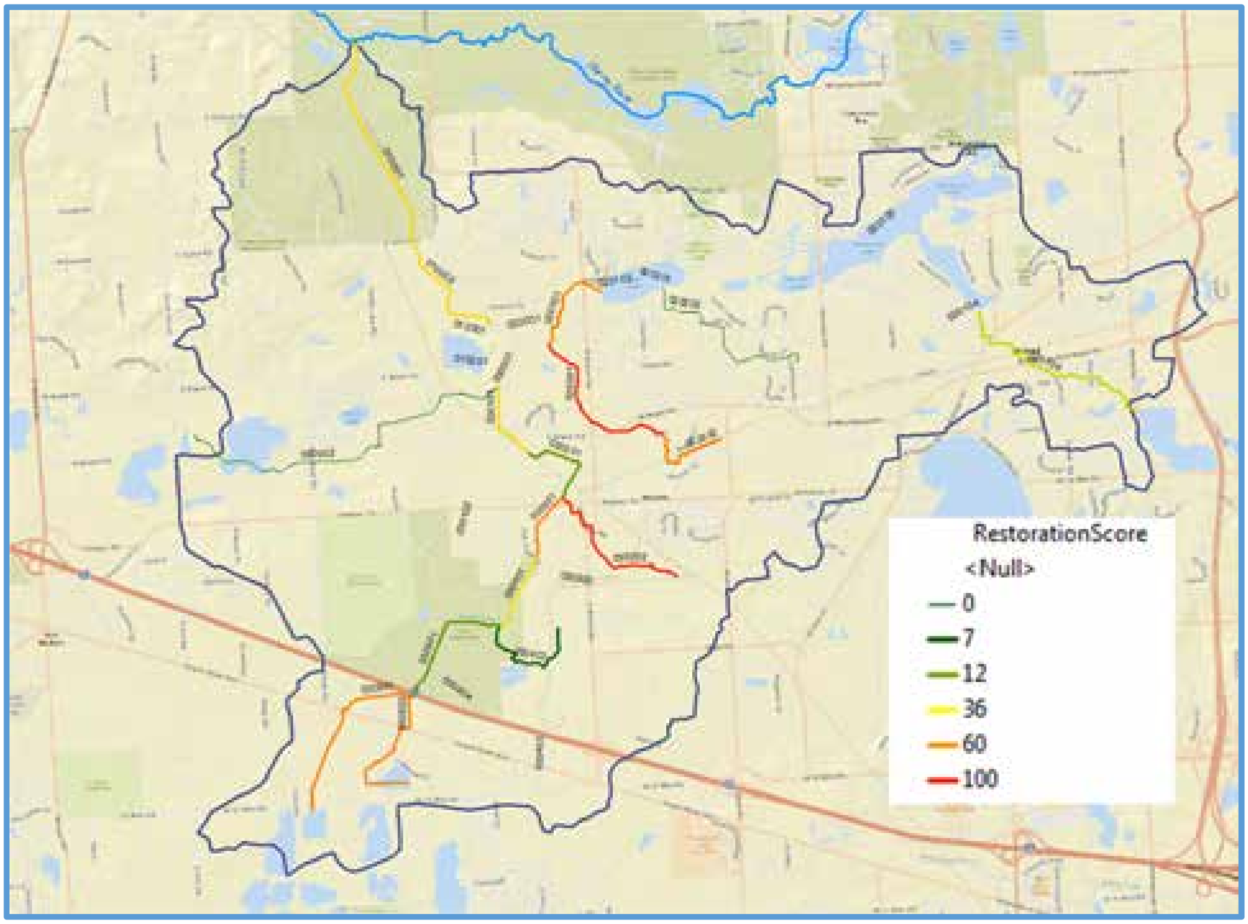


Figure 2. Norton Creek reaches showing restoration potential scores for improving dissolved oxygen and habitat.

Timeframe: 2018-2025
Milestones: Identify restoration project targets and opportunities: 2017-18, recommend restoration improvements to development projects: 2017-2025, implement public projects: 2018-2025.
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. An estimate for 5-7 projects is $250,000 to $750,000
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 6)

1C. Targeted Green Infrastructure Development and Retrofit Program

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. A program to incorporate key Green Infrastructure retrofit designs along key roads or other publicly-owned properties based on targets identified in the Green Infrastructure Opportunities map could be developed. Property owners or managers, such as township governments or the Oakland County Road Commission would need to participate as willing partners. New and redevelopment projects in the Norton Creek watershed should also be encouraged to use Green Infrastructure 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. This 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. 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.

Timeframe: 2017-2025
Milestones: Identify Green Infrastructure project targets and opportunities: 2017-18, recommend Green Infrastructure improvements to development projects: 2017-2025, implement public projects: 2018-2025.
Cost: Highly variable, depending on project, but usually lower than conventional cost of construction or reconstruction and maintenance.
Potential funding sources: Section 319, local government match; local agency or private investment
Success Measures: Reduced runoff volume, pollutant conentrations, and bacteria concentration measured from projects compared to conventional development*,* monitoring (see chapter 6)

1D. Rules and Ordinances for Storm Water Management

This program helps improve dissolved oxygen and reduce the pollutant concentrations in surface water by preventing flooding, modulating flow, treating storm water, and discouraging geese by using native landscape buffers near waterways and ponds. Additionally, this program is meant to revise existing storm water management ordinances to meet required design standards of the Oakland County Water Resources Commissioner. This program was implemented by detaining the first flush for a 24-hour period, thus reducing bacteria count. Revised rules are currently in final draft form and are anticipated to be implemented in 2018 or 2019. The new standards require infiltration of first flush. Most Phase II permitted entities have adopted stormwater ordinances which refer to the Water Resources Commission stormwater standards. In all township areas of the Norton Creek watershed, WRC staff review development proposals to ensure they meet WRC rules. An effort should be made to ensure that all municipalities in the Norton Creekshed adopt the new OCWRC standards.

Timeframe: 2018, ongoing
Milestones: Finalize new rules and standards: 2018. Revise as needed.
Cost: Not tracked. Funded by WRC, in part with Michigan SAW grant funds.
Success Measures: Reduced runoff compared to previous standards*,* monitoring (see chapter 6)

4.4.2 Secondary Priority Projects

The next set of projects are also part of the five-year strategy, but may take some time to develop or will supplement high priority projects.

2A. Information and Education Strategy

Given the low awareness of the water quality status in the social survey results (see Appendix D), it is vital to include basic information that conveys the water quality issue being addressed in addition to encouraging a change in behavior that contributes to a solution. Messaging needs focus on raising awareness of the sources of water quality problems as part of the outreach strategy to encourage positive behavioral responses.

In Norton Creek the I&E goals and objectives are:

- Increase the awareness of the watershed, inspire a sense of pride in one's place within the watershed, and the benefits of a healthy watershed.
- Increase the knowledge of alternatives to current development and land use practices within the watershed.
- Greater 'only rain down the drain' stormdrain awareness: neighborhoods keep their stormdrains clear, more people try to protect waterways by making sure that only rain and melting snow reaches drains, neighbors report illicit discharge.
- Greater awareness of the need to capture and infiltrate stormwater; increased green infrastructure practices on private property such as rain gardens, rain barrels, pervious surfaces, and disconnecting downspouts.
- Greater public awareness of acceptable application and disposal of pesticides and fertilizers and simple water quality-friendly lawn maintenance alternatives.
- Greater public awareness of the need to safely disposal of household hazardous wastes, RV/trailer sanitary waste, chemicals, grass clippings, leaf debris, litter, animal waste, and motor vehicle oil and other fluids as well as the availability, location and requirements of facilities that process the waste.
- Increase knowledge of the impact on water quality of impaired septic systems and promote knowledge of maintenance guidelines.
- Increase public knowledge of proper shoreline-care best practices such as planting trees, native plants, and buffer zones (and why these practices are important.)
- Encourage watershed friendly/GI business practices and site development.

The Information and Education Strategy below first outlines water quality issues and sources, along with target audience and then prioritizes those groupings (see Table 2). Then, the strategy for each issue is described in detail, including key messages, delivery mechanisms and evaluation methods.

Table 2. Water Quality Issue and Target Audiences

SOURCES	TARGET AUDIENCE	SPECIFIC TARGET AUDIENCE	PRIORITY
Stormwater Runoff (NPS pollution)	Property Owners	○ Homeowners ○ Children ○ Waterfront Property Owners ○ Businesses and institutions that own land	1

Phosphorus	Property Owners	○ Homeowners who have yards ○ Residential building owners (condos and townhouses) ○ Grounds keeping managers of businesses and institutions that own land	2
e.Coli	Residents	○ Dog Owners ○ Property owners who have septic tanks ○ Waterfront property owners with little or no buffer plantings along shoreline	3
Stormdrain pollution	Residents	○ Neighborhoods ○ Residents (renters and property owners)	4

Table 3. Target Audience Messaging

Pollutant	Source/Cause	TARGET AUDIENCE	MESSAGE	DELIVERY MECHANISMS	POTENTIAL EVALUATION
Stormwater Runoff (NPS)	Property Owners (leaves/grass clippings, car washing and maintenance, dumping materials and waste, fertilizers, pet waste)	○ Homeowners	Stormwater is biggest threat to water quality but you can help: rain gardens, rain barrels, use professional car wash, don't dump anything down drains, dispose of debris properly, use salt sparingly (during winter)	• Mail: brochures, calendars, flyers from a nonprofit organization in partnership w/ local municipalities where possible) • Mail: "why and how to" flyers from County and City/Townships (with taxes and bills) • Mail: stand-alone brochure on how and what to recycle and dispose of household waste, including hazardous materials • Offer discounts on rain barrels (Township) • Tabling at community events • Engage volunteers to plant/tend public gardens (ask local news to cover events) • County: offer rain garden and composting classes to the public • Field trips for kids: learn about local creek water and inhabitants with basic information on how we can all do our part to protect it (schools, youth groups, nonprofit organizations)	• Number of mailings • Number of people who visit booths • Number of volunteers at events • News coverage • Enrolled students in classes • Soil testing requests • Number of field trips, how many participated, and follow up comments • Number of inquiries/sales of rain barrels. • Materials drop-off site visits and measuring amount • Social Survey after I&E programs implemented. Information gathered should be comparable to WMP survey to compare results and changes, if any.

Pollutant	Source/Cause	TARGET AUDIENCE	MESSAGE	DELIVERY MECHANISMS	POTENTIAL EVALUATION
Stormwater Runoff (NPS)	Lawns up to shore, few trees and plants, pesticide and fertilizer use	○ Waterfront Property Owners	Be a first responder: capture runoff (include why it is needed). Plant a buffer zone (or don't mow near edge) and avoid pesticides and fertilizers. Got geese? Here's how to get them to move on: plant natives, don't mow.	• Mail Waterfront Wisdom booklets to all creek and lake shore property owners • Engage the owners in creek clean-ups	• Number of booklets mailed • How many engaged volunteers
Stormwater Runoff (NPS)		○ Businesses and institutions that develop and/or manage their land	What water quality issues exist, healthy water increases economy and quality of life—which helps to recruit and retain employees. If they do something, their business will get highlighted.	• Mail the Economic Impact of the Huron River report • Mail: flyers on eco-friendly grounds care • Mail: toolkits that help businesses communicate with tenants re: disposing of waste, salt on walkways, conserving water • Event and PR: Green Biz awards (Township or county) to recognize efforts	• Track efforts by submissions: businesses encouraged to let the township/county know about their GI efforts to be eligible for green business award.
Phosphorus	Property Owners	○ Homeowners who have yards ○ Residential building owners (condos and townhouses)	Phosphorus use leads to algal blooms/impaired waterbodies. Use phosphate free fertilizers, grow natives	• Mail: flyers (county water commission or nonprofit org) • Public events/fairs-informational booths	• How many people visited booths • Number of flyers mailed

Pollutant	Source/Cause	TARGET AUDIENCE	MESSAGE	DELIVERY MECHANISMS	POTENTIAL EVALUATION
Phosphorus		○ Businesses and institutions that own land	See above re: linking economic growth and healthy water. Phosphorus promotes algal growth. Use phosphate free fertilizers	• Mail: flyers (county water commission or nonprofit org) • See green biz award above	• See Stormwater runoff evaluation above
e.coli	pet waste	○ Dog Companions	Poop pollutes-and it's gross-so scoop it.	• Dog waste stations with bags and signs at popular dog walking areas (townships/county) • Mail flyers to those with dog licenses and those applying for dog licenses (township/nonprofit) • Ask local vets, pet supply stores, shelters, dog boarding, and dog grooming businesses to display flyers • Video- why it's important, how to for social network platforms	• How often bags need to be replenished • Engagement rates on social networks
e.coli	Spetic systems	○ Property owners who have septic systems	Poorly maintained septic systems pollute ground water and nearby waterways. They need to be serviced every 2 years	• Mail flyers to all property owners with message and offer free inspections (county/nonprofit) • Send flyers to plumbers, hardware store outlets • Offer information at public event tabling opportunities and social networks (nonprofit org, county, township)	• Number of flyers mailed. • Number of inspections requested.

Pollutant	Source/Cause	TARGET AUDIENCE	MESSAGE	DELIVERY MECHANISMS	POTENTIAL EVALUATION
e.coli	Goose poop	○ Waterfront property owners with little or no buffer plantings along shoreline	Geese got you down? Stop mowing your lawn to get them to move on. Their waste is harmful to water so grow along the shore to protect the water	• Mail: Waterfront Wisdom book • Digital/Social Networking: Township, county and nonprofits offer tips in emails, social networks, newsletters	• Number of pieces delivered • Engagement rates on social networks
Stormdrain	Neighborhoods and Residents	○ Residents who own property on streets with run-off issues	Only Rain down the drain. Volunteer to label and adopt a drain.	• Field: Stormdrain labeling • Door hanger flyer (preferably when streets are getting labeled) • Engage local volunteers for storm drain labeling and Stormdrain adoption program (nonprofit organization)	

Timeframe: 4 years (2018-21)
*Milestones: E*ducation materials developed: 2018-19. Materials distribution: 2019-20. Survey and evaluation: 2020.
Cost: Print and distribution of existing materials: $8,000; New material production and distribution: $50,000; Post-Campaign Evaluative Surveys: $8,000. Total: $64,000.
Potential funding sources: Section 319, local government match; local agency stormwater funds
Success Measures: Survey awareness measures, program participation rates, monitoring (see chapter 5).

2B. Buffer Enhancement Program

Vegetated stream buffers are important permanent measures for water quality and habitat enhancement in the watershed. 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. A stream buffer zone is a strip of undisturbed native vegetation, either original or reestablished, bordering a stream or 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.

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 it enters the stream. In addition, as discussed previously in the plan, many reaches of Norton Creek are lacking in buffers.

Restoring natural vegetation in bacteria hot spots will 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 part of outreach efforts discussed in activity 2F, property owners will be encouraged to seek Wildlife Habitat Incentive Program (WHIP) contracts 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.

The Buffer Enhancement Program would also encourage residential land owners to establish native vegetation and properly manage stream buffers. Interested land owners would be given planting designs and instruction, management guidelines and native plant seedlings and seed at no or reduced cost. Technical assistance would also be provided. In turn, the land owner would sign a commitment to manage the land as a natural buffer for 15 years.

The goal of this activity is to add 30 stream buffer acres in the Norton Creek watershed across areas targeted for buffer enhancement.

Timeframe: 5 years (2018-22)
Milestones: Compile and confirm target mailing list: 2018. Introduction letters and education materials distribution (see 2A): 2018-19. Site visits with interested land owners: 2019-20. Implementation of buffers: 2020-22.

Cost: Plants and seed @ $500/ac for 30 ac: $15,000; mailing, site visits, planning, technical assistance, reporting: $25,000. Total: $40,000.
Potential funding sources: Section 319, local government match; NRCS Programs
Success Measures:

- # of land owners participating in the buffer program by area and practice type
- # of acres of buffers installed by monitoring (see chapter 5)

2C. Canine Source Detection and Identification
The professional services of a trained sewage detection canine will be contracted to confirm human sewage sources in critical pathogen areas. Canine detection has been shown to have a high detection rate with low false positive rate. Canine detection is also specific to human sewage, so can be used to filter out non-human animal sources. Current Illicit Discharge Detection programs in the watershed do not use these services, so they will be contracted for the first time. The service has been shown to be helpful in identifying illicit connections as well as septic system failures.

Surface and outfall connections upstream of sampling sites will be evaluated by the canine team in coordination with OCWRC. Positive detections from surface water connections will be followed upstream until the source is identified. Positive detections from outfalls will be followed up to storm system access points for further evaluation until a direct source is identified. Positive detection information will be provided to relevant agencies for follow-up.

Timeframe: 2 years (2019-20)
Milestones: Conduct detection and identification surveys: 2019, Final detection and identification report: 2020.
Cost: Inspection of 25,000 linear feet @ $0.36/lf = $9,000; 1260 mi driving @ $0.56/mi = $706; 9 days @ $30 per diem = $270. Total = $9,976
Potential funding sources: Section 319, local government match
Success Measures: Total linear feet inspected, number of human sources identified

2D. Illicit discharge elimination program
The purpose of the IDEP is to remove non-storm discharges to storm sewers and surface waters to improve water quality. This program locates and eliminates any illicit connections in sanitary and storm pipes, thus preventing untreated sewage flow to Norton Creek and the Huron River. The program is also meant to help meet the Norton Creek TMDL by potentially removing a source of BOD, and, in some locations, fulfill storm water permit obligations.

Project data include sampling records, video and a dye-test database. The following entities will be involved in the IDEP: Oakland County, the City of Wixom, Village of Wolverine Lake, Village of Walled Lake, and Michigan Department of Environmental Quality (MDEQ).

Currently, Oakland County (via the Water Resources Commissioner) only implements the program on county drains in the urbanized area to meet stormwater regulations. This leaves several county drains outside the urbanized area and many stream reaches that are not county drains, not being inspected.

To address impairments in Norton Creek, results from canine detection will be shared with the WRC, and municipal authorities. HRWC will consult with municipalities and private landowners, and, if necessary MDEQ, to remediate any illicit connections found in this area. Parties found responsible for illicit connections will be expected to conduct remediation. Multiple inspections during differing conditions may be needed in these critical reaches to detect contaminated flow and trace it back to the source.

Timeframe: 2 years (2019-20)
Milestones: 1 year summary of illicit discharges detected and eliminated.
Cost: Follow-up inspection and remediation of unknown number of connections estimated at $15,000 per year = $30,000.
Potential funding sources: Section 319, local government match; SAW; agency stormwater funds
Success Measures: Percent of sources identified in item 1A inspected and eliminated, monitoring (see chapter 5)

<u>2E. Storm Drain Marking Project</u>
The purpose of storm water drain marking is to eliminate waste entering Norton Creek through storm drains, by means of creating public awareness of the impact from dumping into these drains. Storm drains are marked with a warning stating that any waste entering the drain goes straight to the stream. Along with the marking, the project places educational fliers (produced as part of activity 2A) on the doors of residences in the vicinity of newly marked drains. It is a simple, cost-effective program that should reduce dumping of pollutants, nutrients, pet waste and other material into the drains.

Under this activity, HRWC, working in coordination with municipal authorities and the WRC will purchase 2,000 lexan markers for placement in neighborhoods. Volunteers provide the labor to apply markers and hang educational fliers on doors. Pricing is estimated locally at approximately $1.50 for each new lexan marker, while $3.05 is spent on each "crystal" coated marker.

Timeframe: 5 years (2018-22)
Milestones: Survey neighborhoods to identify needed marker locations: 2018. Produce door hangers (see 2A) and purchase markers: 2018-19. Recruit volunteers to apply markers and place door hangers: 2019. Resurvey neighborhoods for marker maintenance: 2021-22.
Cost: 2,000 markers and adhesive @ 3.00 ea: $6,000; Planning, neighborhood drain surveys, volunteer recruitment and management, reporting: $15,000. Total: $21,000.
Potential funding sources: Section 319, local government match
Success Measures:

- # of markers and door hangers placed
- # of calls from door hangers

Monitoring (see chapter 5)

2F. Targeted enforcement of phosphorus fertilizer law

The high concentrations of phosphorus found in Norton Creek were not accompanied by evidence of erosion or high TSS concentrations. Therefore, it is assumed that most of the phosphorus is entering the waterways in dissolved form. Fertilizer is a primary source of dissolved phosphorus. The State of Michigan banned the use of fertilizers containing phosphorus for most uses in 2012. However, phosphorus-based fertilizers are still widely available, and enforcement of the law is based on neighbor complaint. Following proper education (see 2A) and warning, HRWC will work with local municipal law enforcement agencies to observe violations and enforce the law within target neighborhoods. A few enforcement actions should encourage greater compliance over the long term.

Timeframe: 2 years (2021-22)
Milestones: In spring and fall, at common fertilizer application times, and following education distribution from 2A, patrol target neighborhoods and document violations followed up with warnings for first-time violators. Enforce the law on serial offenders: 2021. Follow-up observation: 2022.
Cost: $10,000 for enforcement staffing and training. Total: $10,000.
Potential funding sources: Section 319, local government match
Success Measures:

- Reduction in violations
- Reduced application of phosphorus fertilizer
- Monitoring

2G. Pooper Scooper Ordinance and education

The purpose of this program is to educate the general public on the impact of pet waste on surface water quality, and to reduce pet waste entering the storm sewer. The program should decrease discharge into Norton Creek by reducing a source of pollution. A partnership with the City of Wixom, other interested municipalities, and HRWC will be developed to assist in the development of an ordinance, combined with proper residential education. The ordinance would require the removal and proper disposal of pet waste with fines for infractions. While complete enforcement of such an ordinance is unlikely, its existence will serve to raise awareness of township residents.

Passage of a pooper scooper ordinance in the watershed could be combined with educational information (see 2A above) and installation of signage and pet waste disposal bags/receptacles at township and county parks to be more effective.

Timeframe: 3 years (2020-22)
Milestones: Draft ordinance developed, revised and passed: 2020-21. Education Materials distribution: 2020. Ordinance enacted: 2021.

Cost: Technical assistance with ordinance development: $8,000; Elected official time in review and enactment: $10,000. Total: $18,000. Education costs are included in item 2A.
Potential funding sources: Section 319, local government match
Success Measures: Ordinance enactment, volume of calls about ordinance, ordinance enforcement rate, monitoring (see chapter 5).

2H. Doggie Bags at target locations
This program provides bags for pet waste clean-up. This should reduce pet waste in parks, and other high traffic areas, subsequently reducing the amount of *E. coli* entering Norton Creek from pet waste. This project can be modeled after an ongoing program in other regional municipalities. Target locations include county parks and residential dog walk areas. Installation of bag dispensers and trash receptacles should be completed in partnership with targeted home owner associations in target areas of the watershed.

HRWC and partners will work with neighborhood associations to confirm specific installation locations and coordinate with trash pick-up. Bag dispensers will be regularly monitored for resupply as maintenance as well as success measurement. 30 dispensers will be placed initially with additional stations added as use volume warrants.

Timeframe: 4 years (2020-23)
Milestones: Meet with homeowner groups and park officials, confirm locations: 2020. Install 30 stations: 2021. Education Materials distribution (see 2A): 2018-21. Install additional stations: 2023.
Cost: 50 dog waste stations @ $100 ea.: $5,000; technical assistance, installation, maintenance labor: $10,000. Total: $15,000.
Potential funding sources: Section 319, local government match
Success Measures: Number of stations installed, bag volume utilized, pounds of feces removed, monitoring (see chapter 5).

3C. Protect Priority Conservation Areas
While this activity is not part of the list of short-term primary and secondary projects, it is important to the long-term quality and conservation of Norton Creek.

HRWC performed a Natural Green Infrastructure Opportunity Analysis to determine on a watershed scale where to target conservation efforts. The analysis combined Green Infrastructure network maps of natural area hubs, sites and links created by Oakland County for each local government; HRWC's Bioreserve Map which maps and ranks the remaining natural areas in the watershed; and ownership information. See Appendix F for details. The resulting map gives a comprehensive view of the creekshed's natural areas and which areas should potentially be targeted for field assessments and for preservation efforts (see figure 3)

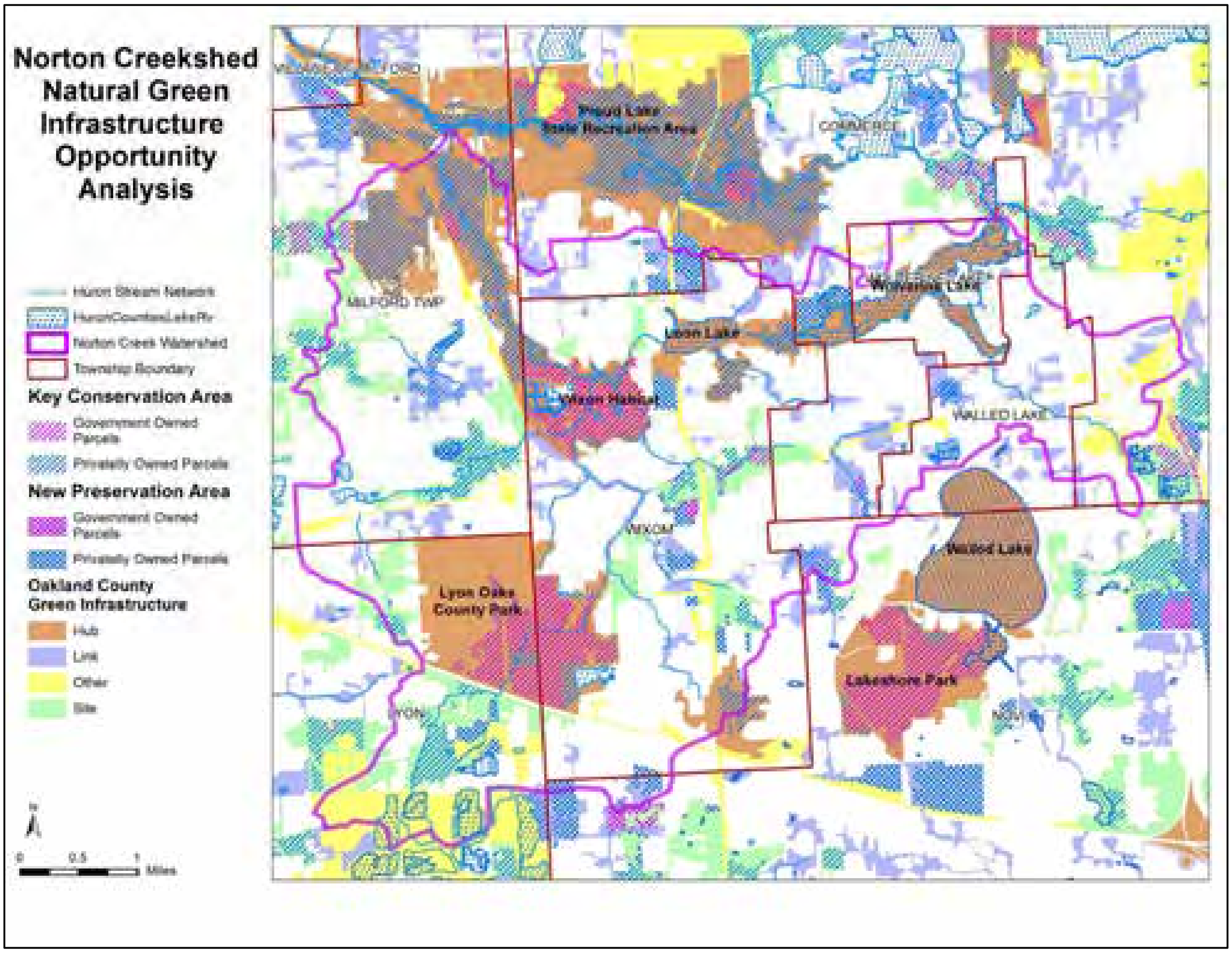


Figure 3. Natural Green Infrastructure Opportunity Analysis map showing key new conservation areas for both government and private-owned lands.

Staff sent 27 letters to properties within the natural Green Infrastructure opportunities area that were found to be potential high quality natural areas worth exploring to pursue protection. Only one owner replied and agreed to have an assessment. This is not a surprisingly small return since these property owners have not heard of this program before. Given time and repeated contacts and other outreach, more assessments will be possible. Following assessments, properties should be considered for purchase of development rights or outright purchase by government entities or a land conservancy.

Chapter 4 References and Endnotes

[1] http://iaspub.epa.gov/tmdl_waters10/attains_waterbody.control?p_list_id=&p_au_id=MI040900050103-04&p_cycle=2008&p_state=MI

5. Accountability Structure for Implementation

5.1 Overcoming Barriers and Closing Gaps

As framed by the terms of the TMDL, the ultimate measure of implementation success will be documented changes in water quality, showing improvement over time. However, potential barriers to this accomplishment exist and must be considered in implementation planning.

Positive feedback from even the most diligent efforts may be several years in the future due to the lead time needed to implement best management practices throughout the watershed. Participants must set realistic expectations about the amount of time needed to continue identified programs while awaiting positive results. Otherwise, impatience, discouragement, or competition for limited local funding could lead to discontinuation of effective programs. Prompt communication of small successes through news releases, web sites, and community newsletters will be important to encourage the continued efforts of TMDL partner communities.

The tracking of quantitative results over time carries a set of technical and logistical challenges. Variation in weather patterns over the years of a study adds to the complexity of trend analysis of the data. Collecting correctly timed wet weather samples is particularly daunting, as personnel may not be available during a particular major summer storm occurring outside of business hours.

The next few years will provide a challenge to demonstrate that an increase in dissolved oxygen in Norton Creek can be achieved given the difficulty to control general urban sources, creek channelization, and county/municipal maintenance. With the current economics of government funding restricting government and institutional resources, another challenge will be to identify the most cost-effective measures and to continue funding them. Managers and programs will both need to become adaptive, while continuing to appeal to the public's expectation that the waters of our state will attain the standards set forth by Congress through the passage of the Clean Water Act in 1972.

There are also gaps in our knowledge of bacterial survival and reproduction under conditions found in yards, parks, ditches, and ponds. For example, requiring a certain number of hours of onsite retention for storm water runoff is thought to guarantee that live *E. coli* bacteria will not escape and reproduce elsewhere. This has been established elsewhere. A systematic study of real world conditions to detail the effectiveness of retention, infiltration, and other strategies for control of bacteria, would further confidence in, and understanding of, these control measures. The knowledge gap has begun to close with a recent laboratory study conducted simulating urban stormwater runoff conveyed through conventional bioretention media to investigate the bacteria removal efficiency of this media. It was concluded that bacterial removal could be effective and sustainable, and that indigenous protozoa can facilitate this process. Exploring opportunities with the scientific community, such as this, may prove to be beneficial in finding a workable solution to *E.coli* contamination where the urban sources of the bacteria are difficult to control.

5.2 Participants, Reporting, Contingency Plans

The stakeholders for this implementation plan are committed to continued water quality improvement in the Norton Creek watershed. Those who have taken on this responsibility are:

- City of Wixom
- Huron River Watershed Council
- Michigan Department of Environmental Quality
- Oakland County Water Resources Commissioner
- Oakland County Roads Department
- Oakland County Parks and Recreation
- Milford Township
- City of Walled Lake
- Commerce Township
- Village of Wolverine Lake

The following units of government will also be subject to the TMDL for dissolved oxygen and requirements that may apply to other impairments:

- Michigan Department of Transportation
- Michigan Department of Environmental Quality

The stakeholders listed above are committed to continued water quality improvement in the Norton Creek contributing area. Toward this end, local governments, the Huron River Watershed Council have conducted a variety of actions, prior to TMDL development, to improve water quality and promote stewardship. Pre-TMDL activities included bio-monitoring, habitat assessment, illicit discharge elimination, mass media educational campaigns, development standards, water resources protection ordinances, wetlands protection and wetlands restoration. Many of these actions have involved stakeholder collaboration; others are unique to individual stakeholders and their constituencies.

Although a great many ongoing actions to restore water quality and habitat in Norton Creek are voluntary, each stakeholder has assumed responsibility to continue their efforts, as resources allow and needs dictate. Through initiating and continuing these voluntary actions, each stakeholder has assumed responsibility for a share of water quality restoration in the Huron River Basin. These discretionary programs are dependent on funding, perceived needs, sound and reliable technical assistance, clear regulatory authority, constituent support, and demonstrated effectiveness. Some actions have been required under the permit regulations of the Clean Water Act.

Municipalities regulated by stormwater rules have been under permit since 2003. Their permits specify best management practices to achieve water quality improvement, including reduction of impairments. Permit renewal applications will continue to include provisions consistent with the Norton Creek TMDL, such as illicit discharge elimination, and public information and education.

Regulated municipalities and agencies must submit detailed compliance language that must also include provisions consistent with the Norton Creek dissolved oxygen TMDL and future *E. coli* and TDS TMDLs. Municipalities with Certificates of Coverage are required to submit an approvable plan to comply with all six minimum measures, including provisions consistent with any TMDL affecting the jurisdiction or watershed. The Michigan Department of Transportation, Oakland County, and public school systems received separate Certificates of Coverage and must meet the same requirements as local governments.

Under their storm water permits, these communities and agencies are obligated to develop, implement, and enforce a storm water management program designed to reduce the discharge of pollutants from the drainage system to the “maximum extent practicable,” to protect the designated uses of the waters of the state, to protect water quality, and to satisfy the appropriate water quality requirements of state and federal law. Storm water controls designed to attain the goals of the TMDL must be incorporated into the storm water management plan, and each permittee must implement appropriate best management practices to comply with the TMDL implementation plan. Both separately and jointly, through a coordinated public education and involvement strategy, stakeholders will also engage in communication with the public that addresses TMDL problems, solutions, and successes.

Additionally, the permittees are required to submit biannual progress reports to the MDEQ which shall contain the following: a description of the status of compliance with general permit conditions, an updated assessment of the water quality conditions within their jurisdiction, a description of identified water quality stresses, and a summary of all information collected and analyzed—including monitoring data. The report must include a summary of upcoming storm water activities and a description of planned changes in BMPs or measurement of goals.

Since each storm water permit requires biannual reporting, and TMDL goals and activities must be incorporated into the measures prescribed by the permit, separate TMDL reporting is unnecessary for those partners covered by permits. In 2017, and at subsequent five-year intervals, the MDEQ is scheduled to complete basin-wide monitoring of the Huron River watershed. Future projects under this implementation plan may incorporate additional monitoring if resources allow. Stakeholders' storm water permit reporting will include an updated assessment of the water quality conditions within their jurisdiction in either narrative or numeric form. The purpose of this update is to show any obvious changes in dissolved oxygen and pollutant levels since the previous progress report. Change may be demonstrated by use of data collected by other sources or a group monitoring program.

Through adaptive management—a process that assesses conditions and trends throughout plan implementation, and provides feedback to stakeholders so that adjustments can be made—this watershed plan is intended to ultimately achieve TMDL compliance. Through the annual meetings of a Norton Creek Advisory Group, or broader regional body, the TMDL Implementation Plan working group will meet to review efforts and plans. The MDEQ will track permit compliance through storm water permit oversight, including monitoring activities that address the TMDL implementation goals. Unless the EPA determines that it is necessary to separate TMDL enforcement from the storm water permit process, enforcement authority will reside in the MDEQ's authority under the provisions of the storm water rules.

5.3 Evaluation and Monitoring

The ultimate success of this watershed management plan will be determined by the degree to which it results in an increase in dissolved oxygen in Norton Creek and reduction of other impairments. Although achieving water quality standards is the goal of plan implementation, other means will need to be employed to ascertain what effects individual and collective best practices 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 practice-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 best practices.

5.3.1 Quantitative Evaluation

Progress toward the goal of achieving water quality standards should be measured using a long-term water quality and benthic monitoring program, supplemented with additional sampling following project implementation. Table1 below outlines a simple monitoring framework for Norton Creek.

Table 1. Norton Creek Watershed Monitoring and Evaluation

Monitoring Site[1]	Parameter Target	Type of Analysis	Protocol	Frequency	Test Agent
Norton Creek		Stream Habitat Assessment	HRWC Protocol	3- 5 yr interval	HRWC, MDEQ
Adopt @ Gibson Pk		Total Suspended Solids	SM20 2540 D	1-2x/Mo + Rain event	HRWC to lab

WQ NC02, NC04	S, N, DO, T, I, B, Bio	Total Phosphorus, Nitrates, Nitrites	SM20 4500	1-2x/Mo + Rain event	HRWC to lab; MDEQ
		Temp, DO, pH, Conductivity	Horiba U10 Meter	1-2x/Mo Apr-Sept	HRWC
		E. coli	SM20 9213 D	1-2x/Mo + Rain event	HRWC to lab
		Benthic Macroinvertebrates	HRWC Protocol	2-3x/year	HRWC, MDEQ
1) Adopt = HRWC Adopt-a-Stream; WQ = HRWC tributary nutrient monitoring; MDEQ = MDEQ lake monitoring					
2) S= Sediment; N= Nutrients; DO= Dissolved Oxygen; T= Temperature; I= Ions; B= Bacteria; Bio= Biota					
3) Specific sites will be included as part of MDEQ Water Bureau's rotational water quality monitoring program; Lakes program monitors water quality monthly					
4) HRWC staff and volunteers to collect samples and deliver to a laboratory TBD for analysis under their direction.					
5) Analytical protocols follow "Standard Methods for the Examination of Water and Wastewater", 20th edition, by the American Waterworks Association					

In addition, stream flow can be measured at NC02 each time samples are collected, and at least once in 5 years, flow is measured continuously from April until the threat of freeze-over (late November).

Following initial implementation of the short-term strategy (year 4, or 2021 at the earliest), additional sampling should be conducted for key sites in critical areas. A second round of sampling at these sites should be conducted again 1-2 years following completion of the 5-year strategy.

Table 2. Qualitative Evaluation Measures

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 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.	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. Some cost involved.	Identify parameters to evaluate. Use form, such as the USA, 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: Good, but limited, form of communication.	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 to do well.	Select random sample of population as participants. 6-8 people per group. Plan questions, facilitate. Record and transcribe discussion.

5.3.2 Qualitative Monitoring

Qualitative measurements are important in determining changes in behavior and visible changes in the watershed. Surveys, participation records, and meeting/workshop evaluations can all be used to gauge whether activities aimed at public education and outreach are effective. Better survey results, an increase in participation, and favorable meeting/workshop evaluations can all be an indication of a greater understanding by the public on watershed-related issues. Results that do not yield improvements will signal that current activities and/or education methods should be modified and improved.

Visible changes in the watershed can also be used as an indication of progress in the watershed. Stream surveys can identify riparian and aquatic improvements and help identify recreational opportunities. BMP implementation can also be documented visibly, with the number and location of BMPs recorded.

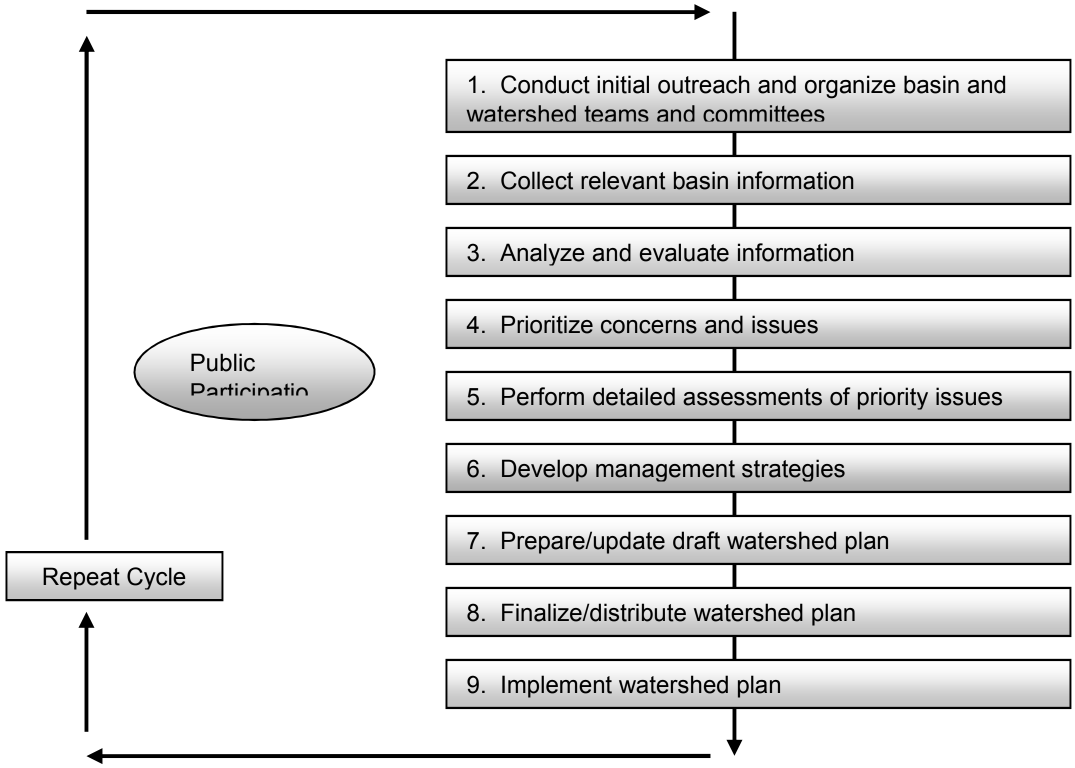
Table 2 summarizes the qualitative methods that will be used to measure progress, with the exception of focus groups, which are determined not to be necessary or helpful for this watershed plan. A simple post-implementation survey may be deployed if other behavioral and outcome measures cannot provide sufficient success measurement. Surveys are often the only reasonable way to obtain awareness and behavior changes. However, in a small population area like Norton Creek, it is often very difficult to obtain sufficient survey responses to allow for statistical comparisons. Other process measures will be obtained as described in the action plan (see chapter 4).

5.4 Determining the Need for Revisions

It is the intent of TMDL stakeholders in the watershed that this plan should be revised, on average, every five years. Several of the collaborative groups previously mentioned in this plan will continue to meet on a regular basis to ensure that the plan is being implemented on a watershed-wide basis. Many partners have a vested interest in assuring that the plan is implemented. In addition, updates regarding watershed plan implementation and activities related to it will be updated on the HRWC's website.

Applying the concept of adaptive management to the revision process is essential for successful implementation of the plan. Evaluation of a specific management alternative (using the methods discussed in the next section) may suggest a change is needed to affect the desired result, or a shift in focus from one management alternative to another may be needed. The iterative nature of watershed planning, implementation, and revision is shown below in figure 1.

Figure 1. Typical Steps in a Watershed Management Cycle[1]



Chapter 5 References and Endnotes

[1] Adapted from: MSU Institute of Water Research, et al. 2000. Developing a Watershed Management Plan for Water Quality. Lansing, MI: Michigan State University.