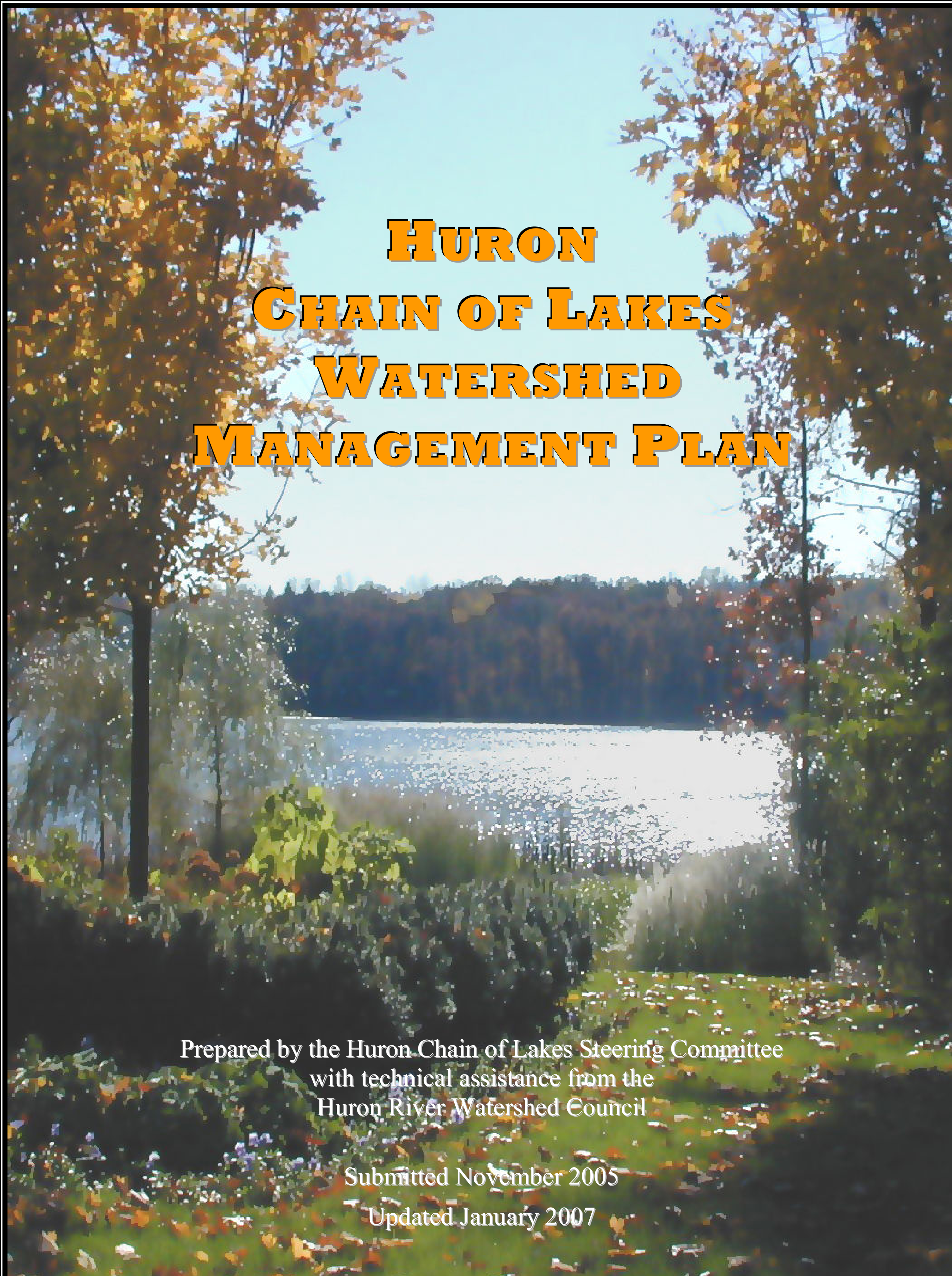


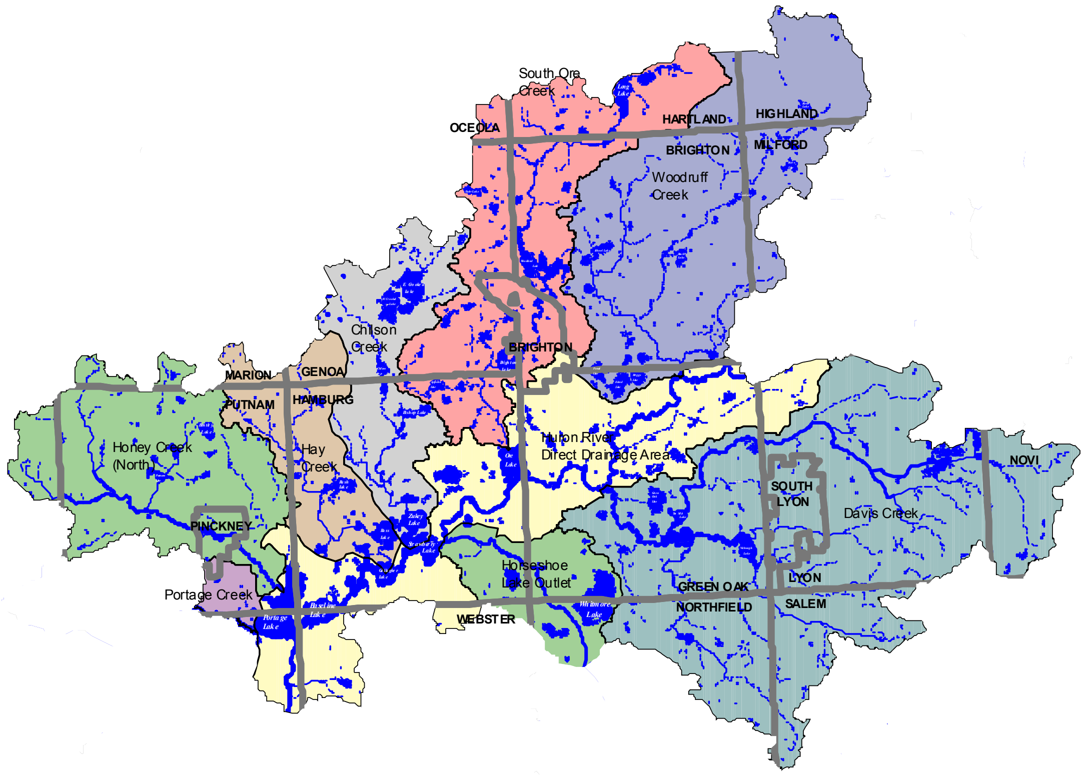
Huron Chain of Lakes Watershed Management Plan

Prepared by the Huron Chain of Lakes Steering Committee
with technical assistance from the
Huron River Watershed Council

Submitted November 2005

Updated January 2007

HURON CHAIN OF LAKES WATERSHED MANAGEMENT PLAN



Prepared by the Huron Chain of Lakes Steering Committee:

City of Brighton ~ Charter Township of Brighton
Genoa Township ~ Charter Township of Green Oak
Livingston County Drain Commission
Livingston County Road Commission
Village of Pinckney ~ Putnam Township

with technical assistance from
the Huron River Watershed Council

Huron River Watershed Council

Novmber 2005

ACKNOWLEDGEMENTS

The members of the Huron Chain of Lakes Steering Committee, who provided content, oversight, and funding for this watershed management plan, are:

City of Brighton – David Blackmar, Assistant Director of Public Services Department

Charter Township of Brighton –David Murphy, Manager; H.E. “Bud” Prine, Supervisor; Marcia Strong, former Manager

Genoa Township – Kelly Kolakowski, Planning Director

Charter Township of Green Oak – Mark St. Charles, Supervisor; Teri Olson, Deputy Supervisor

Livingston County Drain Commissioner – Brian Jonckheere, Drain Commissioner; Rebecca Simpson, Water Resources Coordinator

Livingston County Road Commission – Kim Hiller, Utilities and Permits Engineer; Steve Wasylk, Director of Operations

Village of Pinckney – Amy Felty, Clerk; Rebecca Foster, President

Putnam Township – Pat Carney, Zoning Administrator

Other interested parties and representatives who attended meetings, received communications and in other ways showed interest in the development of this watershed management plan are:

Livingston County MSU Extension – Mike Gaden, Natural Resources Agent

Lyon Township – Sue Tepatti, Giffels-Webster Engineers

Livingston County Planning Department – Florence Davis, Principal Planner

Michigan Department of Environmental Quality – Cheryl Bartley

Milford Township – Vicki Pultala, Milford Township resident

Oakland County Drain Commissioner – Ron Fadoir, Environmental Planner; Jim Wineka, Environmental Unit Supervisor

Southeast Michigan Council of Governments – Amy Mangus, Senior Environmental Planner

Technical assistance was provided by the **Huron River Watershed Council**:
Chris Riggs – main author and facilitator
Kris Olsson – GIS and modeling
Debi Weiker – codes and ordinances review and field data compilation

cover art: altered photograph of Brighton Lake by HRWC

Huron Chain of Lakes Watershed Management Plan
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ABBREVIATIONS

BMP: Best Management Practice

GIS: Geographic Information System

HRWC: Huron River Watershed Council

IDEP: Illicit Discharge Elimination Program

LCDC: Livingston County Drain Commissioner

LCRC: Livingston County Road Commission

LID: Low Impact Development

L-THIA: Long-Term Hydrologic Impact Assessment

MDEQ: Michigan Department of Environmental Quality

MNFI: Michigan Natural Features Inventory

MS4: Municipal Separate Storm Sewer System

NPDES: National Pollutant Discharge Elimination System

NRCS: Natural Resources Conservation Service

OSDS: On-site Disposal Systems (septic systems)

PCB: Polychlorinated Biphenyls

PEP: Public Education Plan

SEMCOG: Southeast Michigan Council of Governments

SWPPI: Stormwater Pollution Prevention Initiative

TMDL: Total Maximum Daily Load

U.S. EPA: United States Environmental Protection Agency

USDA: United States Department of Agriculture

USGS: United States Geological Survey

WMP: Watershed Management Plan

WQS: Water Quality Standards

WWTP: Wastewater Treatment Plant

GLOSSARY OF TERMS

Critical Area	That part of the watershed that is contributing a majority of the pollutants and is having the most significant impacts on the waterbody.
Designated Use	Recognized uses of water established by state and federal water quality programs.
Desired Use	Additional uses for land and water resources as defined by stakeholders in the watershed.
E. coli	Bacterium used as an indicator of the presence of waste from humans and other warm-blooded animals.
Erosion	Detachment and movement of rocks and soil particles by gravity, wind, and water.
Groundwater	The subsurface water supply in the saturated zone below the water table.
Headwaters	The origin and upper reaches of a river or stream.
Impervious	A surface through which little or no water will move.
Infiltration	The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls.
Managerial Controls	measures or practices that usually involve the use of programs related to training and education of local stakeholders that promote pollution prevention and stormwater management principles.
Nonpoint Source Pollution	Pollution caused when rain, snowmelt, or wind carry pollutants off the land and into waterbodies.
Point Source	The release of an effluent from a pipe or discrete conveyance into a waterbody or a watercourse leading to a body of water.
Pollutant	Any substance of such character and in such quantities that when it reaches a body of water, soil, or air, it contributes to the degradation or impairment of its usefulness or renders it offensive.
Riparian	Person who lives along or holds title to the shore area of a lake or bank of a river or stream.
Riparian Corridor	Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants requiring saturated soils during all or part of the year.

Runoff	That portion of the precipitation or irrigation water that travels over the land surface and ends up in surface streams or waterbodies.
Sediment	Soil, sand, and minerals which can take the form of bedload, suspended, or dissolved material.
Soil Erosion	The wearing away of land surface by wind or water. Erosion occurs naturally from weather or runoff but can be intensified by land-clearing practices related to farming, residential, or industrial development, road building, or clear-cutting.
Stakeholder	Any organization, governmental entity, or individual that has a stake in or may be affected by a given approach to environmental regulation, pollution prevention, or energy conservation.
Storm Drain (Storm Sewer)	A slotted opening leading to an underground pipe or an open ditch that carries surface runoff.
Stormwater	Runoff from a rainstorm, snow melt runoff, and surface runoff and drainage.
Structural Controls	Control measures or practices that usually involve the use of "brick and mortar" technologies to address stormwater runoff quantity and quality.
Surface Water	All water naturally open to the atmosphere (rivers, lakes, streams, reservoirs, wetlands, impoundments, and seas).
Suspended Solids	Sediment particles in the water column and carried with the flow of water.
Topography	The physical features of a surface area including relative elevations and the position of natural and man-made features.
Tributary	A river or stream that flows into a larger river or stream.
Vegetative Controls	Control measures or practices that usually involve the use of cropping systems, permanent grass, or other vegetative cover to reduce erosion and sedimentation.
Water Quality	The biological, chemical, and physical conditions of a waterbody, often measured by its ability to support life.
Watershed	The geographic region within which water drains into a particular river, stream, or body of water. Watershed boundaries are defined by the ridges separating watersheds.
Wetland	An area that is regularly saturated by surface or groundwater and subsequently is characterized by a prevalence of vegetation adapted for life in saturated soil conditions. Examples include swamps, fens, bogs, and marshes.

EXECUTIVE SUMMARY

Brighton Lake *Photo: HRWC*

Huron Chain of Lakes Watershed

The Huron Chain of Lakes Watershed covers 253 square miles of the 908-square-mile Huron River Basin, draining an area from just below the Kent Lake dam on the Oakland County/Livingston County border to two miles below Portage Lake in Washtenaw County. Within this area, the Huron River flows southwest for 27 miles through a series of wetland complexes and large glacial kettle lakes. Eight major tributaries and numerous smaller streams provide an estimated 593 miles of streams, which comprise the eight "creeksheds" in the Huron Chain of Lakes Watershed. Over 22,000 acres of wetlands remain in the Watershed as of 2000, comprising over 13% of the total watershed area, along with 172 lakes greater than 5 acres in size. The watershed contains a number of protected natural areas including Island Lake State Recreation Area, Huron Meadows Metropark, Gregory State Game Area, Brighton State Recreation Area, portions of Pinckney State Recreation Area and Hudson Mills Metropark. These areas contain high quality habitat and biological diversity, including several threatened and endangered species.

The majority of the watershed lies within Livingston County, with eastern portions in southwest Oakland County and southernmost areas in Washtenaw County. All or portions of 20 local communities are situated in the Huron Chain of Lakes Watershed, of which the largest portions are within the townships of Brighton, Genoa, Lyon, Green Oak, Hamburg, and Putnam, as well as the Village of Pinckney, the City of Brighton, and the City of South Lyon. Other communities with smaller areas in the watershed include the townships of Highland, Hartland, Oceola, Milford, Marion, Unadilla, Salem, Northfield, Webster, and Dexter, as well as the City of Novi. The Huron Chain of Lakes Watershed is experiencing intense development pressures from a growing economy and urban sprawl. Livingston County has been the fastest growing county in Michigan for the past decade, and most of the County's growth over the next 30 years is expected to take place in the Huron Chain of Lakes Watershed.

The purpose of the WMP is to identify and execute the actions needed to resolve water quality and water quantity concerns by fostering cooperation among the various public and private entities in the watershed

Purpose of the Watershed Management Plan

The Huron Chain of Lakes Watershed Management Plan is part of an effort undertaken by the communities of Huron Chain of Lakes Watershed seeking the NPDES

Wastewater Discharge General Permit MIG619000 (watershed-based). As that permit states “the permittee shall participate in the development and implementation of a Watershed Management Plan (WMP). The purpose of the WMP is to identify and execute the actions needed to resolve water quality and water quantity concerns by fostering cooperation among the various public and private entities in the watershed…. The emphasis of the WMP shall be to mitigate the undesirable impacts caused by wet weather discharges from separate storm water drainage systems.” This Watershed Management Plan is a strategy document that is intended to define the state of the watershed by describing its natural resources

A TMDL refers to a lake or portion of a stream that has been determined by the MDEQ as failing to meet the State’s minimum water quality standards due to excessive pollutant

As required by the General Permit, this Plan also will address Total Maximum Daily Loads (TMDLs) established within the Huron Chain of Lakes Watershed. A TMDL refers to a lake or portion of a stream that has been determined by the MDEQ as failing to meet the State’s minimum water quality standards due to excessive pollutant loads. TMDLs in the Watershed are addressed by detailing appropriate actions specific to storm water controls to meet the TMDLs. To date, three phosphorus TMDLs have been established in the watershed for Brighton, Strawberry, and Ore Lakes. Six TMDLs for other pollutants and impairments are scheduled by MDEQ for future establishment in the watershed.

The permit holders that were involved in the development of this Plan are committed to protecting the sensitive natural areas of the watershed, mitigating the impacts of stormwater discharges and preventing future increases, and restoring degraded areas. While compliance with the NPDES Phase II permitting process is the Plan’s primary and mandatory function, the authors intend for the Plan to fit into a broader context of watershed management planning by laying the groundwork for a comprehensive, long-term effort to restore and protect the Watershed’s water resources for future generations.

Huron Chain of Lakes Steering Committee

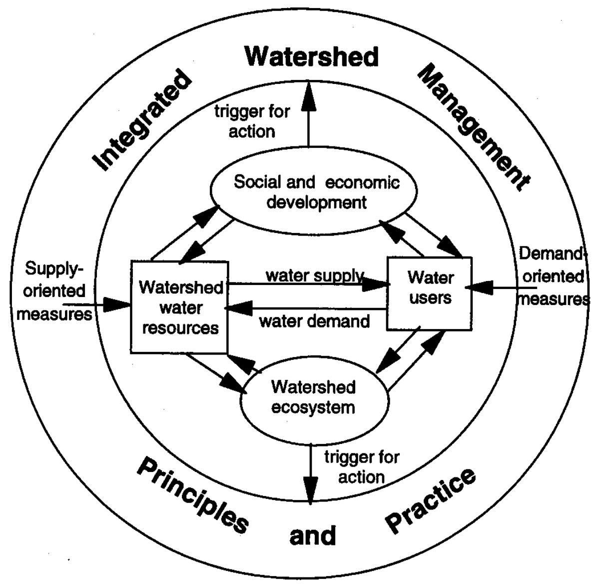
Since December 2002, the Livingston County Drain Commissioner has sponsored monthly meetings to facilitate a coordinated effort among watershed-based Phase II permit holders in Livingston County. These county-wide meetings address administrative and procedural issues common to all watershed-based permit holders. In February 2004 a group of eight local governments and county agencies located within the Huron Chain of Lakes Watershed formed the Huron Chain of Lakes Steering Committee to coordinate the study, development, preparation, and timely filing with the MDEQ of a Huron Chain of Lakes Watershed Management Plan as part of the required NPDES Phase II stormwater compliance. Core members of the Steering Committee represented the following communities and agencies:

City of Brighton	Livingston County Drain Commissioner
Brighton Township	Livingston County Road Commission
Genoa Township	Village of Pinckney
Green Oak Township	Putnam Township

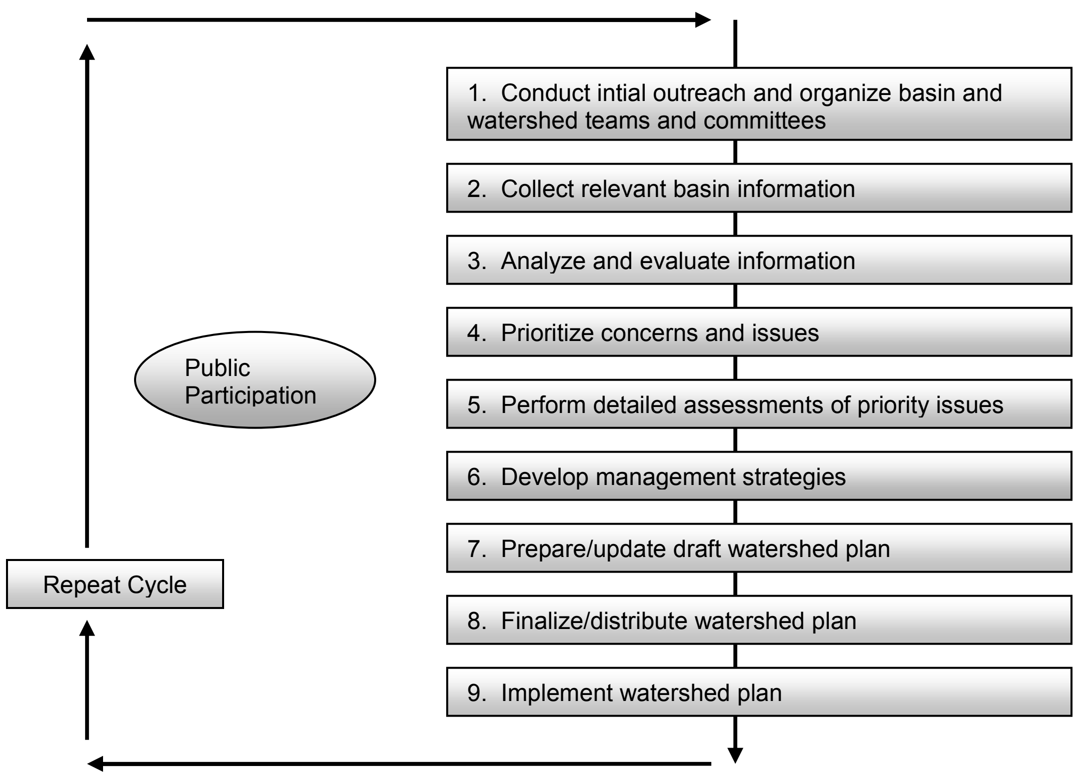
Other communities and agencies located in the Watershed, as well as individual residents, also attended regular meetings of the Steering Committee. The Huron River Watershed Council was commissioned by these same eight local governments and county agencies to work with the Steering Committee to facilitate the development of, and write, the Huron Chain of Lakes Watershed Management Plan.

The Watershed Planning Process

A watershed is a complex integrated system with the whole being greater than the sum of its parts. This complexity stems for the ever-changing interaction of social, economic, and biophysical forces. The interplay of these forces, as shown in the diagram to the right (from Integrated Watershed Management by Isobel W. Heathcote), is the basis for the concept of integrated watershed management.



The Huron Chain of Lakes Watershed Management Plan is rooted in the concept of integrated watershed management and was developed following the process outlined in “Developing a Watershed Management Plan for Water Quality – an Introductory Guide” which was developed by the Michigan State University Institute of Water Research, MSU Extension, and MDEQ. The diagram below outlines a schematic for the general steps of a watershed planning process.



Throughout the nine steps described in the diagram, ongoing public involvement is key to developing a plan that addresses the needs and concerns of the watershed’s residents. The last step of repeating the cycle illustrates the iterative nature of watershed planning. A watershed management plan must be updated and revised as new information becomes available and the successes and shortcomings of implementation efforts are realized over time.

Designated and Desired Uses

According to the Michigan Department of Environmental Quality, the primary criterion for water quality is whether the waterbody meets designated uses. Designated uses are recognized uses of water established by the state and federal water quality programs. In Michigan, the goal is to have all waters of the state meet all designated uses. It is important to note that not all of the uses listed below may be attainable, but they may serve as goals toward which the watershed can move.

Designated uses are recognized uses of water established by the state and federal water quality programs.

All surface waters of the state of Michigan are designated for and shall be protected for all of the following uses. Those that apply to the Huron Chain of Lakes Watershed are in boldface:

- **Agriculture**
- **Industrial water supply**
- **Public water supply at the point of intake**
- Navigation
- **Warmwater fishery**
- **Other indigenous aquatic life and wildlife**
- **Partial body contact recreation**
- **Total body contact recreation between May 1 and October 31**
- Coldwater fishery

Due to human impacts throughout the Huron Chain of Lakes Watershed, not all of the designated uses are fulfilled. Warmwater fishery is impaired due to elevated levels of PCBs in Whitmore Lake and Woodland Lake and high mercury levels in fish tissue samples from Bishop Lake. Other indigenous aquatic life and wildlife is also impaired due to poor macroinvertebrate communities in portions of Honey Creek and Horseshoe Lake Drain, and low levels of dissolved oxygen in a small segment of Yerkes Drain between the South Lyon Wastewater Treatment Plant and Nichwagh Lake. Partial and total body contact recreation uses are threatened throughout the watershed due to high nutrient loads that can cause nuisance algal blooms in non-riverine environments – most notably in Brighton, Ore, and Strawberry Lakes, for which phosphorus TMDLs have been established.

In addition to state-designated uses are uses of the watershed that are desired by its residents but not yet achieved. The Steering Committee that developed this Watershed Management Plan identified the following desired uses:

- **Coordinated development**
  Promote a balance of environmental and economic considerations through intentional community planning and coordinated development within and among the Huron Chain of Lakes communities

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

- **Open space and greenways**
  Protect priority natural habitat, recreational areas and trails, and agricultural lands from development in order to maintain their natural functions, preserve rural character, and enhance recreational opportunities for present and future generations

Challenges to the Health of the Huron Chain of Lakes Watershed

The Steering Committee spent one year gathering the information necessary to understand the impairments, or pollutants, to the Watershed, and their sources and causes. While the Huron Chain of Lakes Watershed contains several areas of high quality natural habitat, aquatic ecosystems, and recreational opportunities, analysis of existing data indicate that the Huron Chain of Lakes Watershed also has stretches of medium- and low-quality waterways that require mitigation of existing impairments.

Although the partners who authored the Huron Chain of Lakes Watershed Management Plan intend to address all of these challenges in the long term with targeted programs, it is important to prioritize and identify the most pressing concerns in the watershed so that resources can be spent cost-effectively in a phased approach. The impairments have been prioritized based upon analysis of existing data, the results of the road stream crossing inventory, and contributions from Steering Committee members and citizens. This information was used to prioritize the impairments from greatest threat to least threat. The sources and causes are not prioritized but known causes (k) are listed above suspected causes (s). As additional information is obtained that indicates a lower ranked impairment, source or cause should be elevated in priority, the ranking should be adjusted to reflect the new information. The following table identifies the challenges to the health of the watershed, and their sources and causes.

It is important to prioritize and identify the most pressing concerns in the Watershed so that resources can be spent cost-effectively.

Prioritized Impairments, Sources and Causes in the Huron Chain of Lakes Watershed

Impairment: High Nutrient Loading (k)	
Sources	**Causes**
Excessive runoff from developed areas (k)	Lack of BMPs at existing development areas (k) Impervious surfaces (k) Poor storm drain maintenance (s)
Failing septic tanks (k)	Old units are too small or don't meet codes (k) Lack of a required maintenance program (k) Poor maintenance/lack of education (s)
Fertilizers from residential, commercial, and golf courses (k)	Lack of buffers (k) No ordinance in place (k) Overuse/improper application of fertilizers (s)
Illicit discharges (k)	Aging sanitary sewer infrastructure (s) Inadequate inspection/detection and repair due to cost (s) Illegal septic application and trailer waste disposal (s)
NPDES permitted facilities (k)	Nutrients in effluent (k)
Agricultural runoff from fertilizers/ livestock waste (s)	Lack of BMPs (upland and riparian buffers) (s) Exposed soils (s)
Pet and wildlife waste (s)	Improper disposal of pet waste (s) Ponds increase habitat for waterfowl, wildlife (s)

Impairment: Altered Hydrology (k)	
Sources	**Causes**
Runoff from developed areas (k)	Lack of BMPs at existing development areas (k) Impervious surfaces (k) Removal of woodland/forest, wetlands, and other pervious areas (k)
Runoff from construction sites, new development (k)	Removal of woodland/forest, wetlands, and other pervious areas (k) Rerouting channel for development (k) Lack of resources for enforcement/inspection (s) Site exemptions (s) Lack of education on alternatives (s)
Engineered drains and streams (k)	Loss of connection between stream and floodplain from channelization (k) Removal of riparian buffer (k)

Impairment: Sedimentation, Soil Erosion (k)	
Sources	**Causes**
Eroding stream banks and channels (k)	Flashy flows (k) Channelization (k) Drain maintenance (k) Eroding crossing embankments (k) Clear cutting/lack of riparian buffers (k)
Construction sites (k)	Clear cutting/lack of riparian buffers (k) Lack of resources for enforcement/inspection (s) Lack of soil erosion BMPs and BMP education (s) Exposed soils (s) Site exemptions (s)
Developed areas (k)	Lack of BMPs at existing development areas (k) Impervious surfaces (k) Clearcutting/lack of riparian buffers (k)
Dirt, gravel roads (k)	Poorly designed/maintained road stream crossings (k) Poor road maintenance (s)
Agricultural field runoff (s)	Lack of BMPs (upland and riparian buffers) (s) Exposed soils (s)

Impairment: Pathogens (k)	
Sources	**Causes**
Failing septic tanks (human waste) (k)	Old units are too small or don't meet codes (k) Lack of a required maintenance program (k) Inadequate enforcement by Health Departments (s) Poor maintenance/lack of homeowner education (s)
Illicit Discharges (k)	Aging development sanitary sewer infrastructure (k) Illegal septic application and trailer waste disposal (s) Inadequate inspection/detection and repair due to cost (s) Lack of education (s)

Impairment: Pathogens (k)	
Sources	**Causes**
Pet and waterfowl waste (s)	Improper disposal of pet waste (runoff from paved areas) (s) Ponds increase habitat for waterfowl, wildlife (s)
Illegal/improper septage application (s)	Lack of adequate septage disposal facilities (s)
Livestock waste from agricultural operations (s)	Lack of BMPs (s)

Impairment: Salts, Organic Compounds and Heavy Metals (k)	
Sources	**Causes**
Developed areas (k)	Lack of stormwater BMPs (k) Illegal dumping (s) Illicit connections (s)
Roads (k)	Auto emissions (k) Lack of BMPs during road de-icing (s) Poor road maintenance (s)
Existing in-stream pollution (k)	Illegal dumping (s) Oil spill in Yerkes Drain in 1970s (k) PCBs in Whitmore Lake and Woodland Lake (k) Excessive mercury in Bishop Lake (k)
NPDES permitted facilities (s)	Inadequate inspection (s) Lack of BMPs (upland and riparian buffers) (s)
Turfgrass chemicals from residential, commercial lawns (s)	Improper lawn care (s) Illegal disposal (s)
Agricultural runoff (s)	Lack of BMPS (upland, riparian buffers) (s)

Impairment: High Water Temperature (k)	
Sources	**Causes**
Directly connected impervious areas (k)	Heated stormwater from urban areas (k)
Eroded soil areas (s)	Soil erosion from channel and upland (k)
Solar heating (s)	Lack of vegetated canopy in riparian zone (k)

Impairment: Debris/Litter (k)	
Sources	**Causes**
Roadways, parks, urban areas, residential areas (k)	Illegal littering/dumping (s) Unsecured garbage containers and vehicles (s) Inadequate refuse containers (s)

Goals and Objectives for the Huron Chain of Lakes Watershed

The designated and desired uses for the Huron Chain of Lakes Watershed, along with the watershed's impairments, sources, and causes, provide a basis from which to build long-term goals and objectives. Long-term goals describe the future condition of the watershed toward which the permittees will work. Long-term goals are not expected to be met within the first five years of plan implementation, but are to be met at some time beyond the first five years of implementation. No single community or agency is responsible for achieving all of the goals or any one of the goals on its own. The goals represent the desired end product of many individual actions, which will collectively protect and improve the water quality, water quantity and biology of the watershed. The permittees will strive together to meet these long term goals to the maximum extent practicable, by implementing a variety of BMPs over time. Selection and implementation of applicable BMPs will vary among communities or agencies according to specific priorities, authority, and resources.

> **The designated and desired uses for the Watershed, along with the watershed's impairments, sources, and causes, provide a basis for developing long-term goals and objectives**

> **The goals represent the desired end product of many individual actions, which will collectively protect and improve the water quality, water quantity and biology of the**

Goals and Objectives for the Huron Chain of Lakes Watershed, and the Designated and Desired Uses They Address

Long-Term Goal	Short-Term Objective	Uses(s) Addressed
1. Increase public awareness of their role in protecting water resources	a. Increase opportunities for public involvement in protection of watershed resources b. Promote education, incentive, and stewardship programs that encourage individual source control of pollutants c. Promote coordination among local units of government in educational program development and implementation. d. Encourage partnerships between public and private entities in funding and promoting educational messages and activities	Designated Uses: all Desired Uses: all
	Long-Term Objective	
	e. Reduce pollution impacts to the Watershed by providing practical knowledge to key audiences	
2. Reduce nonpoint source nutrient loading	**Short-Term Objective**	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Partial and total body contact recreation Desired Uses: Hydrologic functions of natural features
	a. Support establishment of water quality monitoring programs to measure progress toward phosphorus TMDL goals. b. Develop ordinances, strategies, and/or programs for reducing nutrient loading. c. Promote implementation of structural and vegetative BMPs at new and existing developed areas.	
	Long-Term Objective	
	a. Meet established TMDL goals for Brighton, Ore, and Strawberry lakes.	

3. Reduce flow variability	**Short-Term Objective** a. Establish current stream flow dynamics through established monitoring strategy b. Increase the use of Low Impact Development (LID) principles c. Develop ordinances, strategies, and/or programs to manage peak flow rates **Long-Term Objective** d. Protect and increase storage in wetlands, floodplains, groundwater, and other pervious areas with infiltration capacity	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Desired Uses: Hydrologic functions of natural features
4. Reduce soil erosion and sedimentation	**Short-Term Objective** a. Establish baseline data for sediment desposits in monitored streams through established monitoring program b. Improve application and enforcement of soil erosion and sedimentation controls (SESC) c. Increase education of BMPs among property owners and the building community **Long-Term Objective** d. Increase clarity in surface waters	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Industrial water supply; Public water supply Desired Uses: Hydrologic functions of natural features
5. Protect and mitigate loss of natural features for indigenous riparian and aquatic animals and plants	**Short-Term Objective** a. Integrate natural features mapping data into land use planning decisions b. Develop policies that protect natural areas c. Monitor water quality and biota to measure progress d. Educate local decision makers and the public about the benefits of critical habitat protection e. Consider groundwater recharge data when identifying priority natural features protection areas **Long-Term Objective** f. Maintain or improve the aquatic community, including meeting TMDL goals for poor macroinvertebrate communities in Horseshoe Lake Drain and Honey Creek. g. Increase areas of natural features, including wetlands, woodlands, riparian buffers, and floodplains	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Industrial water supply; Public water supply Desired Uses: Hydrologic functions of natural features; Open space and greenways
6. Protect existing open space and agricultural land	**Short-Term Objective** a. Identify and prioritize key opportunities for protection of undeveloped lands b. Develop policy and planning tools that address urban sprawl c. Facilitate regional coordination in preserving open space corridors, especially riparian corridors d. Work with land conservancies and other land preservation groups to facilitate use of land protection/conservation tools	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Desired Uses: Hydrologic functions of natural features; Open space/greenways
7. Protect and enhance recreational opportunities	**Short-Term Objective** a. Identify and reduce sources of pollution that inhibit recreational activities b. Increase regional coordination of recreational planning efforts c. Research and pursue grant opportunities for recreational planning efforts	Designated Uses: Partial and total body contact recreation; Warmwater fishery; Desired Uses: Open space/greenways; hydrologic functions of natural features

8. Increase monitoring of water quality, water quantity, and biological indicators	**Short-Term Objective** a. Develop a monitoring strategy b. Secure funding and develop partnerships to conduct short-term and long-term monitoring of key indicators c. Implement and maintain Illicit Discharge Elimination Program (IDEP) investigations	Designated Uses: all Desired Uses: all
9. Balance environmental and economic benefits in the subwatershed	**Short-Term Objective** a. Integrate stormwater management in planning and site plan review process b. Educate land use decision makers and developers on long-term economic benefits of stormwater BMPs, impacts of development on the watershed, and tools for low impact development c. Increase coordinated planning efforts and implementation among local units of government	Designated Uses: all Desired Uses: all
10. Attain full plan implementation	**Short-Term Objective** a. Establish financial and institutional arrangements for WMP fulfillment b. Ensure the long-term viability of the Huron Chain of Lakes Steering Committee to guide watershed-wide planning decisions. c. Increase public awareness of progress in WMP implementation	Designated Uses: all Desired Uses: all

Watershed Management Alternatives (Best Management Practices)

After establishing goals and objectives for the watershed, the Steering Committee discussed various management alternatives, also known as Best Management Practices (BMPs), that could be employed to fulfill them. A stormwater BMP is a technique, measure, or structural control that is used for a given set of conditions to manage the quantity and quality of stormwater runoff in the most cost-effective manner. BMPs fall into one of three categories:

> **Structural BMPs** are engineered and constructed systems that improve the quality and/or control the quantity of runoff such as detention ponds and constructed wetlands. Structural BMPS are inherently site-specific and are designed to treat or manage stormwater at a specific location.
>
> **Vegetative BMPs** are natural processes that preserve existing vegetation or establishes ground cover to minimize soil erosion. Vegetative BMPs are sometimes considered as a sub-set of structural BMPs.
>
> **Non-structural BMPs**, also known as **Managerial BMPs**, are institutional, educational or regulatory pollution prevention practices designed to limit the generation of stormwater runoff or reduce the amounts of pollutants contained in the runoff. These BMPs focus on modifying behaviors and practices through a wide variety of activities such as adopting new policies and ordinances, providing watershed education to residents, conducting studies and inventories, and tracing illicit connections.

No single BMP can address all stormwater problems. Each practice has certain limitations based on drainage area served, available land space, cost, pollutant removal efficiency, as well as a variety of site specific factors such as soil types, slopes, depth of groundwater table, etc. Careful consideration of these factors is necessary in order to select the appropriate group of BMPs for a particular location or situation.

Nintey-six management alternatives, are presented in the Action Plan at the end of Chapter 4 as actions that will help achieve the goals and objectives for the Huron Chain of Lakes Watershed. Where applicable, each management alternative in the Action Plan is presented with which goals it addresses, level of effort, estimated capital and maintenance costs, technical and/or financial resources, and intent of the permittees to employ the actions.

A stormwater BMP is a technique, measure, or structural control that is used for a given set of conditions to manage the quantity and quality of stormwater runoff in the most cost-effective manner

Watershed Management Plan Implementation, Coordination and Evaluation

A successful watershed plan is ultimately defined not by what is written on the pages, but by how the recommended plans and programs are put into action. A successful plan for implementation also recognizes that the state of the watershed changes over time. As such, evaluating the effectiveness and appropriateness of the actions taken to implement the Plan, as well as the ability to adapt these actions to the changing conditions of the watershed, is critical.

While individual Phase II permit holders are required to provide the State with annual reports on their NPDES Phase II-related activities, which includes efforts to implement the Watershed Management Plan, a well-organized framework for implementing and revising the Plan on a watershed-wide level still is needed to keep the Steering Committee on track toward achieving the broad goals of water quality and natural resource protection and improvement. To ensure successful implementation, nine key elements should be addressed, as shown below.

Key Elements of Successful Watershed Plan Implementation

1.	Appoint a single lead agency to act as an advocate and facilitator for the plan with the community and with political representatives.
2.	Strong linkages to existing programs, including local and regional land use planning processes, water quality and flow monitoring programs, and similar programs, to optimize use of available information and minimize duplication of effort.
3.	Clear designation of responsibilities, timetables, and anticipated costs for project actions.
4.	Effective laws, regulations, and policies to provide a framework for the tasks identified in Element 3.
5.	Ongoing tracking of the degree of implementation of management actions and of the success of those actions once implemented.
6.	Ongoing monitoring and reporting of progress, both to assess the effectiveness of individual actions and to sustain public and political interest in and enthusiasm for the plan.
7.	Ongoing public education and communication programs to consolidate and enhance the social consensus achieved in the planning process.
8.	Periodic review and revision of the plan.
9.	Adequate funding for these activities.

Advisory Committee Structure

To facilitate implementation of the Huron Chain of Lakes Watershed Management Plan over time, a framework for a series of working groups will help to provide a useful feedback loop for determining how, and the extent to which, the goals and objectives of the Plan are being successfully implemented. These working groups would ideally be comprised of the following groups of stakeholders:

- Managers, planners, coordinators, and their staff members
- Boards and steering committees
- Volunteers (citizens and watershed stewards)
- Environmental Interest Groups
- Funding Groups

These groups of stakeholders should ultimately allow for input and implementation assistance from a broad cross-section of all stakeholder and interest groups in the watershed, as outlined in the Huron Chain of Lakes Watershed Public Participation Plan (see Appendix H).

Expansion of the existing committee structure into two tiers is recommended to oversee the implementation and evaluation of the Plan. In addition to a steering committee, a set of advisory committees and/or sub-committees could be established to allow focus on specific aspects of the plan, such technical, scientific, or public involvement. The steering committee might be comprised of stormwater program managers and staff. The advisory committees and/or subcommittees might be staffed by land use planners, commissions, boards, interested citizens, environmental group advocates, scientists, etc. that would pull together various aspects of the data and results during the implementation phases of the Plan (i.e. water quality data, public education initiatives, illicit discharge investigations, etc.). The Livingston County Drain Commissioner's Office will provide support for, and oversight of, the activities of the Steering Committee and smaller committee/ subcommittee levels.

The importance of public representation and broad stakeholder involvement throughout any advisory committee structure must be stressed, as these individuals are in a position to explain and influence community opinion and help to build support for needed changes. One of the first tasks of the Livingston County Drain Commissioner's Office and current members of the Huron Chain of Lakes Steering Committee should be to begin developing an advisory committee structure that allows for involvement by a broad range of stakeholders as discussed above.

Evaluation Methods

Measurement and evaluation are important parts of planning because they can indicate whether or not efforts are successful and provide a feedback loop for improving project implementation as new information is gathered. The ability to demonstrate measurable results increases support for the Plan from the partnering communities and agencies and local decision makers, and also increases the likelihood of project sustainability and success. Monitoring and measuring progress in the watershed necessarily will be conducted at the local level by individual agencies and communities, as well as at the watershed level, in order to assess the ecological affects

The ability to demonstrate measurable results increases support for the Plan and also increases the likelihood of project sustainability and success.

of the collective entity actions on the health of the Watershed.

Because achievement of water quality standards is the ultimate goal of plan implementation, direct measurement of environmental improvements through instream monitoring is ideal. Such methods are beneficial in monitoring the long-term progress and effectiveness of the cumulative watershed efforts in terms of water quality, water quantity and biological monitoring. Examples of direct measurement of environmental improvements include:

1) Measuring specific water quality or chemistry parameters, such as phosphorus loadings or *E. coli* levels;
2) Physical and hydrological indicators such as physical habitat monitoring, flooding frequencies, or changes in stream shape due to erosion and sedimentation; and
3) Biological indicators such as macroinvertebrate or fish assemblages.

However, directly measuring environmental indicators requires large investments of time and resources. Benchmarks of existing conditions and future targets must be established in order to ascertain improvements in the health of the Watershed.

In addition to directly measuring physical improvements in the environment, progress in implementing various programs or individual program elements can also be measured. Although such methods of measuring progress are not tied directly to measurements in the river, it is fair to assume that the success of these actions and programs, collectively and over time, will impact positively on the instream conditions in the Watershed. Examples of indicators that can be used as surrogates for direct environmental improvement include:

1) Social indicators, such as public awareness surveys and tracking of public involvement in stewardship and monitoring efforts;
2) Programmatic indicators, such as tracking the number of illicit connections identified/corrected, number and types of ordinances adopted/amended, number of structural BMPs installed, and quantities of public education materials distributed;
3) Site indicators, such as BMP performance monitoring at specific sites.

Such indicators provide relatively easy-to-measure and cost-effective alternatives to direct environmental measurements that can be costly and time-consuming. These types of indicators provide a means for measuring interim or short-term progress of individual or specific programs or actions.

The dynamic nature and complex interaction of social, economic, and biophysical forces in the Watershed require a continuous cycle of evaluating the effectiveness of the management alternatives in meeting the Plan's

Watershed Management Plan Revision Process

Implementing the Huron Chain of Lakes Watershed Management Plan in a way that follows the principles of integrated watershed management requires continuous evaluation of the effectiveness of the management alternatives in meeting the Plan's goals and objectives. The concept of "adaptive management" is central to successful implementation of the Plan. Adaptive management incorporates research into conservation action. Specifically, it is the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn.

The goals and recommendations of this Plan are based on the understanding of the conditions of the natural watershed ecosystem at the time this Plan was developed. However, both the conditions of the watershed and the goals and actions will change over time as new information is collected, available resources for implementation are assessed, and the values and needs of the watershed's residents evolve.

Changes in social and economic forces can trigger changes in watershed management practices. Similarly, changes in a watershed's ecosystem can indicate a need for altered watershed management practices. Adaptive management recognizes the dynamic interplay of these forces, which implies a need to continually evaluate progress toward the meeting the Plan's goals and objectives.

CHAPTER 1: INTRODUCTION

Huron River at the Kent Lake Dam *photo: HRWC*

1.1 THE HURON CHAIN OF LAKES WATERSHED

The Huron Chain of Lakes Watershed is part of the Huron River Watershed (see Figure 1.1), one of Michigan's natural treasures. The Huron River supplies drinking water to approximately 150,000 people, supports one of Michigan's finest smallmouth bass fisheries, and is the State's only designated Scenic River in southeast Michigan. The Huron River Watershed is a unique and valuable resource in southeast Michigan that contains ten Metroparks, two-thirds of all southeast Michigan's public recreational lands, and abundant county and city parks. In recognition of its value, the State has officially designated 27 miles of the Huron River and three of its tributaries as Michigan Department of Natural Resources Country Scenic River under the State's Natural Rivers Act (Act 231, PA 1970). The Huron is home to one-half million people, numerous threatened and endangered species and habitats, abundant bogs, wet meadows, and remnant prairies of statewide significance.

The Huron River basin is located in southeastern Michigan and encompasses approximately 900 square miles (576,000 acres) of Ingham, Jackson, Livingston, Monroe, Oakland, Washtenaw, and Wayne counties (Figure 1.1). The main stem of the Huron River is approximately 136 miles long, with its origin located at Big Lake and the Huron Swamp in Springfield Township, Oakland County. The main stem of the river meanders from the headwaters through a complex series of wetlands and lakes in a southwesterly direction to the area of Portage Lake. Here, the river begins to flow south until reaching the Village of Dexter in Washtenaw County, where it turns southeasterly and proceeds to its final destination of Lake Erie. The Huron is not a free-flowing river. At least 98 dams segment the river system, of which 17 are located on the main stem.

The immediate drainage area to the Huron Chain of Lakes Watershed is 253 square miles (161,919 acres), representing approximately 28% of the Huron River Watershed. The majority of the watershed lies within Livingston County, with eastern portions in southwest Oakland County and southernmost areas in Washtenaw County. All or portions of 20 local communities are situated in the Huron Chain of Lakes Watershed, of which the largest portions are within the townships of Brighton, Genoa, Lyon, Green Oak, Hamburg, and Putnam, as well as the Village of Pinckney, the City of Brighton, and the City of South Lyon. Other communities with smaller areas in the watershed include the townships of Highland, Hartland, Oceola, Milford, Marion, Unadilla, Salem, Northfield, Webster, and Dexter, as well as the City of Novi.

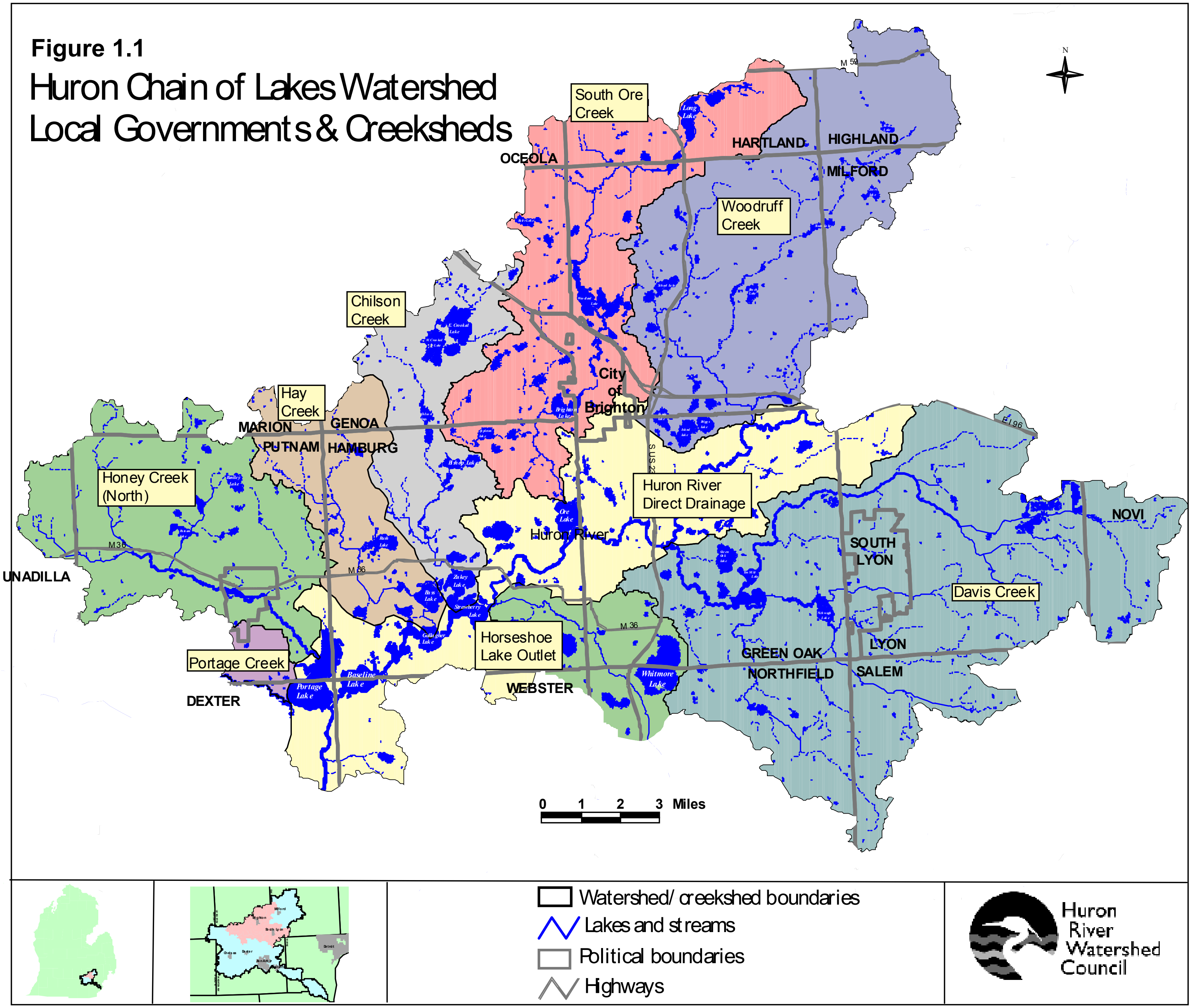


Figure 1.1
Huron Chain of Lakes Watershed
Local Governments & Creeksheds
South Ore Creek
Woodruff Creek
Chilson Creek
Hay Creek
Honey Creek (North)
Huron River Direct Drainage
Davis Creek
Horseshoe Lake Outlet
Portage Creek
OCEOLA
HARTLAND
HIGHLAND
MILFORD
City of Brighton
MARION
GENOA
PUTNAM
HAMBURG
UNADILLA
Huron River
SOUTH LYON
NOVI
GREEN OAK
LYON
NORTHFIELD
SALEM
WEBSTER
DEXTER
Portage Lake
Baseline Lake
Whitmore Lake
0 1 2 3 Miles
Watershed/ creekshed boundaries
Lakes and streams
Political boundaries
Highways
Huron River Watershed Council

The segment of the Huron River in the Huron Chain of Lakes Watershed begins at the outfall of the Kent Lake Dam on the Oakland County/Livingston County border and ends approximately two miles downstream of Portage Lake, where it straddles the border between Livingston and Washtenaw Counties. From the Kent Lake outlet, the river flows southwest through a series of wetland complexes and several large glacial kettle lakes in Livingston County before reaching Portage Lake. Eight major tributaries, corresponding to eight distinct sub-basins, or "creeksheds", drain into this direct drainage area of the Huron River. The mainstem of the Huron River in the Watershed is approximately 27 miles long with additional 593 miles of contributing streams. Over 22,000 acres (34 sq. miles) of wetlands remain in the Watershed as of 2000, comprising over 13% of the total watershed area. The Huron Chain of Lakes area contains nearly 1000 lakes and impoundments, of which 172 are greater than five acres and 84 of which are greater than twenty acres.

The watershed contains a number of protected natural areas including Island Lake State Recreation Area, Huron Meadows Metropark, Gregory State Game Area, Brighton State Recreation Area, portions of Pinckney State Recreation Area and Hudson Mills Metropark, as well as numerous public and private local parks. Low-density residential areas, grasslands/old agricultural fields, forested lands, and wetlands are found throughout the watershed while medium- and high-density residential and commercial and industrial areas are concentrated in the more urbanized areas.

In recent decades, the Huron River Watershed, particularly in the Huron Chain of Lakes, has experienced amplified development pressures from a growing economy and urban sprawl. According to the U.S. Census data and the Southeast Michigan Council of Governments (SEMCOG)[1], the total population of the nine communities that comprise nearly ¾ of the Chain of Lakes Watershed[*] increased 52% from 1990 to 2005. The forecast to 2030 show a 74% increase in population from 2005 levels. The number of households in these nine communities increased 61% from 1990 to 2005. The forecast to 2030 show a 91% increase in total households from 2005 levels.

Livingston County has been the fastest growing county in the state for the past decade, reflecting a trend in growth out from Detroit to the more outlying areas spurred by highway improvements, infrastructure, and a desire for open space. According to SEMCOG, Livingston County's population increased by over 13% from 2000 to July 2004, compared with 1.6% in Oakland County and 6.5% in Washtenaw County. SEMCOG predicts that most of Livingston County's growth in the next 30 years will take place in Genoa, Brighton, Hamburg, and Green Oak Townships, the heart of the watershed. Putnam Township and Lyon Township are also experiencing tremendous growth, with populations increasing more than 10 % and 14% respectively since the 2000 Census.[2]

If current development practices are employed to accommodate the projected increase in population and associated infrastructure, then SEMCOG estimates 40% of the remaining open spaces will be developed within the Huron River Watershed by 2020. Much of this projected conversion of undeveloped land will occur in the Huron Chain of Lakes area where it will hasten degradation of the hydrology and water quality of surface

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[*] Includes Brighton Township, City of Brighton, Genoa Township, Green Oak Township, Hamburg Township, Lyon Township, Village of Pinckney, Putnam Township, and City of South Lyon.

waters. Common practices that impact hydrology and water quality include draining of wetlands, straightening and dredging of streams ("drains"), removal of riparian vegetation, installation of impervious surfaces and storm sewers, inadequate soil erosion controls, poorly designed stream crossings, and elevated nutrients. Such practices result in altered hydrology ("flashy" flows and flooding), soil erosion and sedimentation, nuisance algal blooms, dangerous levels of pathogens, and degraded fisheries.

1.2 Purpose of the Huron Chain of Lakes Watershed Management Plan

The Huron Chain of Lakes Watershed Management Plan (WMP) is part of an effort led by communities in the Huron Chain of Lakes Watershed seeking compliance with the federal National Pollutant Discharge Elimination System (NPDES) Phase II Stormwater Program. In Michigan, the U.S. Environmental Protection Agency (U. S. EPA) has authorized the Michigan Department of Environmental Quality (MDEQ) to administer the Phase II permitting process. The Huron Chain of Lakes WMP is being developed to meet one of the requirements of Michigan's watershed-based stormwater permit (MIG619000), one of two permit options available to communities in Michigan.

As that permit states "the permittee shall participate in the development and implementation of a Watershed Management Plan. The purpose of the WMP is to identify and execute the actions needed to resolve water quality and water quantity concerns by fostering cooperation among the various public and private entities in the watershed…. The emphasis of the WMP shall be to mitigate the undesirable impacts caused by wet weather discharges from separate storm water drainage systems." Furthermore, the General Watershed-Based Permit requires that "Those concerns related to Total Maximum Daily Loads (TMDLs) established within the watershed should be included and details for those actions specific to storm water controls shall be listed in the WMP."

This Plan was developed with the intention of fulfilling the watershed management planning criteria for the NPDES Phase II Program, as mentioned above, as well as for the U.S. EPA's Clean Water Act §319 Program and MDEQ's Clean Michigan Initiative Program.

The communities involved in the development of this plan are committed to protecting the sensitive natural areas of the Huron Chain of Lakes Watershed, mitigating impacts of existing and future stormwater discharges and nonpoint source pollution, and restoring degraded areas.

1.3 Huron Chain of Lakes Steering Committee

Efforts to comply with Phase II stormwater regulations in Livingston County are being coordinated under leadership of the Livingston County Drain Commissioner (LCDC). In order to facilitate a coordinated effort throughout the County to meet the watershed-based permit requirements, LCDC has held monthly joint meetings for permitees in the Huron Chain of Lakes and South Branch Shiawassee watersheds since December 2002. This countywide group works together to address administrative and procedural Phase II issues that are common to permitees in both watersheds.

The Huron Chain of Lakes Steering Committee (the Steering Committee) was formed in February 2004 to coordinate the study, development, and timely filing with MDEQ of a Huron Chain of Lakes Watershed Management Plan as required under the Phase II stormwater requirements. The Steering Committee met monthly following the county-wide regular meetings. Through an intergovernmental agreement administered by the County, representatives from the following Huron Chain of Lakes Phase II entities in Livingston County formed the core of the Steering Committee, which commissioned the services of the Huron River Watershed Council (HRWC) to facilitate the development of, and write, the Huron Chain of Lakes Watershed Management Plan:

City of Brighton	Livingston County Drain Commissioner
Brighton Township	Livingston County Road Commission
Genoa Township	Village of Pinckney
Green Oak Township	Putnam Township

These core Steering Committee entities are considered “primary permittees,” meaning that they are covered under the watershed-based Phase II permit through the Huron Chain of Lakes planning efforts, are voting members of the Steering Committee, and financed the Plan’s development. Details on the machinations of the Steering Committee are found Appendix K of this Plan.

Listed below are seventeenl other entities that are located within the Huron Chain of Lakes Watershed. With the exception of Unadilla Township, which is not regulated under Phase II, these entities are either primarily associated with the Kent Lake Watershed Phase II group, the Upper-2 Shiawassee Watershed Phase II group, or are covered by a jurisdictional Phase II permit. These entities were all encouraged to participate in the planning process, and some of these entities participated in the monthly meetings of the Steering Committee and contributed to the development of this Plan.

Dexter Township	**City of Novi**
Hamburg Township	**Oakland County**
Hartland Township	Oceola Township
Highland Township	Salem Township
Lyon Township	City of South Lyon
Marion Township	Unadilla Township
Milford Township	Webster Township
Northfield Township	Washtenaw County Drain Commissioner
Huron Valley School District	

Entities in **bold** from the list above are considered to be “secondary permittees”, meaning that they are required to participate, along with the eight primary permittees, in implementing the Huron Chain of Lakes Watershed Management Plan.

Additionally, the following other organizations participated in the development of the Huron Chain of Lakes Watershed Management Plan:

Livingston County MSU Extension Service
Southeast Michigan Council of Governments
Michigan Department of Environmental Quality

1.4 Coordination with Federal Water Quality Programs and Existing Watershed Management Plan Efforts

1.4.1 National Pollutant Discharge Elimination System (NPDES) Phase II Stormwater Permit

As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes. According to the U.S. Environmental Protection Agency (U.S. EPA), individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit. However, industrial, municipal, and other facilities must obtain permits if their stormwater discharges go directly to surface waters. Stormwater discharges are generated by runoff from land and impervious areas such as paved streets, parking lots, and building rooftops during rainfall and snow events that often contain pollutants in quantities that could adversely affect water quality. Most stormwater discharges are considered point sources and require coverage by an NPDES permit.

A 1987 amendment to the Federal Clean Water Act required the U.S. EPA to develop regulations setting NPDES permit application requirements for stormwater discharges from communities with municipal separate storm sewer systems (MS4s). An MS4 is a drainage system that discharges to waters of the State and is owned or operated by a federal, state, county, city, village, township, district, or other public body of government. Such drainage systems may include roads, catch basins, curbs, gutters, parking lots, ditches, conduits, pumping devices, or man-made channels.

Phase I of the NPDES regulations, which went into effect in 1990, regulated stormwater discharges from communities with MS4s and populations greater than 100,000. The regulations for Phase II of the NPDES regulations, which capture the next tier of communities, were issued in 1999. Communities with MS4s that are located within the U.S. Census Bureau's urbanized areas, based on the 2000 census, are required to obtain stormwater discharge permits under Phase II of the NPDES regulations. A majority of communities in the Huron River Watershed, including all communities in the Huron Chain of Lakes Watershed except Unadilla Township, must comply with these regulations as of March 2003.

As mentioned above in section 1.2, the Huron Chain of Lakes WMP is being developed to meet a requirement of Michigan's watershed-based stormwater permit (MIG 619000). The watershed-based permit is unique to Michigan and has been "strongly endorsed" by the U.S. EPA. This permit requires the formation of watershed working groups composed of communities and other political and public agencies responsible for the management of stormwater discharges to work cooperatively to develop and implement plans to address stormwater pollution. The watershed-based permit requires communities to complete five different components:

1. *Watershed Management Plan (WMP)* to identify and address water quality and quantity issues within the Huron Chain of Lakes Watershed. This WMP will be

developed in cooperation with other communities and stakeholders within the Huron Chain of Lakes Watershed;

2. *Public Education Plan (PEP) to* promote, publicize, and facilitate watershed education to encourage the public to reduce the discharge of pollutants in storm water;
3. *Public Participation Plan (PPP)* to solicit input and encourage participation from all watershed stakeholders in developing the Huron Chain of Lakes WMP;
4. *Storm Water Pollution Prevention Initiative (SWPPI)* to detail the actions that a community will take to meet the goals of the WMP and to reduce discharge of pollutants to the maximum extent practicable;
5. *Illicit Discharge Elimination Program (IDEP)* to find, eliminate, and prohibit illicit discharges to a community's storm water drainage system.

1.4.2 Total Maximum Daily Load Program

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

The state also monitors water quality to determine the adequacy of pollution controls from point source discharges. If a waterbody cannot meet the state's water quality criteria with point-source controls alone, the Clean Water Act requires that a TMDL must be established. TMDLs provide a basis for determining the pollutant reductions necessary from both point *and non-point* sources to restore and maintain the water quality standards. In Michigan, the responsibility to establish TMDLs rests with the MDEQ. Once a TMDL has been established by the MDEQ, affected stakeholders must develop and implement a plan to meet the TMDL, which will bring the waterbody into compliance with state water quality standards

To date, three TMDLs, all for phosphorus, have been established in the watershed for Brighton, Strawberry, and Ore Lakes. Six TMDLs for other pollutants are scheduled for future establishment in the watershed, as described in Table 1.1.

Table 1.1: Waterbodies requiring TMDLs in the Huron Chain of Lakes Watershed
(Source: MDEQ 2004 303(d) list of nonattaining waterbodies)

Waterbody	Pollutant or Problem	TMDL Year	Location/Area
Brighton Lake	Nutrient enrichment (phosphorus)	Established in 2000	158 acre impoundment of South Ore Creek, downstream of City of Brighton
Ore Lake	Nutrient enrichment (phosphorus)	Established in 2000	192 acre impoundment of South Ore Creek, downstream of Brighton Lake near Huron River
Strawberry Lake	Nutrient enrichment (phosphorus)	Established in 2000	Hamburg Twp. 247 acre lake on Huron River just downstream of M-36.
Honey Creek	Poor macroinvertebrate community	Scheduled for 2007	Vicinity of Pinckney. 16 miles from headwaters to Mill Pond at Toma Rd.
Horseshoe Lake Drain	Poor macroinvertebrate community	Scheduled for 2009	Northfield Twp in Washtenaw County. 1.4 miles from Horseshoe Lake outlet, downstream to Barker Rd.
Bishop Lake	Fish Consumption Advisory for Mercury	Scheduled for 2011	119 acre lake in Brighton State Rec. Area, Hamburg Twp
Whitmore Lake	Fish Consumption Advisory for Polychlorinated Biphenyls (PCBs)	Scheduled for 2010	677-acre lake in vicinity of Whitmore Lake, MI.
Woodland Lake	Fish Consumption Advisory for Polychlorinated Biphenyls (PCBs)	Scheduled for 2010	309 acre lake on South Ore Creek, north of City of Brighton.
Yerkes Drain	Water Quality Standard Exceedance for Dissolved Oxygen	Scheduled for 2013	.7 miles from South Lyon WWPT downstream to Nichwagh Lake.

These individual TMDLs are discussed in greater detail in Chapter 2. As previously mentioned, concerns related to established TMDLs in the watershed, and stormwater-related actions to address those TMDLs, are included in this Plan. However, because the problems associated with Mercury and PCB TMDLs are not likely to be closely linked to stormwater, actions designed to address such TMDLs are not emphasized in this Plan.

1.4.3 The Brighton Lake Subwatershed Management Plan

In August 2002 a Watershed Management Plan for the Brighton Lake Subwatershed (a part of the Huron Chain of Lakes Watershed) was completed under the guidance of the Huron River Watershed Council and approved by the MDEQ. The primary purpose of the Brighton Lake Subwatershed Management Plan was to establish a state-approved methodology to diminish the adverse effects of nonpoint source phosphorus pollution throughout the subwatershed and meet the established phosphorus loading Total Maximum Daily Load (TMDL) for Brighton Lake.

The recommendations of these two plans are inherently complementary because: the Brighton Lake Subwatershed is inclusive in the Huron Chain of Lakes Watershed; the Huron Chain of Lakes WMP must also address concerns related to the Brighton Lake TMDL; and the TMDL for Brighton Lake cannot be addressed without improving stormwater management practices. Therefore, implementation of either plan will necessarily advance implementation of the other plan.

CHAPTER 2: CURRENT CONDITIONS

Jewelweed near Davis Creek *Photo: HRWC*

An effort has been made to collect all readily available information to establish a baseline of current conditions of the Watershed. This effort included requests to Steering Committee members and researchers in the area. Comprehensive literature searches resulted in acquisition of studies, as well. Numerous studies and datasets of relevance were obtained in this process. In addition, spatial data was gathered and analyzed in a Geographic Information System. However, the information contained in this chapter should not be considered comprehensive.

2.1 LANDSCAPE AND NATURAL FEATURES

2.1.1 Climate and Topography

Seasonal changes are the most important feature of Michigan's, and therefore the watershed's, climate. The Huron River Watershed receives an average of 30 inches of precipitation annually as it is located in the drier portion of Michigan. Seasonal patterns of this precipitation are fairly stable due to warmer temperatures that hold more moisture in the air. Since southern Michigan thaws and refreezes regularly through most of the winter, the Huron River does not experience as much variability as more northern rivers with their low and high flows.

Evaporation in the watershed is higher than most of the state, due to higher temperatures and slightly drier air found in southeast Michigan. As a result, the Watershed has one of the lowest amounts of total annual runoff in Michigan. For a 30-year period, the average high temperatures ranged from 32ºF in January to 84ºF in July in the Watershed, while the average low temperatures ranged from 15ºF in January to 59ºF in July.

The Huron Chain of Lakes Watershed falls into two distinct regional landscape ecosystems according to the USGS classification, the Jackson Interlobate area and the Ann Arbor Moraines. The Nature Conservancy identifies the Huron River Watershed as located within the North Central Till Plain and the Great Lakes ecoregions. Ecoregions are areas that exhibit broad ecological unity, based on such characteristics as climate, landforms, soils, vegetation, hydrology and wildlife. The Huron Chain of Lakes area lies entirely within the North Central Till Plain ecoregion.

The surface topography of the Huron Chain of Lakes area was created by the most recent glaciation in Michigan's history, the Wisconsonian. Following the glacier's final retreat approximately 10,00 years ago, it left behind a region of rolling hills interspersed with flat areas. The terrain is characterized by a dendritic pattern of tributaries, numerous pothole lakes, and extensive wetland areas.

2.1.2 Geology and Soils

Glacial outwash plains and coarse to medium textured end moraines characterize much of the Watershed (Figure 2.2). 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 Moraine are areas where glacial processes deposited huge quantities of rock and soil material of various sizes in one place. The mixture of varying sized soil particles increases the soils' ability to hold moisture and nutrients, which is conducive to agriculture. Coarse textured end moraines, which are found mainly in the northern and western portions of the Watershed, have low to moderate permeability, while the medium textured end moraines in patches around the Watershed's periphery have lower permeability.

The soils in the upper Huron River Watershed, which includes the Huron Chain of Lakes Watershed, are largely sandy loams or friable-clay mixtures. Soils near the river and streams in upland plains are associated with the Fox-Oshtemo-Plainfield groups. Areas away from the river and streams become more rolling and hilly highlands and contain soils of the Bellefontaine-Hillsdale-Coloma association. Figure 2.3 shows the soil groups according to their hydrological classification, ranging from high to low infiltration. The vast majority of the Huron Chain of Lakes area is composed of soils with moderate infiltration, scattered with smaller areas of high to moderate infiltration.

2.1.3 Significant Natural Features and Biota

While much of the Huron Chain of Lakes Watershed has been altered and degraded, pockets of high quality habitat and diverse species remain. The extent and ecological quality of the remaining open spaces and native habitats directly impact the quality of life and quality of water in the Watershed. Researchers have recognized plant and animal species, as well as plant community types, as significant for protection in the Watershed. Among those conservation targets are the threatened and endangered species, or element occurrences, that have been observed in the watershed (Table 2.1). Many of the 60 plant and animal element occurrences in the table are partially or entirely dependent on aquatic ecosystems for survival.

Table 2.1. Threatened, Endangered, and Special Concern Occurrences in the Huron Chain of Lakes Watershed[3]

SC = Special Concern *T = Threatened* *C= being considered for federal status*
PE = Proposed Endangered *E = Endangered*

Common name	Scientific NAME	state status	federal status
ANIMALS			
American Burying Beetle	*Nicrophorus americanus*	E	E
Blanchard's Cricket Frog	*Acris crepitans blanchardi*	SC	
Blanding's Turtle	*Emys blandingii*	SC	
Blazing Star Borer	*Papaipema beeriana*	SC	
Brindled Madtom	*Noturus miurus*	SC	
Cerulean Warbler	*Dendroica cerulea*	SC	
Dwarf Hackberry	*Celtis tenuifolia*	SC	
Eastern Box Turtle	*Terrapene carolina carolina*	SC	
Eastern Massasauga	*Sistrurus catenatus catenatus*	SC	C
Eastern Sand Darter	*Ammocrypta pellucida*	T	
Gravel Pyrg	*Pyrgulopsis letsoni*	SC	
Hooded Warbler	*Wilsonia citrina*	SC	
Indiana Bat	*Myotis sodalis*	E	E
King Rail	*Rallus elegans*	E	
Least Shrew	*Cryptotis parva*	T	
Northern Madtom	*Noturus stigmosus*	E	
Persius Duskywing	*Erynnis persius persius*	T	
Pugnose Shiner	*Notropis anogenus*	SC	
Purple Wartyback	*Cyclonaias tuberculata*	SC	
Red-legged Spittlebug	*Prosapia ignipectus*	SC	
Regal Fern Borer	*Papaipema speciosissima*	SC	
Regal Fritillary	*Speyeria idalia*	E	
Southern Redbelly Dace	*Phoxinus erythrogaster*	E	
Spotted Turtle	*Clemmys guttata*	T	
Swamp Metalmark	*Calephelis mutica*	SC	
Wavy-rayed Lampmussel	*Lampsilis fasciola*	T	
Woodland Vole	*Microtus pinetorum*	SC	
PLANTS			
Broad-leaved Puccoon	*Lithospermum latifolium*	SC	
Canadian Milk-vetch	*Astragalus canadensis*	T	
Clinton's Bulrush	*Scirpus clintonii*	SC	
Creeping Whitlow-grass	*Draba reptans*	T	
Downy Gentian	*Gentiana puberulenta*	E	
Edible Valerian	*Valeriana edulis var. ciliata*	T	
English Sundew	*Drosera anglica*	SC	
False Hop Sedge	*Carex lupuliformis*	T	
Ginseng	*Panax quinquefolius*	T	
Green Violet	*Hybanthus concolor*	SC	
Hairy Angelica	*Angelica venenosa*	SC	
Horsetail Spike-rush	*Eleocharis equisetoides*	SC	
Kentucky Coffee-tree	*Gymnocladus dioicus*	SC	
Mat Muhly	*Muhlenbergia richardsonis*	T	
Nodding Mandarin	*Disporum maculatum*	X	
Orange/Yellow Fringed Orchid	*Platanthera ciliaris*	T	
Pale Avens	*Geum virginianum*	SC	
Prairie Dropseed	*Sporobolus heterolepis*	SC	
Prairie Fringed Orchid	*Platanthera leucophaea*	E	T
Purple Milkweed	*Asclepias purpurascens*	SC	
Ram's Head Lady's-slipper	*Cypripedium arietinum*	SC	

Common name	*Scientific NAME*	*state status*	*federal status*
Red Mulberry	*Morus rubra*	T	
Richardson's Sedge	*Carex richardsonii*	SC	
Sedge	*Carex squarrosa*	SC	
Showy Orchid	*Galearis spectabilis*	T	
Side-oats Grama Grass	*Bouteloua curtipendula*	T	
Spike-rush	*Eleocharis radicans*	X	
Tamarack Tree Cricket	*Oecanthus laricis*	SC	
Vasey's Pondweed	*Potamogeton vaseyi*	T	
Virginia Flax	*Linum virginianum*	T	
Wahoo	*Euonymus atropurpurea*	SC	
Water-willow	*Justicia americana*	T	
White Lady-slipper	*Cypripedium candidum*	T	
Yellow Nut-grass	*Cyperus flavescens*	SC	
NATURAL COMMUNITIES AND GEOGRAPHIC FEATURES			
Prairie fen	Alkaline Shrub/herb Fen, Midwest	n/a	n/a
Oak barrens	Barrens, Central Midwest Type	n/a	n/a
Dry Sand Prairie	Dry Sand Prairie, Midwest Type	n/a	n/a
Pitted outwash	Geographical Feature	n/a	n/a
Kettle	Geographical Feature	n/a	n/a
Stagnation topography	Geographical Feature	n/a	n/a
Great blue heron rookery	Great Blue Heron Rookery	n/a	n/a
Southern wet meadow	Wet Meadow, Cent. Midwest Type	n/a	n/a
Bog	Bog	n/a	n/a

Recovering these species requires protecting the natural systems on which they depend. Key conservation areas of the Huron Chain of Lakes system include critical habitat for plant and animal communities, such as wetlands, large forest tracts, springs, spawning areas, habitat for rare, threatened or endangered species, and native vegetation areas; the aquatic corridor, including floodplains, stream channels, springs and seeps, steep slopes, and riparian forests (Figure 2.4).

In addition to their importance as wildlife habitat, undeveloped areas such as forest, meadow, prairie, wetlands, ponds and lakes, and groundwater recharge areas, provide a host of ecological services to the Watershed including the following:

- Groundwater. Natural systems allow rainwater and snowmelt to infiltrate into groundwater aquifers. About 50% of Michigan residents rely on groundwater for drinking water. Groundwater also provides irrigation water for agriculture and cooling water for industry.
- Surface water. By intercepting runoff and keeping surface waters supplied with a constant flow of clean, cool groundwater, natural systems keep streams, rivers and lakes clean. New York City has recognized the benefits natural systems provide to their drinking water system. The City has budgeted $660 million towards protecting the upper Hudson River Watershed, which drains into their drinking water supply. The City calculated that if the watershed undergoes development without watershed protection, the water source would degrade, making a $4 billion water treatment plant necessary.
- Pollutant removal. As water infiltrates into the ground or passes through wetlands, soil filters out many pollutants. Vegetation also takes up nutrients and

other pollutants, including phosphorus, nitrogen, bacteria, and even some toxic metals.

- Erosion control. Vegetation intercepts and soil soaks up water, keeping it from eroding streambanks and hillsides. River- and lakeside wetlands are especially important for erosion control along riverbanks and lakeshores.
- Air purification. Vegetation purifies the air we breathe.
- Flood and drought control. Vegetation and soil intercept runoff water, moderating floods and droughts. In the 1970s, the U.S. Army Corps of Engineers purchased about 8,500 acres of wetlands along the Charles River, in Massachusetts, after concluding that preserving natural systems was a more cost effective way to control flooding than building more dams on the river.
- Wildlife habitat and biodiversity. Natural systems are vital to the survival of aquatic and terrestrial wildlife. In addition to its aesthetic value, maintaining the biodiversity of species is vital to our economy and health. For instance, 118 of the top 150 prescription drugs are based on natural sources.
- Recreation. Natural areas provide recreation such as hiking, bird watching, canoeing, hunting, and fishing that generate revenues to the local community.
- Property values. Natural areas enhance the value of neighboring properties.

Remaining undeveloped, or natural areas, in the Huron Watershed were mapped and prioritized in 2002 through the Conservation Planning in the Huron Watershed project of the Huron River Watershed Council.[1] In order to help prioritize protection and conservation efforts, the mapped sites were ranked based on the following ecological and hydrological factors: size; presence of water; presence of wetlands; groundwater recharge potential; potential for rare remnant plant community; topographical diversity; and glacial diversity. 328 sites (41,90 acres) in the Huron Chain of Lakes Watershed were identified as priority natural areas, with 57sites (19,235 acres) ranked as highest priority for protection, 165 sites (18,305 acres) ranked as medium priority for protection, and 106 sites (4,360 acres) ranked as lower priority for protection.[4] The results of the project are shown in Figure 2.5.

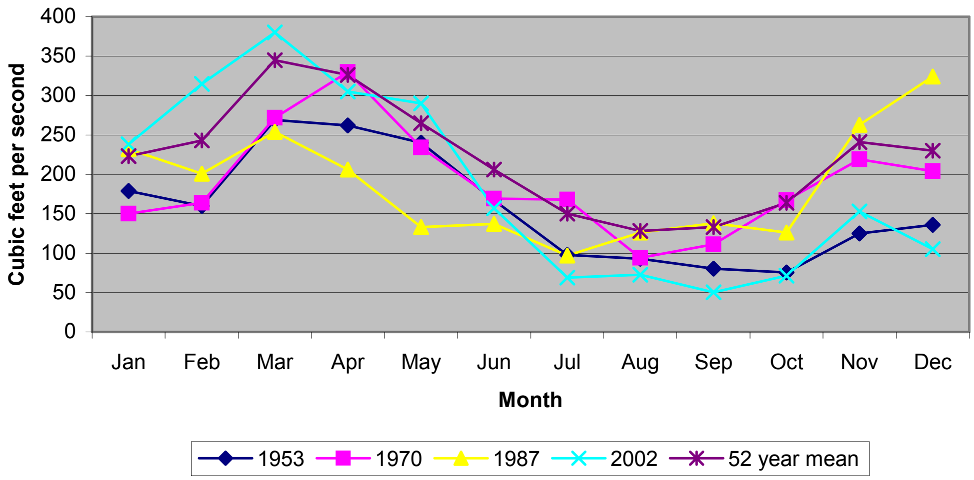
2.1.4 Hydrology

The Huron River begins at an elevation of 1016 feet in the headwaters and descends 444 feet to an elevation of 572 feet at its confluence with Lake Erie, for an average gradient of 2.95 feet per mile. By comparison, the Huron Chain of Lakes portion of the Huron River is relatively flat, dropping only 22 feet between the Kent Lake Dam and Baseline Dam, for an average of less than 1 foot per mile. The chain of lakes, a natural feature, reflects this low gradient landscape, and has been artificially enhanced through the many lake-level control structures along this stretch of the river. This low river channel gradient is a controlling influence on river habitat such as flow rates, depth, width, channel meandering, and sediment transport.

[1] Other projects to map and prioritize natural areas are happening in Livingston and Oakland Counties. These efforts have used varying methodologies and criteria, resulting in similar but not identical prioritization of natural areas. This document uses the 2002 analysis performed by the Huron River Watershed because it is the only analysis of natural areas that includes all three Counties in the Huron Chain of Lakes Watershed. Livingston County's High Quality Natural Areas Report (2003) can be downloaded from the Livingston County Planning Department's website: http://co.livingston.mi.us/planning/other.html. Oakland County's 2004 Potential Conservation/Natural Areas Report can be downloaded from the Oakland County Planning and Economic Development Services web site at http://www.co.oakland.mi.us/peds/.

Stream flow data for the Huron River in the Huron Chain of Lakes Watershed has been collected at the U.S. Geological Survey (USGS) gage station at the Huron River near Hamburg Road since 1951. Mean annual flow at this station is 214 cubic feet per second (cfs), representing a drainage area of 308 square miles, or .63 cfs per square mile.[5] Mean monthly streamflow for four typical rainfall years, as well as the mean monthly streamflow based on the 52 years of record, are presented in Figure 2.1. Seasonally high flows generally occur in early spring around winter snowmelt and spring rains, with baseflow conditions most apparent between July and October. While monthly streamflow naturally varies from year to year, Figure 2.1 shows that conditions in the watershed have remained relatively similar over the last 52 years. One possible reason for this observation is the large number of lakes, wetlands, and impoundments in the watershed that act as stormwater and flood control storage.

Figure 2.1. Mean Monthly Streamflow for Four Typical Hydrologic Years and the 52-Year Mean for the USGS Gage Station # 04172000 (Huron River at Hamburg Road)[6]



While mean monthly streamflows at the Hamburg Road sites have have shown little change over the 52-year period, the road crossing inventory indicates some important hydrologic impacts. Increasing development and resulting changes to the hydrology and hydraulics are still a significant threat to the watershed. Human impacts and development have generally increased daily fluctuations in the Huron's streamflow. Land drainage for urban or agricultural use has degraded the original, fairly stable flow regime. Draining wetlands, channelizing streams, and creating new drainage channels have decreased slow stability by increasing peak flows and diminishing recharge in groundwater tables. All tributaries to the Huron River suffer from comprehensive channelization, lack of cover, and large flow fluctuations as a result of efforts to accelerate drainage through these streams. Summer water temperatures have become warmer and more variable due to lower base flows, channel widening and clearing of shading stream-side vegetation. Landscape alterations and increased peak flows have accelerated erosion within the basin and increased the sediment load to the river.[7]

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

Direct drainage areas (Figure 2.6) are areas that have significant spatial and temporal influence on the quantity and quality of water entering the river system via groundwater or surface water flows. Much of this flow may come from direct flow from impervious surfaces. Excluded from direct drainage are portions of the landscape that form depressions where the dominant flow of water is to groundwater through infiltration. The map presented in Figure 2.6 was derived from a flow accumulation model that is influenced by the amount of imperviousness in each area.

The groundwater recharge potential map utilizes Darcy's Law to predict the probability of groundwater recharge areas in the watershed. As shown in Figure 2.7, Darcy's Law predicts that areas adjacent to the river and tributary systems generally hold the greatest probability of having groundwater recharge. Figures 2.8 and 2.9 illustrate the depth to groundwater and soil permeability characteristics for the watershed. Such information is useful when considering the applicability of certain stormwater control structures (i.e., best management practices), especially infiltration-based, and the appropriateness of certain development proposals that may require added water quality precautions within the watershed (i.e., gas stations, chemical storage facilities, etc.). Some of this data yield conflicting results. A more detailed analysis of groundwater recharge should be undertaken to resolve or clarify these areas of conflict.

Another attribute contributing to the hydrology of the Huron Chain of Lakes Watershed is the presence of dams and impoundments. According to the National Inventory of Dams, twenty dams are located in the watershed (Figure 2.10 and Table 2.2). Dams may be constructed for uses such as hydropower, recreation, or stormwater and flood control. Most of the dams in the Huron Chain of Lakes dams were developed for recreational purposes and none are used for active hydropower or flood control. Once useful dams can outlive their intended purpose and become hazards and ecological detriments to the river. Dams can create hazards by collecting debris or just requiring circumventions by recreationalists. They act as ecological detriemtns by holding back silt, and nutrients; altering river flows; decreasing oxygen levels in impounded waters; blocking fish migration and eliminating spawning habitat; increasing nuisance plant growth in impoundments; altering water temperatures; and injuring or killing fish.

Table 2.2 Inventoried Dams in the Huron Chain of Lakes Watershed[8]

Dam Name	**Waterway**	**Community**	**Downstream Hazard Potential**	**Purpose**	**Date Built**	**Dam Height** (Feet)	**Pond Area** (acres)
Pettysville Mill	Chilson Creek	Hamburg	Medium	Recreation	1840	21	5
Chilson Pond #1	Chilson Creek	Genoa/ Hamburg	Low	Recreation	1961	6	55
Lower Chilson Pond	Chilson Creek	Genoa	Medium	Recreation	1961	11	55
Caroga Lake LCS	Chilson Creek	Hamburg	Low	Recreation	1970	8	119
Bass Lake LCS	Hay Creek	Hamburg	Low	Recreation	1964	1	141
Gregory SGA #2	Honey Creek Trib.	Putnam	Low	Recreation	1965	8	12

Dam Name	Waterway	Community	Downstream Hazard Potential	Purpose	Date Built	Dam Height (Feet)	Pond Area (acres)
Gregory SGA #3	Honey Creek Trib.	Putnam	Medium	Other	1965	9	80
Wildlife Flooding	Honey Creek Trib.	Putnam	Low	Recreation	1980	8	5
Marsh Unit #4	Honey Creek Trib.	Putnam	Medium	Other	1965 ?	7	5
Kent Lake	Huron River	Green Oak	Medium	Recreation	1946	20	1200
Lake of the Pines	Huron River Trib.	Brighton	Low	Recreation	1960	5	89
Nichwagh Lake	Nichwagh Lake Outlet	Green Oak	High	Retired Hydropower	1830	12	130
General Motors	Mann Creek	Brighton Twp	Low	Recreation	1926	13	69
Moraine Lake	Mann Creek	Brighton	Low	Recreation	1970	16	25
Brighton Mill Pond	South Ore Creek	City of Brighton	Low	Recreation	1878	6	612
Woodland Lake	South Ore Creek	Brighton Twp	High	Recreation	1928	19	290
Brighton Lake	South Ore Creek	Green Oak	Medium	Recreation	1929	20	600
Long Lake LCS	South Ore Creek Trib.	Hartland	Low	Recreation	1951	7	146
Horseshoe Lake LCS	Horseshoe Lake Outlet	Northfield	Low	Recreation	1979	5	90
Flook Dam	Huron River	Dexter	Medium	Other	1965	13	769

2.1.5 Physical Stream and Riparian Conditions

In early December 2004 an inventory of physical instream and riparian conditions at several road stream crossings in the Huron Chain of Lakes Watershed was conducted by HRWC staff and trained volunteers with the Livingston County Road Commission. The Survey followed the *Stream Crossing Watershed Survey Procedure* (see Appendix C), which is a stream visual assessment procedure established by the MDEQ. The Survey serves as a proxy for more detailed and intensive survey methods, such as walking significant sections of streams, because it can be done with less investment of time and resources while still yielding information about stream health. Goals of the Survey include: 1) increasing available information on the water quality of surface waters and sources of pollutants; and 2) serving as a quick screening tool to identify issues of concern and the need for more in-depth investigations.

A GIS was first used to access current land used data of the Huron Chain of Lakes Watershed to identify all bridge, culvert, and other stream crossings on residential, county, and state roads. Approximately 300 stream crossing sites were identified, from which 1/3 were selected for surveying following the *Survey Procedure* guidelines. Drainage areas, including streams, drains and other tributaries to the main stem of the Huron River, were delineated and named. Within each drainage area, approximately 30% of all road crossings were selected for inventory, beginning with the most downstream site and then choosing upstream sites based on proximity to the confluence of other feeder streams as well as representative distribution among the subwatershed stream network.

Locating selected inventory sites using maps, surveyors completed a two page survey sheet created by MDEQ. Surveyors visually assessed background information, physical appearance, substrate, instream cover, river morphology, stream corridor, adjacent land uses, and potential sources and severity of nonpoint source pollution in both upstream and downstream directions based on observations from the actual stream crossing. Surveyors performed all the requested survey sites within a given drainage area over a maximum period of three to four days in order to facilitate relative data comparisons among stations under similar stream flow and seasonal conditions. Where possible, volunteers recorded photographs in the upstream and downstream direction at each crossing.

Surveyors returned completed survey sheets to HRWC staff. Data sheets and photographs were then sent to the MDEQ for incorporation in a statewide database of road stream crossing sites and later made available to the Watershed Council for further tabular and GIS analyses. The database of raw data from the road stream crossing sites in the Huron Chain of Lakes Watershed is included in Appendix C. A narrative summary of survey results by drainage area is presented below. Unusual observations are noted, otherwise, the summaries are from basic survey listings.

Anderson Drain (Putnam and Unadilla Townships)

Three sites were chosen for assessment along the Anderson Drain of the Honey Creekshed; two on State Highway M-36 and one on Spears Rd. The stream was noted as a recovering channel at all three sites and was ranked in good condition. The stream segments are all designated as county drains.

The stream channel was less than ten feet wide and one foot deep at each road crossing site, with clear running water and low to moderate water flow. There were aquatic plants observed at all sites both up and downstream of the road crossing, and foam was noted at only one site. Channel substrates were primarily sand, with some gravel and cobble.

No undercut banks were observed at any of the sites. There was overhanging vegetation at 2 sites, woody debris at one site, and riffles present both up and downstream of the crossing at one site. Riparian buffers varied from 10-30 feet up to >100 feet in width. Stream canopy was <25% and the streamside cover consisted primarily of trees at all three sites. No bank erosion data was collected in the surveys.

The two road crossings on M-36 were bridges and the Spears Rd. crossing was a round culvert. No culvert problems were observed and no erosion associated with the crossing was noted for any of the sites. Adjacent land uses were old fields and shrubs, forest and maintained lawn. Only one potential nonpoint pollution source was observed, which was transportation-related.

Chilson Creek (Hamburg and Genoa Townships)

The Chilson Creek surveys were conducted at six sites along the stream. The stream channel segments were considered to be natural as they are not designated county drains.

Of the six sites surveyed, two road crossings were culverts and the remaining four were bridges. Crossing erosion was observed at three of the sites; and one of the culverts (on Pettysville Rd.) had an impounding water problem. Crossing erosion was observed at three sites, however, the extent of the erosion was difficult to determine due to high water flows at the time the surveys were done.

The stream itself had averaged 10-25 feet in width and 1-3 feet deep with clear running water. Aquatic plants were visible at all sites, although channel bottoms were mostly covered with silt and muck. There was no evidence of trash, foam, algae or bacterial sheens at any of the sites. All sites had overhanging vegetation and two sites had logs or other woody debris in the stream channel. Riffles were present at two of the sites.

Streamside cover consisted primarily of grasses and shrubs, and the canopy was generally less than 25%. Bank erosion was inconclusive due to high water flows. In fact, the stream was out of bank at two sites, flowing onto the surrounding land/wetlands. Stream buffers varied from 10-100 feet, but were mostly in the 30-100+ foot range.

Adjacent land uses were listed as wetlands at all sites except for the site at Trinity Lane. Residential or maintained lawn and impervious cover were observed at two sites; shrubs/old fields were also noted. Observations of potential sources of nonpoint source pollution included transportation, riparian vegetation removal, steambank erosion, urban residential runoff, and stream impoundment.

Davis Creek (Green Oak and Lyon Townships)

Seven sites were selected for assessment along Davis Creek. Five stream segments (all along the mainstem of Davis Creek) were judged to be natural channels. The remaining two sites were on Greenock Drain between Limekiln and Nichwagh Lakes and were judged to be recovering. The overall quality ranking of all the sites was good. Stream widths ranged from 10-25 feet and 25-50 feet with stream depths of 1-3 feet. Six of the sites had clear water and the site at Silver Lake Rd. had brown water. The physical appearance of the stream at each road crossing was quite good; aquatic plants were observed at all the sites and trash was present at only one site.

Overhanging vegetation was noted at five of the seven sites and woody debris was seen in the stream at six sites. Only 2 sites had undercut banks and no overhanging vegetation. Streambank erosion was considered low to none at all 7 sites. Streamside cover was primarily trees with 36% of the sites surveyed as having stream canopies of 25-50%. Canopy cover at the rest of the sites was <25%. Riparian buffers were good to excellent at over 80% of the areas with widths of 30-100+ feet.

Two of the road crossings were culverts and the one located on Kirby Lane showed a problem with water flow obstruction. The other road crossings were bridges and no problems were reported. No crossing erosion was noted for any of the sites.

Land use surrounding the sites was mostly forest, shrubs/old fields and some wetlands. There were a few areas where there was no vegetation adjacent to the stream and could allow for higher rates of nutrient or sediment runoff. Other potential nonpoint source pollution inputs were observed to be grazing, riparian vegetation removal, development construction, and urban residential runoff.

Hay Creek (Hamburg Township)

Five stream crossings were assessed in the Hay Creek drainage area. Most of the stream segments were considered to be natural channels, as they are not designated county drains. At each of the sites, the stream was 10-25 feet wide and 1-3 feet deep with medium water velocity. Although the water color was noted as clear by the surveyors, for three sites there were also notations of turbidity. Aquatic plants were present at each site on both the up and downstream sides of the crossing, and the channel substrate was primarily sand, cobble and gravel except at one site (Rush Lake Rd.) where the substrate was undetermined. Overall, the physical appearance of the stream segments was very good.

With regard to instream cover, overhanging vegetation was noted at all five sites. Aquatic plant cover and logs or woody debris was observed at four of the sites. Three sites also had riffles present. These characteristics suggest that the habitat for fish and other macroinvertibrates may be of moderate to good quality.

The stream buffer at four of the sites was good to excellent, with widths of 30-100+ feet; only one site had buffer zones averaging 10-30 feet wide. Bank erosion was not assessed for any of the sites in this sub-basin. Streamside cover consisted of shrubs and trees, with the canopy cover at approximately 25%. Canopy cover at the Rush Lake Rd. site was noted at >50%.

One of the crossing culverts was considered to be in poor condition, which was located on Rustic Dr. Adjacent land uses were observed as wetlands, forest, and fields/shrubs. Potential sources of nonpoint pollution are transportation and mining.

Honey Creek and County Drain #7 (Putnam Township)

The Honey Creek surveys were conducted at three sites on the mainstem, and one on a tributary designated as County Drain #7 and located on Spears Rd. near Pingree Rd. At the time of the surveys, high water flows were observed at the three Honey Creek road crossing sites and low water flow was observed at the County Drain site. Stream width and depth at the Honey Creek survey sites were 10-25 feet and 1-3 feet respectively. The County Drain site had a stream width of <10 feet and a depth of less than one foot. The water color was noted as clear at all four sites.

Aquatic plants and instream plant cover was observed at each site including County Drain #1; overhanging vegetation and woody debris were present in stream at two of the Honey Creek sites and the County Drain site. Good to excellent riparian buffers were noted at all four sites, with streamside cover listed as trees and grasses for the Honey Creek sites. Canopy cover ranged from <25% to 50%. No data was collected regarding streambank erosion.

No culvert problems or road crossing erosion were reported. The quality ranking for each of these sites was good. Land use adjacent to the stream was wetlands, fields, forest and maintained lawn. Transportation was the sole potential nonpoint pollution source listed for these sites.

Horseshoe Lake Drain (Northfield and Hamburg Townships)

Three sites were chosen for assessment on Horseshoe Lake Drain along Eight Mile Rd. near Lemen Rd., Schrum Rd. and Merrill Rd. The stream channels at both Eight Mile and Schrum Roads were maintained, and are also designated drains; the channel at Merrill Rd. was considered to be natural as it is not a designated county drain. There were no culvert or bridge problems reported, however crossing erosion was observed at Schrum and Eight Mile Roads. The surveyor noted that the crossing at Eight Mile appeared to be fairly new, and that runoff was directed away from the stream to surrounding wetlands.

Stream widths were generally 10-25 feet and depths were 1-3 feet; water flow was moderate to high. The water color at Eight Mile Rd. was brown and turbid, while the water was clear at the other two sites. There was overhanging vegetation and woody debris in stream at all three sites. There was a deep pool at the Merrill Rd. site and instream boulders were noted at the Eight Mile Rd. site. Aquatic plants were observed only at the Merrill Rd. site.

The riparian buffer zones at Schrum Rd. were fairly poor (<10-30 feet); whereas they were much better at Merrill Rd. and Eight Mile Rd. (30-100 feet). Low to moderate streambank erosion was observed at the Schrum Rd. site and moderate erosion was reported on the downstream side of the Eight Mile Rd. crossing.

Adjacent land use was observed to be wetlands, old fields/shrubs, cropland, impervious surface, and maintained lawn. Potential nonpoint source pollution inputs are cropland, grazing, transportation, channelization, dredging, streambank erosion, altered hydrology, and stream impoundments.

Huron River Mainstem (Green Oak and Hamburg Townships)

Four road crossings were selected for surveying along the mainstem of the Huron River in Green Oak and Hamburg Townships. The river channels at each of these locations were judged to be in their natural states rather than modified in any way. The crossings are located on Huron River Rd., Kensington Rd. in Island Lake Park, McCabe Rd. and Ricket Rd. All four road crossings were bridges and there were no structural problems or crossing erosion noted for any of the sites.

The river channels were 25-50 feet wide at two sites and >50 feet at the other two; water depth was greater than three feet at all sites. The water color was clear and flowing at a medium to high rate. There was an abundance of aquatic plants at the Huron River Rd. site, but no plants were observed at the other three sites. Also, the substrate was unknown for all sites except at Huron River Rd., which was noted as 50/50 sand and silt or muck. There was also overhanging vegetation at the Huron River Rd. site, but not at the other sites. Logs or woody debris was present in the river at all sites except Ricket Rd.

Good to excellent riparian buffer zones were reported at all the road crossings. Most riparian areas had buffers >100 feet wide. Streamside cover was trees and grasses, and the stream canopy was <25%. There was no streambank erosion data collected at McCabe and Ricket Rd.s, since the river was out of bank at the time of the survey. Streambank erosion at the other two sites was reported as low or none. The land use around these road crossings was listed as wetlands and forest, and some maintained lawn and impervious road cover. The single potential nonpoint pollution source was observed to be transportation.

Park Lake Tributary and Mainstem Huron River (Dexter Township)

The Park Lake Tributary, which drains into the upper Huron River, and another Huron River mainstem site surveyed are both located in Dexter Township. The Park Lake Tributary crossing is on Huron River Rd. near Bell Rd. and the Mainstem Huron River crossing is on Bell Rd. near Chamberlain Rd.. The bridge crossing over the river on Bell Rd. was out and sitting next to the river.

At both sites, the river channels were considered to be in their natural states, and unmodified in any way. At Bell Rd., the river was >50 wide and less than three feet deep, with clear water and high water flow. At Huron River Rd., the Park Lake Tributary was <10 wide and less than one foot deep with clear water running at a medium flow rate. The appearance of the river and tributary was very good, with aquatic plants at both sites and no evidence of trash, foam, bacterial sheens or algae. The substrate at the Bell Rd. site was unknown and at the Huron River Rd. site it was undetermined.

Aquatic plants, overhanging vegetation and instream woody debris were observed at both sites. The riparian buffer was excellent at the Bell Rd. crossing (>100 feet) and good at the Huron River Rd. site (30-100 feet). Streamside cover was trees and grasses and the stream canopies were <25% at both sites. Bank erosion was not determined for either site.

Adjacent land uses were listed as forest and maintained lawn (residential or parkland). Only one potential source of nonpoint source pollution for these sites was noted, which was transportation.

Mann Creek (Brighton and Milford Townships)

Five sites were chosen for assessment along Mann Creek. All the road crossings were over box or round culverts and there were no problems found with the culverts at any of the sites. The stream channels were considered natural. The site at Commerce Rd. is designated as Oakland County Drain #11. The upstream side of the crossing on Pleasant Valley Rd. near Newmann was the GM Proving Grounds and the crossing at Pleasant Valley Rd. near Moraine Rd. had a lake on the downstream side of the crossing. The stream was generally 10-25 feet wide and 1-3 feet deep with clear water and medium flow rates at each site. The stream's physical appearance at each site was good, with no trash, bacterial or oily sheens, or algae present.

There were no aquatic plants observed at any of the sites. Overhanging vegetation and woody debris was present at two sites, and no undercut banks were observed at any of the sites. Stream buffers ranged from <10 – 100+ feet; three sites had very good buffers with widths of 30-100+ feet. Stream canopies at each site were <25%.

Land use adjacent to the stream was wetlands, old fields and shrubs, and maintained lawn. No potential nonpoint pollution sources were noted in the surveys for these sites.

New Hudson Drain (Lyon Township)

Only two sites were surveyed along the New Hudson Drain: one at Milford Rd. near Travis Rd. and the other at Martindale Rd. near Travis Rd. The stream segments at both sites are designated drains and have recovering stream channels. The stream width at the Martindale Rd. crossing was <10 feet and the width at Milford Rd. was 10-25 feet. Both stream segments were less than one foot deep, with clear water and low flow rates.

Aquatic plants were present at both sites and some trash was observed at the Martindale Rd. crossing. The stream channel substrate was 100% sand at the Milford Rd. site and 50/50 sand and silt at the Martindale Rd. site. There was overhanging vegetation and woody debris present in stream at both sites; there were no bacterial/oily sheens, foam or algae observed at either site. The riparian buffers were very good at both sites (30-100+ feet) and no bank erosion was observed. Streamside cover was primarily trees at both sites, with stream canopies of 25-50%. The overall quality ranking of these sites was good.

There were no crossing-erosion or culvert problems observed at either site. Land use at the stream crossings was forest and maintained lawn. Potential nonpoint source pollution inputs were observed to be transportation and residential runoff.

Novi Lyon Drain (Lyon Township)

The Novi Lyon Drain is one of the larger drainage areas in the Chain of Lakes region. Out of the nine road crossing sites surveyed, only two were paved roads: the site on Napier Rd. near 11 Mile Rd. and on 10 Mile Rd. near Currie Rd. Seven of the sites had round culverts to convey the stream beneath the road and three of those sites had two culverts each: Hass Lake Park Rd., 12 Mile Rd. near Martinsdale Rd. and 11 Mile Rd. near Milford Rd. The stream crossing at Currie Rd. was a bridge. There were no culvert or crossing-erosion problems noted for any of the sites.

The stream is a designated drain and described as a recovering channel. The water was clear and water velocity varied from none (stagnant) to medium along the stream. Five of the sites had stream widths of <10 feet; the rest were 10-25 feet wide. The same was true for water depth: five sites had depths of 1-3 feet and the others were <1 foot deep. Aquatic plants were noted at all eight sites. However, aquatic plant instream cover was reported for just two sites. There was no evidence of trash, foam, water sheens or algae at any of the sites. Channel substrates were reported as either sand or “unknown”.

Overhanging vegetation was present at 75% of the sites and logs or woody debris was seen at 38% of the sites. Only one riffle and one deep pool was observed, each at different sites. The stream corridor at many of the road crossings had very good buffer (30-100 ft); 56% of all the riparian areas had buffers over 100 feet wide. Streamside cover was primarily trees, with some grasses and shrubs; stream canopy was good at 25-50% for seven of the sites. No streambank erosion was observed at any of the survey sites.

Land use adjacent to the stream was noted as wetlands, forest and maintained lawn. Potential sources of nonpoint source pollution were identified as transportation and urban residential runoff.

Portage Lake (Dexter Township)

Three sites were selected for survey in the Portage Lake drainage area. Two sites were located on McGregor Rd.: one near Dexter-Pinkney Rd. and the other near Canal Rd. The third site was on Winston Rd. near Clifford Dr. The stream crossings on McGregor Rd. were bridges; on Winston Rd. the stream flowed through a round culvert. There were no culvert problems or crossing erosion observed at any of the sites.

The stream channel at the sites are considered natural, since they are not designated drains. The physical appearance of all three stream sections was very good; the water was clear and flowing at low to moderate rates. The McGregor/Dexter-Pinkney Rd. site had a wide stream channel estimated at >50 feet; the other two sites had channel widths of 25-50 feet wide. Stream depth at the McGregor/Dexter-Pinkney Rd. site was >3 feet; stream depth at the other sites was 1-3 feet. There was no trash, foam, bacterial sheens or algae present at any of the sites.

Aquatic plants were present at all three sites and the stream channel substrates were primarily sand. Overhanging vegetation and woody debris in the water was observed only at the Winston Rd. site. The riparian buffers were poor at both of the McGregor Rd. sites (<10 feet) and excellent at the Winston Rd. site (>100 feet). Land use at the

McGregor Rd. sites was noted as maintained lawn (hence, the lack of riparian buffer). At the Winston Rd. site the land use next to the stream was forest. Canopy cover noted at all three sites was <25%.

Only transportation was listed as a potential source of non-point source pollution. The overall quality ranking of these sites was good.

Putnam Lake Tributary (Putnam Township)

Surveys of the Putnam Lake Tributary were conducted at Kelly Rd., Spears Rd., and two on M-36. All four sites were on designated county drains, and are considered to be recovering channels. The two crossings on M-36 were paved roads; the other two crossings were gravel roads. No culvert problems were reported and no crossing erosion was noted on the surveys.

All four stream segments were in good condition. Each segment was 10-25 feet wide and 1-3 feet deep, with clear running water at medium flow rates. The channel substrate was different at each site, they were reported as 100% cobble/gravel, 100% sand, 100% silt and 100% unknown material. There were aquatic plants and overhanging vegetation at every site and logs or woody debris in stream at three of the sites. There were also riffles and a pool noted at one of the sites. Taken together, these stream characteristics provide good habitat for fish and macroinvertebrates.

The stream buffer was also good at all the sites, with three of them having buffers >100 feet wide. Adjacent land uses were identified as wetlands, old fields, forest, and two areas of maintained lawn. Transportation-related runoff was the only potential nonpoint pollution source observed.

Spring Mill Creek (Green Oak Township)

Three stream crossings were chosen for assessment along Spring Mill Creek. Two of the sites were located on State Park Rd. and the third was on Kensington Rd. The downstream side of the Kensington Rd. site was not easily assessed because the pipe outlet was more than 500 feet from the road. That segment was listed as a maintained channel; the other segments were noted as natural channels. None of the sites are on designated county drains.

The stream segments at State Park Rd. and Kensington Rd. were <10 feet wide; water depth at State Park Rd. was 1-3 feet but unknown at the Kensington Rd. site. The water was clear at both sites, with a medium flow at the State Park Rd. site and stagnant water at the Kensington Rd. site. The site at State Park Rd. near Spring Mill was 10-25 feet wide, 1-3 feet deep, with clear water and medium water flow.

The riparian buffers at all three sites were >100 feet wide, except on the downstream side at the Kensington Rd. crossing. No data was recorded for the physical appearance of the stream at any of the sites. Instream woody debris was noted at two of the sites. However, no other instream characteristics were observed at any of the sites. Stream canopy was estimated at <25%.

All three stream crossings were paved roads over round culverts; no culvert problems were recorded for any of the sites. Adjacent land use was noted only as wetlands at all three stream crossings.

South Ore Creek (Brighton, Hamburg and Hartland Townships; City of Brighton)

The South Ore Creek sub-basin is the largest of the drainage areas in the Chain of Lakes region. The creek runs through fairly well-developed areas in three townships and the eastern edge of the City of Brighton.

Twelve stream crossings were surveyed along this creek. Only one crossing was a bridge, located at Maltby Rd. near Bauer Rd. At this site there was extensive use of silt fences along the road and stream embankment. Upstream of the site on North St. (near West St.), the creek is inaccessible because it flows underground beneath several buildings. The upstream side of the site at Old US 23 was also inaccessible due to heavy traffic and steep embankments. Maxfield Lake is located on the downstream side of the crossing site on Shady Crest Dr; Long Lake is upstream of the site on Blaine St. Four out of the twelve sites were located on private/corporation-owned roads. These locations, described above, are representative of the land use and geographical diversity within the South Ore Creek sub-basin.

All stream segments assessed in the survey were considered to be recovering channels, with evidence of past channelization. Only one crossing was on a designated county drain – at Hidden Pines Dr. on Pine Creek Ridge Drain #2. There was clear water at each of the sites; stream width ranged from <10 feet to 25-50 feet; stream depth varied from <1 foot to 1-3 feet. Ten of the sites had medium water flow rates and the other two had high flow rates. Aquatic plants were observed at 83% of the sites, down and/or upstream of the road crossing. Filamentous algae were present at four of the sites; the presence of foam or trash was minimal. Channel substrates were various combinations of cobble/gravel, sand, silt/detritus/muck, and unknown material.

Logs or woody debris was present at 92% of the sites; overhanging vegetation was observed at 75% of the sites and three sites had undercut banks. Riffles were noted as abundant at the stream crossing located on Hidden Pines Dr.

Half of the sites had good to excellent riparian buffer zones. Moderate/heavy streambank erosion was reported at two sites: Third St. near Franklin and W. North St. The rest of sites had low or no bank erosion or undetermined bank erosion (undetermined due to high water flows or snow cover). Streambank cover was mostly grasses and shrubs; a couple of areas had tree cover. Streambank canopies were 25-50% at two of the crossing sites; the rest of the sites had canopy cover less than 25%.

The impact of upland erosion on the stream was noted at two of the sites. Sediment deposits were nearly obstructing the outlet of a stormwater pipe originating from an upland residential area at the Hilton Rd. site. Gully erosion resulting in sediment deposits in the stream was observed at the Hyne Rd. site.

Land use adjacent to the stream was forest, old fields, wetlands, residential and impervious cover. Nonpoint source pollution inputs were identified as transportation, channelization, riparian vegetation removal, streambank erosion, stream impoundment, urban residential runoff, and development construction.

Tobin Lake Creek (Green Oak and Northfield Townships)

The Tobin Lake Creek surveys were done at four crossings along the creek. The creek is not a designated drain and the stream appeared to be in a natural state at each site. The creek varied in width from <10 feet to 25-50 feet and the depth at each site was 1-3 feet. There was clear running water at every site with medium to high water flow rates. The physical appearance of the stream ranged from fair to good. Aquatic plants were observed at all sites, floating algae at three sites, and foam and trash at two sites. While the water was clear, the channel substrate was undetermined, marked as 100% unknown at each site.

The creek's instream characteristics were diverse. There were logs/woody debris and overhanging vegetation present at all sites, instream plant cover at three sites, and at least one riffle and deep pool observed in the stream segments. The stream's buffer was fair to excellent and there was low to no bank erosion observed. Streamside cover was trees at seven out of the eight up/downstream segments, and canopies ranged from <25% to 25-50%.

There were significant culvert problems found at the road crossing located on Rushton Rd. near Six Mile Rd.: poor alignment, inadequate armoring and structural integrity problems. It was also noted that the stream embankments were eroding and road ditch erosion was evident. Maintenance work by the Road Commission was indicated in the survey.

Land use along the creek corridor was forest, pasture, old fields, wetlands, and maintained lawn. Potential nonpoint pollution sources included grazing, transportation, crop, channelization, riparian vegetation removal, streambank erosion, hydrology, stream impoundment, bridge and development construction, urban residential runoff, recreational, debris in water, and unknown nonpoint source pollution.

Underhill Drain (Green Oak, Lyon and Salem Townships)

Four sites were selected for assessment along the Underhill Drain. The stream had both recovering and natural channels, with only the site at Dixboro Rd. on a designated drain (Oakland County Drain #16. All the road crossings were over culverts. Although there were no culvert problems reported, the culvert at the 9 Mile Rd. near Dixboro Rd. was buried, which prevented assessment. One site (Pontiac Rd.) had erosion noted for the road ditches at the site.

The stream had clear water and low to medium water flows. The stream was <10 feet wide and <1 foot deep at each site. There were aquatic plants and overhanging vegetation present at every site. Three sites had logs or woody debris in the stream and one site had floating algae. Channel substrates consisted of cobble/gravel, sand or unknown material. Bank erosion was low and there were good stream canopies (25-50+%) at all the sites. Streamside cover was listed as trees for each of the sites.

Stream buffer zones ranged from fair to good (10-100 feet wide). Land use along the stream corridor was wetlands, old field and shrubs, forest and maintained lawn. Potential nonpoint source pollution inputs were identified as transportation, channelization, riparian vegetation removal, streambank erosion, bridge & development construction, recreational, and unknown sources.

Walker Drain (Green Oak, Northfield and Salem Townships)

Three stream crossings were selected for the survey of Walker Drain. This stream is a natural channel and was in very good condition. One site (at 8 Mile Rd.) was on a Washtenaw County Drain. The stream is less than 10 feet wide, less than one foot deep, and had clear water and low to moderate stream flow at the time of the survey. Aquatic plants were present and there was no sign of foam, algae, oil sheen or bacterial slime. There was a little trash at just one of the sites. The channel bottom consisted of cobble & gravel, sand and unknown material. There was overhanging vegetation and woody debris at all three sites.

Streambank erosion was low and the riparian buffer was excellent at each site. Streamside vegetation was trees and stream canopy cover was greater than 50% all the sites (75-100% at one site). Adjacent land use was observed to be wetlands, forest, shrubs and old fields, and maintained lawn. Potential sources of nonpoint source pollution were cited as grazing, riparian vegetation removal, bridge construction, urban residential runoff, and unknown sources.

Woodruff Creek (Brighton and Green Oak Townships)

The Woodruff Creek sub-basin is another one of the larger drainage areas surveyed in the Chain of Lakes water system. Eight sites were chosen for assessment to characterize this drainage area, seven along the creek and one on a tributary. Six of the stream crossings were paved roads; the other two road surfaces were gravel. Only one crossing was a bridge and the rest were culverts. Crossing erosion was observed at only one site, Hyne Rd. near Maxfield St; the road ditches at the site were degrading. There were no culvert problems were reported in the surveys. The stream channel type at every site was considered natural and only one of the stream segments was on a designated county drains (Hyne Rd. near Waterside Lane on Taylor Drain), though the other Hyne Rd. site is just downstream of Carter Drain.

The stream width varied from <10 feet to 10-25 feet and the depth was generally 1-3 feet. Water color at each site was clear with medium water flow. The physical condition of the creek was good, although there were no aquatic plants present at any of the sites. There was also no evidence of algae, oil sheen, bacterial slime or foam at any of the sites. Trash was observed at only one site, but not in abundance.

Overhanging vegetation was observed at five of the sites and logs/woody debris was present at four sites. Six of the eight sites had very good riparian buffer zones (30 to 100+ feet). With one exception, the conditions of streamside cover and streambank erosion was not recorded. At the Hyne Rd. site (near Waterside Lane) the streamside cover was grasses and shrubs, and no bank erosion was observed. Stream canopies were <25% at three of the sites and <25% to 25-50% at four of the other sites.

Land use adjacent to the creek was observed to be wetlands, old fields and shrubs, and maintained lawn. Transportation was the only potential source of nonpoint pollution identified.

Yerkes Drain (Green Oak Township)

Yerkes Drain runs through a commercial/residential area in Green Oak Township. Three sites were chosen for assessment along the Drain: Griswold Rd. near 9 Mile Rd., Lafayette St. near Lyons Woods, and Dixboro Rd. near Londonderry Dr. The South Lyon Wastewater Treatment Plant is located upstream of the Dixboro Rd. site. McHattie Park and the City of South Lyon are downstream of the Lafayette St site.

The stream segments were considered to be recovering channels, as there was evidence of past channelization, however, none of the sites were on designated county drains. Stream widths varied from <10 – 25 feet and depths ranged from 1-3 feet. There was brown water at the Dixboro Rd. site; the other two sites had clear water. Stream flows were low to moderate.

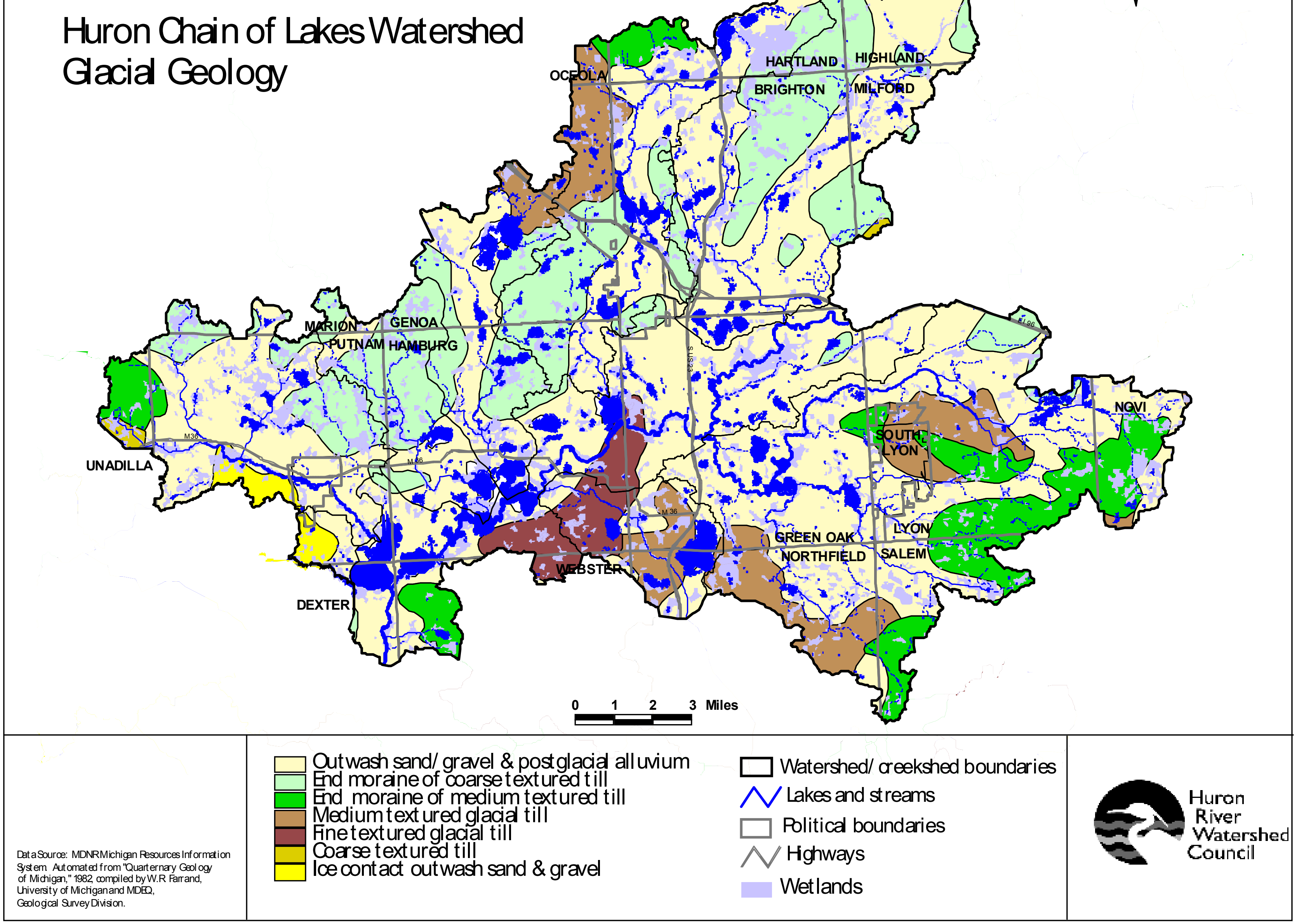
At the Dixboro Rd. site, there was floating algae, oil sheens and abundant trash. There was no physical appearance data recorded in the surveys for the other 2 sites. Overhanging vegetation and woody debris was observed at each site and deep pools were present at 2 of the sites. Stream buffers varied from <10 – 100 feet and bank erosion was generally low. The upstream segment of the Lafayette St. crossing had moderate bank erosion. Streamside cover was noted as trees and grasses with stream canopies generally <25%.

There were 2 culvert problems observed at the Dixboro Rd. stream crossing: poor culvert alignment and impounding water. There was also ditch erosion found at this site. This stream crossing area was ranked as poor, and was flagged for follow-up investigation in the survey.

Land use adjacent to the stream crossings were old fields, wetlands, some forest, maintained lawn, and disturbed ground (at Dixboro Rd.). Potential sources of nonpoint source pollution were observed to be streambank erosion, stream impoundment, bridge construction, development construction, urban runoff, septic systems, recreation, municipal and industrial point sources, instream debris, and natural/unknown sources of nonpoint source pollution.

Figure 2.2

Huron Chain of Lakes Watershed Glacial Geology



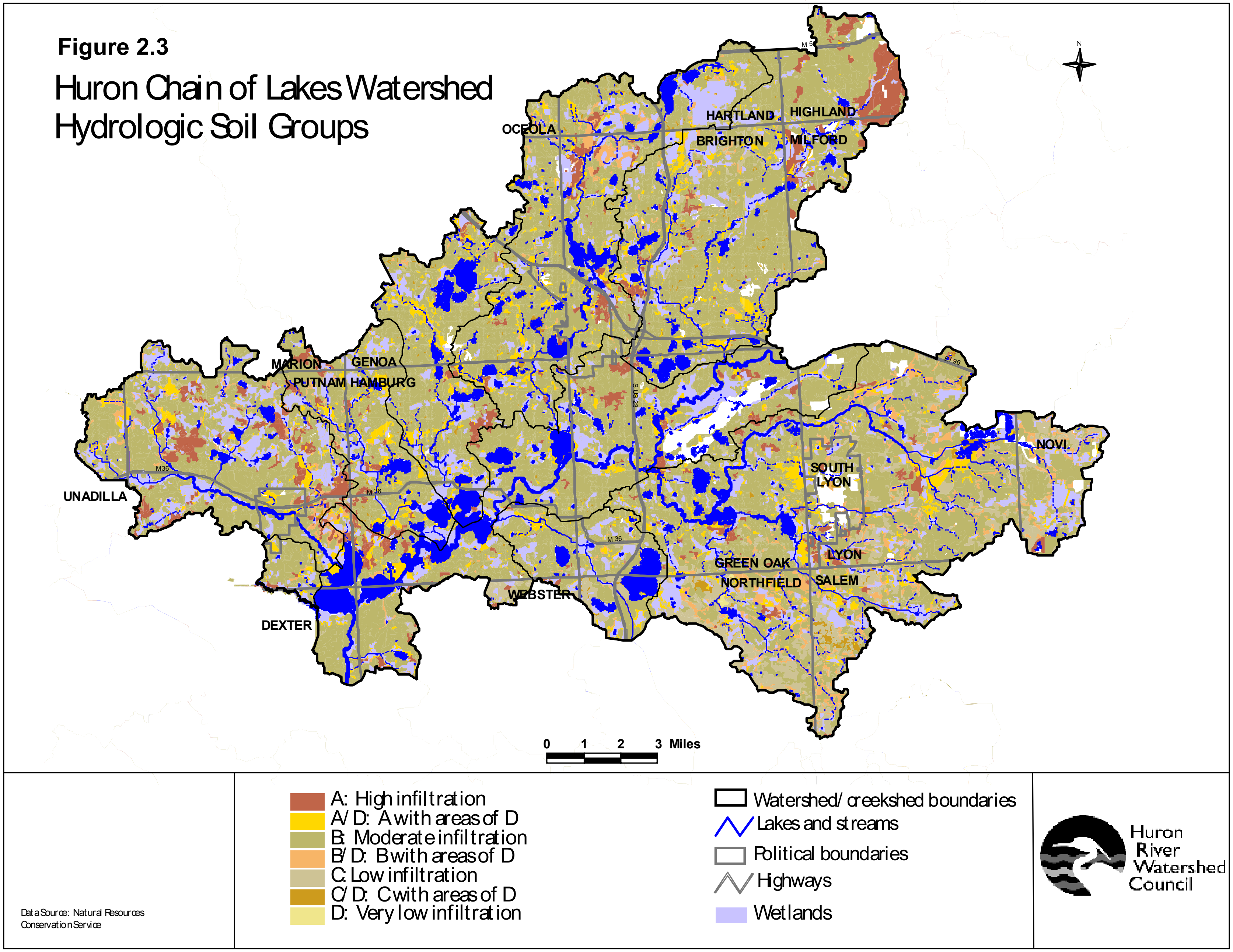


Figure 2.3
Huron Chain of Lakes Watershed
Hydrologic Soil Groups
OCEOLA
HARTLAND
HIGHLAND
BRIGHTON
MILFORD
MARION
GENOA
PUTNAM
HAMBURG
UNADILLA
SOUTH LYON
NOVI
GREEN OAK
LYON
NORTHFIELD
SALEM
WEBSTER
DEXTER
0 1 2 3 Miles
A: High infiltration
A/D: A with areas of D
B: Moderate infiltration
B/D: B with areas of D
C: Low infiltration
C/D: C with areas of D
D: Very low infiltration
Watershed/creekshed boundaries
Lakes and streams
Political boundaries
Highways
Wetlands
Data Source: Natural Resources Conservation Service
Huron River Watershed Council

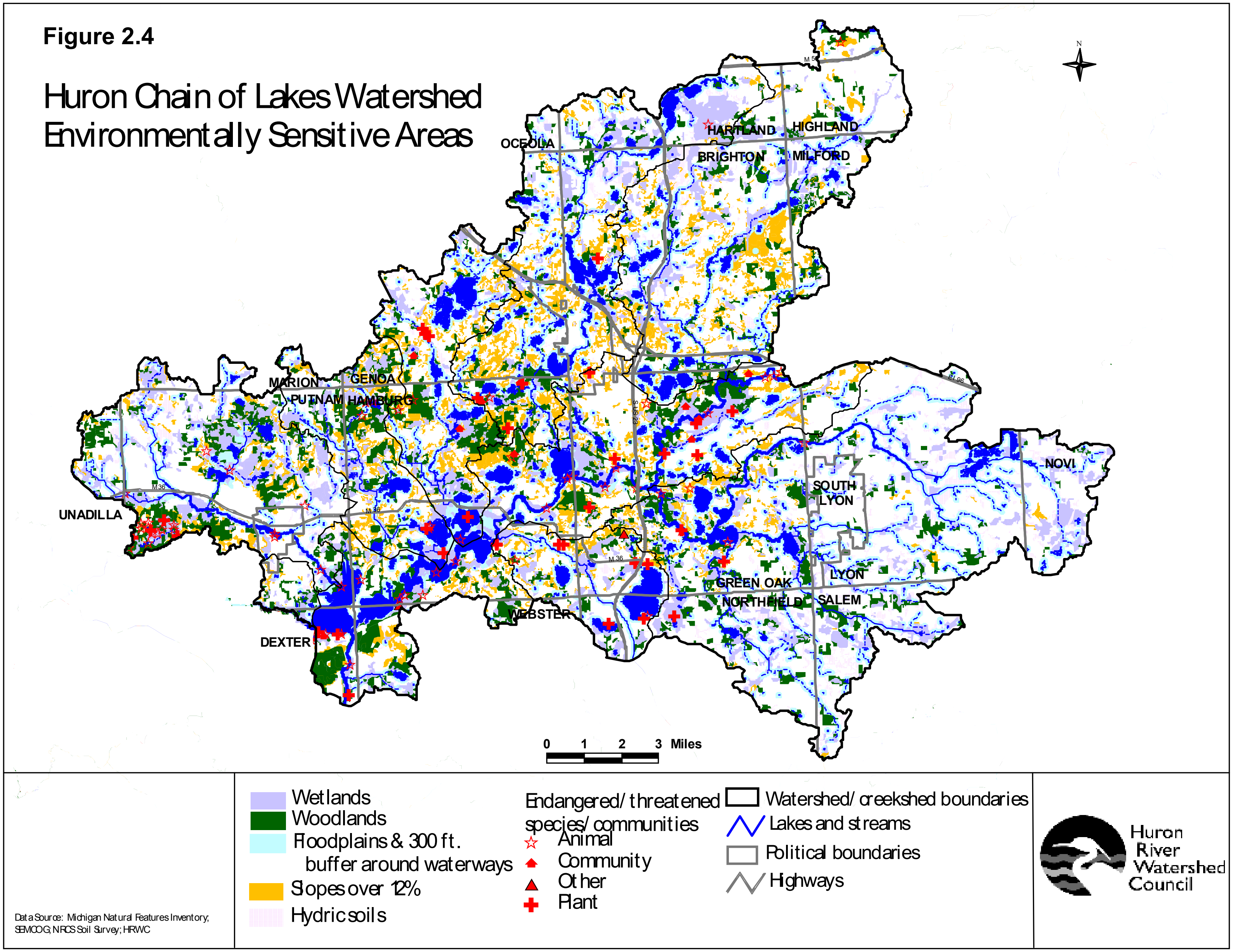


Figure 2.4

Huron Chain of Lakes Watershed Environmentally Sensitive Areas

Figure 2.5

Huron Chain of Lakes Watershed Remaining Natural Areas

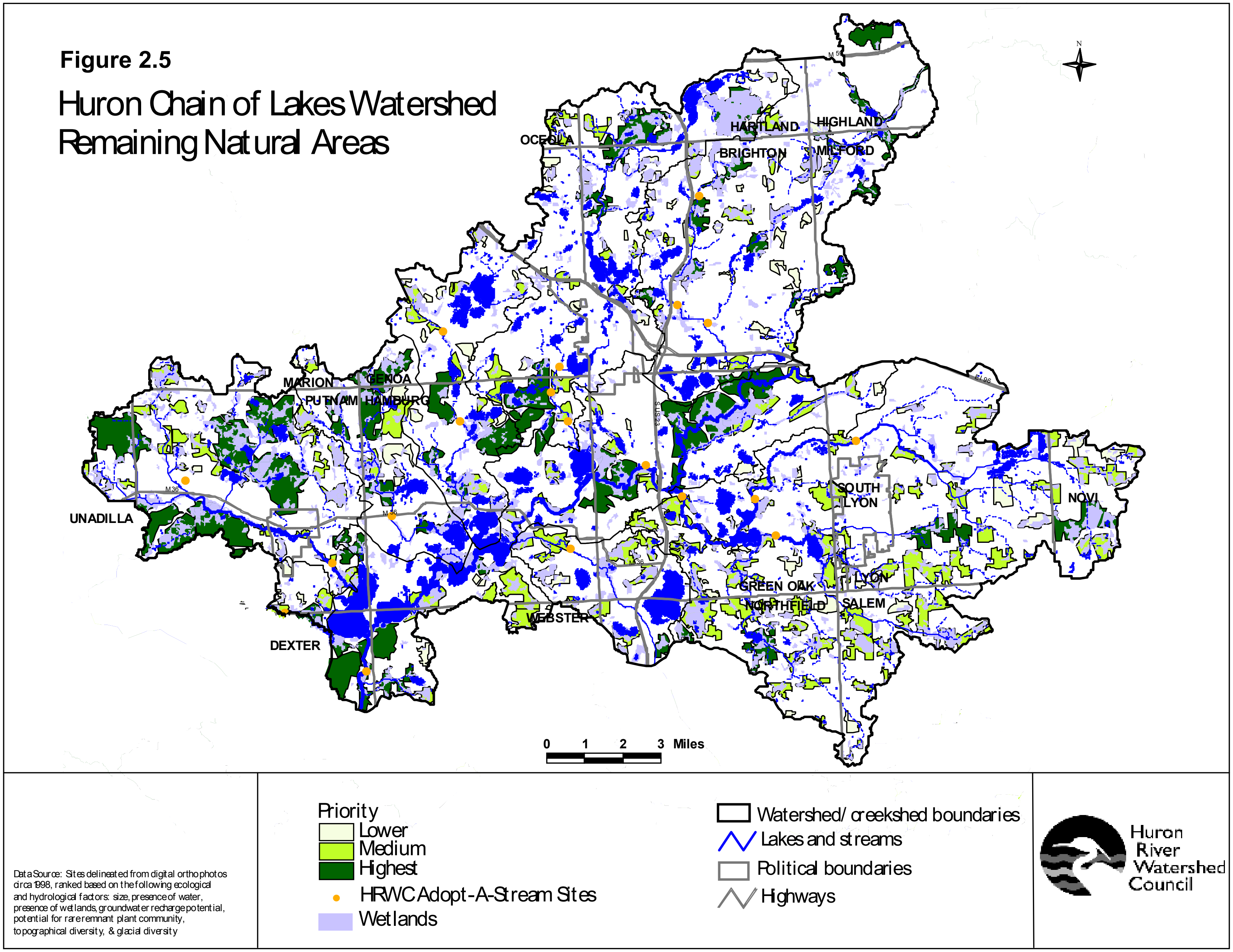
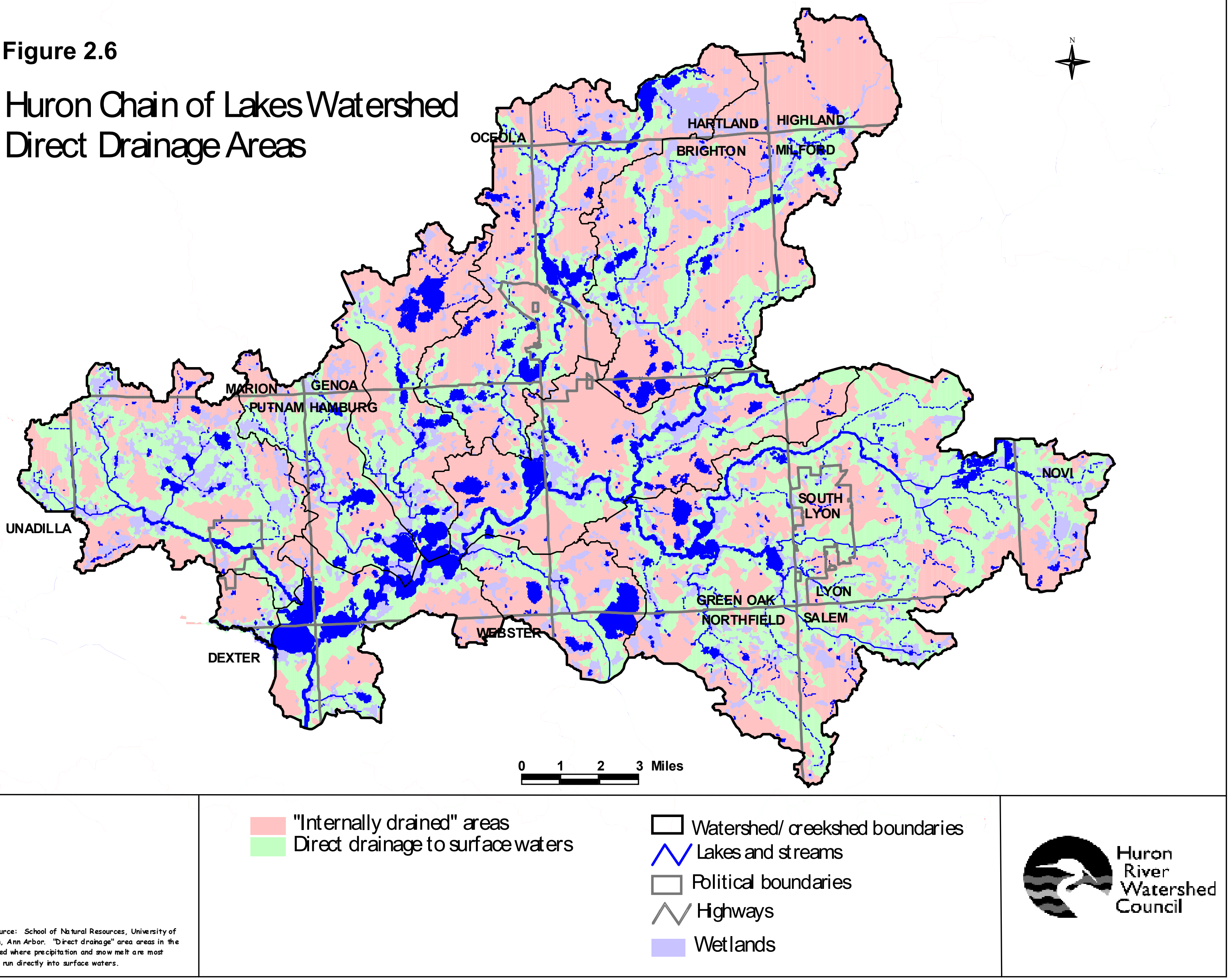


Figure 2.6

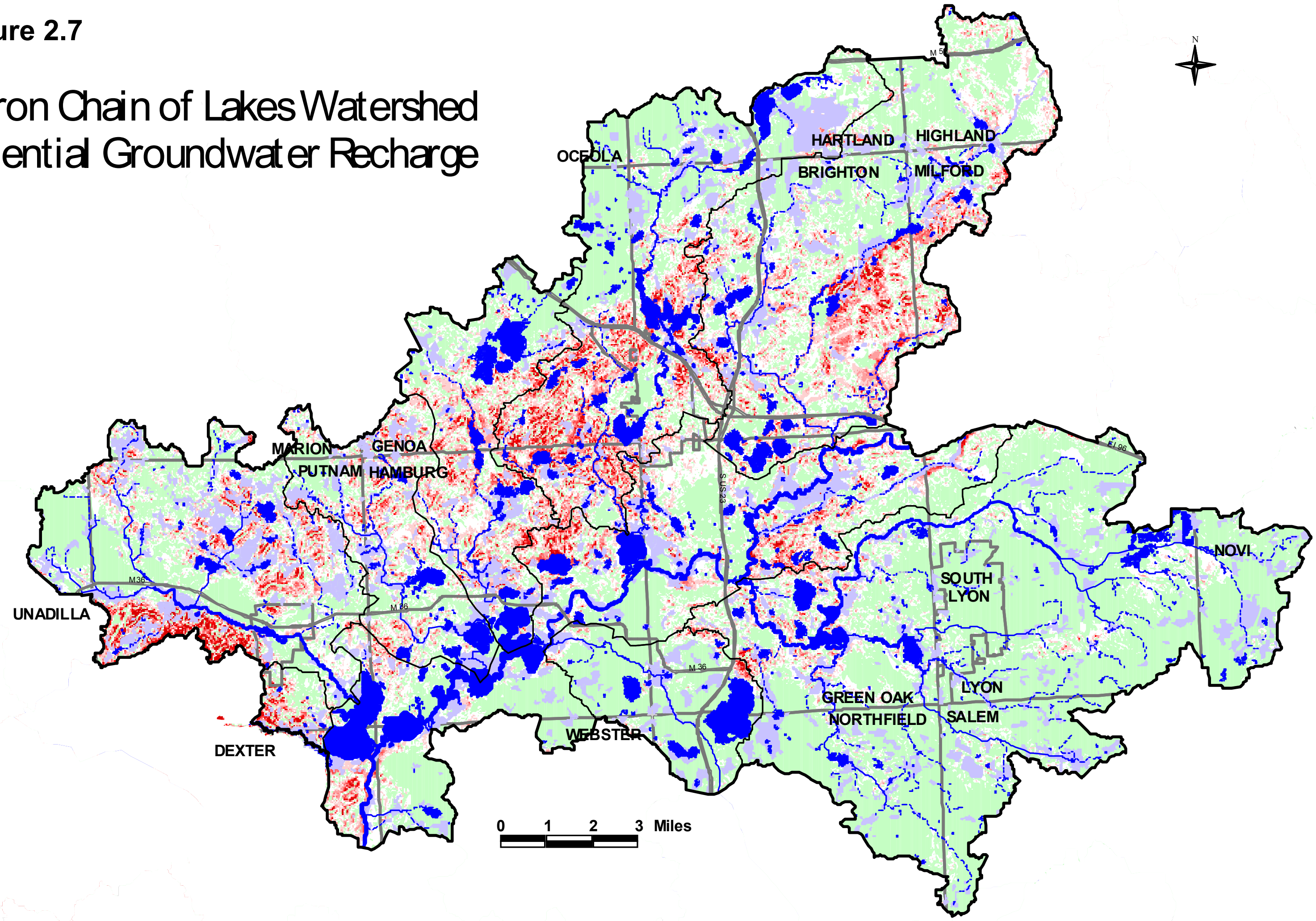
Huron Chain of Lakes Watershed Direct Drainage Areas



Data Source: School of Natural Resources, University of Michigan, Ann Arbor. "Direct drainage" area areas in the watershed where precipitation and snow melt are most likely to run directly into surface waters.

Figure 2.7

Huron Chain of Lakes Watershed Potential Groundwater Recharge



Probability of being groundwater recharge area
- Lower
- Higher

- Watershed/ creekshed boundaries
- Lakes and streams
- Political boundaries
- Highways
- Wetlands

Huron River Watershed Council

Data Source: School of Natural Resources and Environment, University of Michigan, Ann Arbor. Areas of high elevation, permeable soils, and coarse-textured glacial geology have a high probability of being groundwater recharge areas.

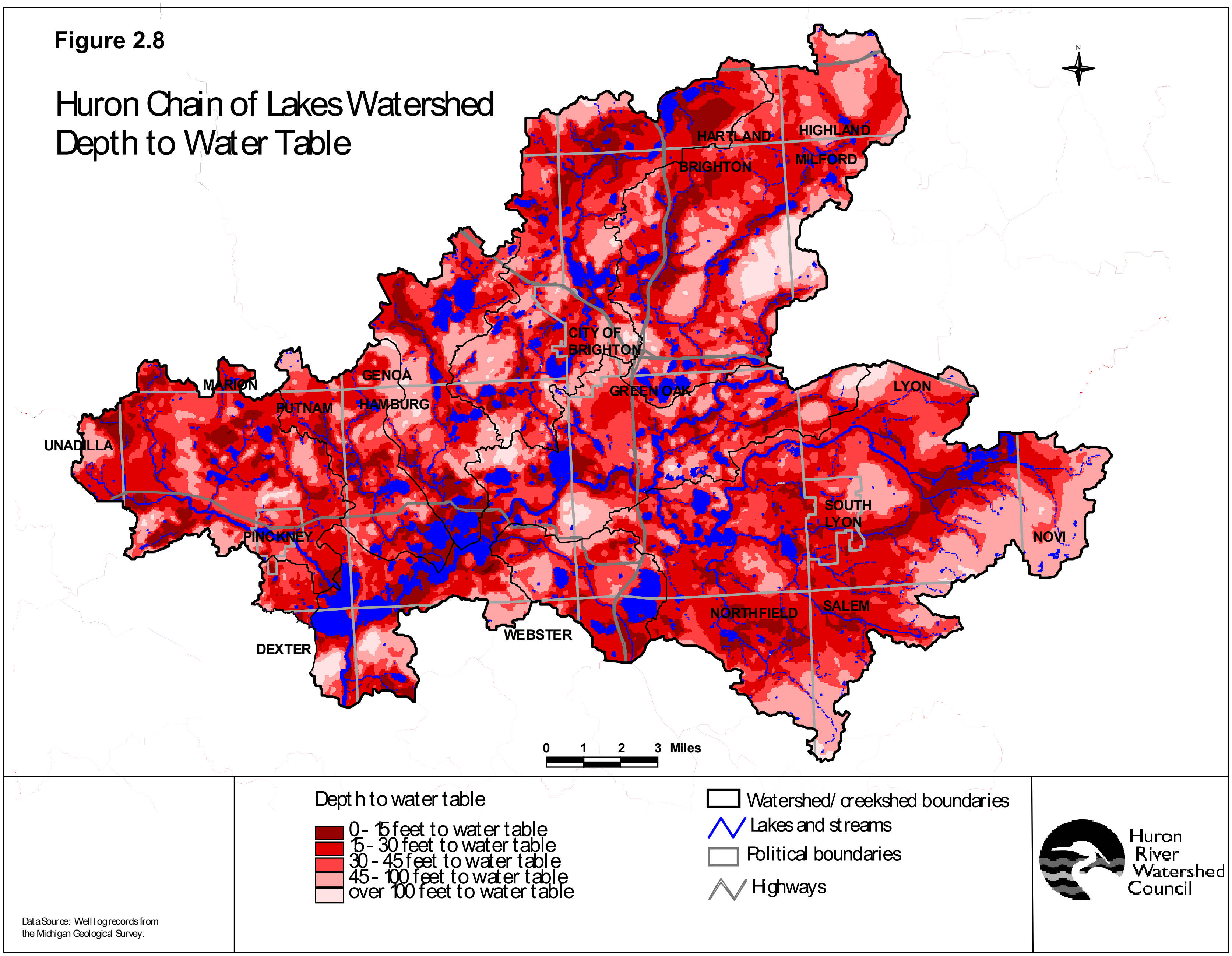


Figure 2.8
Huron Chain of Lakes Watershed
Depth to Water Table
HARTLAND
HIGHLAND
MILFORD
BRIGHTON
CITY OF BRIGHTON
GENOA
MARION
PUTNAM
HAMBURG
GREEN OAK
LYON
UNADILLA
SOUTH LYON
PINCKNEY
NOVI
NORTHFIELD
SALEM
WEBSTER
DEXTER
0 1 2 3 Miles
Depth to water table
0 - 15 feet to water table
15 - 30 feet to water table
30 - 45 feet to water table
45 - 100 feet to water table
over 100 feet to water table
Watershed/ creekshed boundaries
Lakes and streams
Political boundaries
Highways
Huron River Watershed Council
Data Source: Well log records from the Michigan Geological Survey.

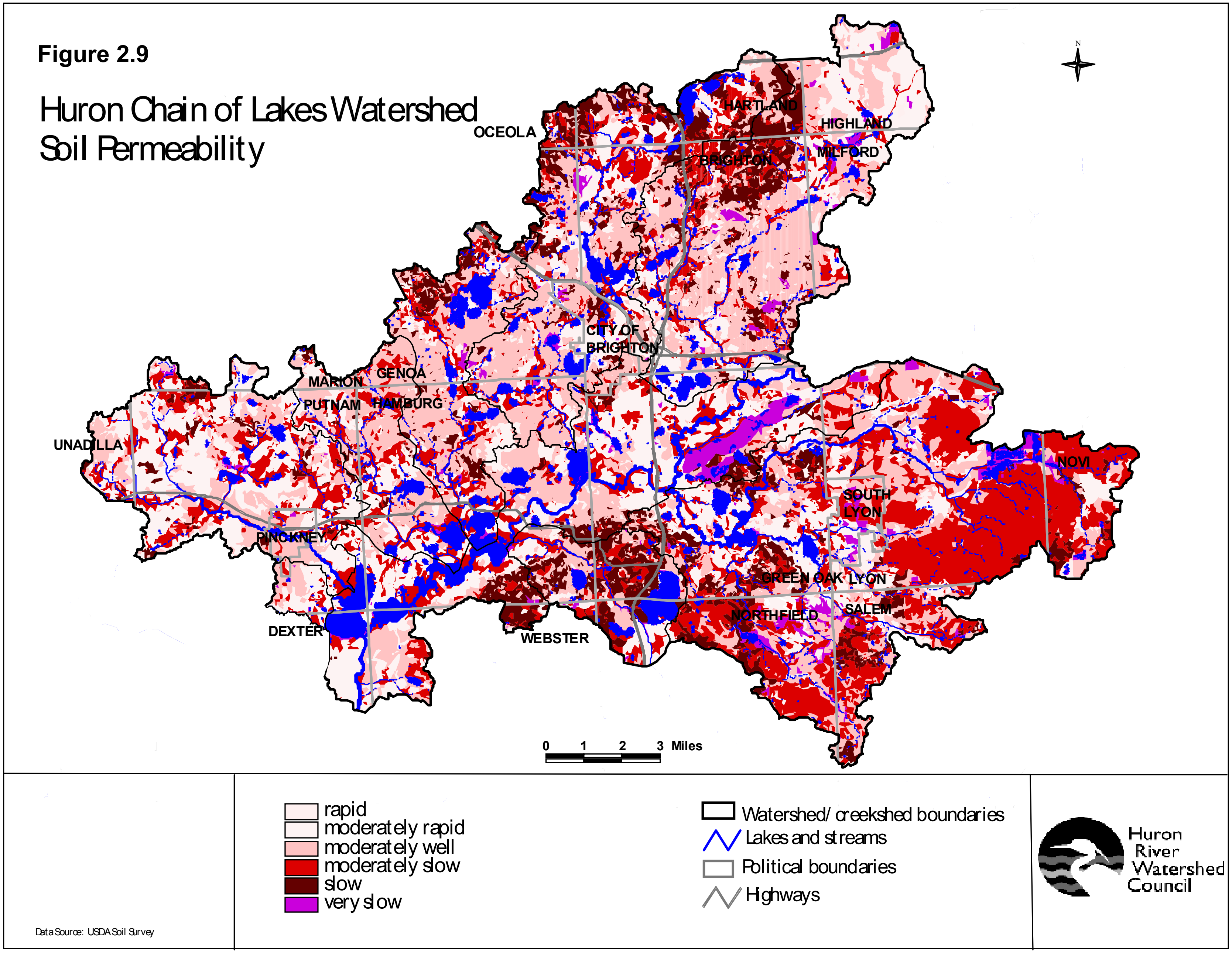
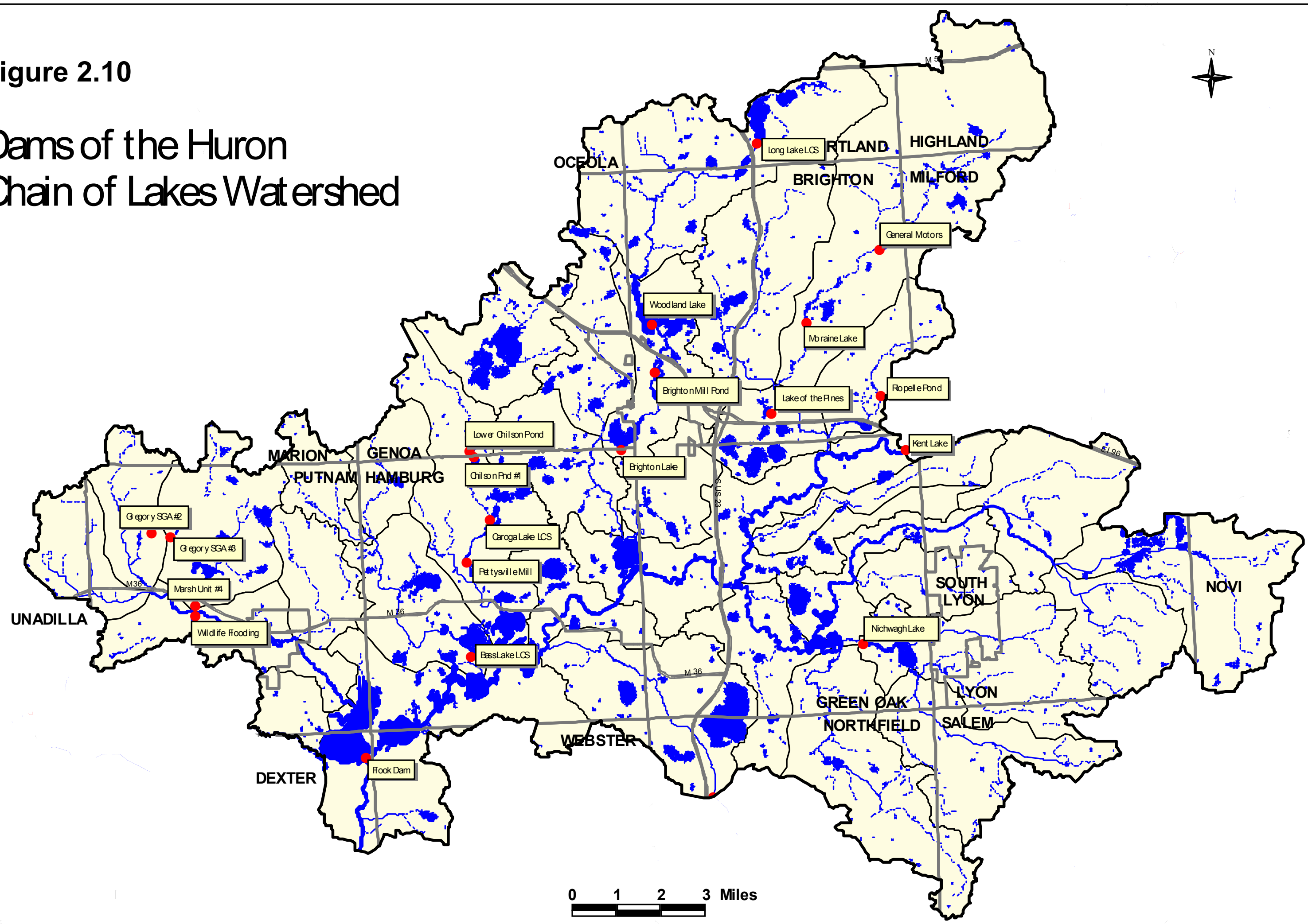


Figure 2.9
Huron Chain of Lakes Watershed
Soil Permeability
OCEOLA
HARTLAND
HIGHLAND
BRIGHTON
MILFORD
CITY OF
BRIGHTON
MARION
GENOA
PUTNAM
HAMBURG
UNADILLA
NOVI
SOUTH
LYON
PINCKNEY
GREEN OAK
LYON
SALEM
NORTHFIELD
DEXTER
WEBSTER
0 1 2 3 Miles
N
rapid
moderately rapid
moderately well
moderately slow
slow
very slow
Watershed/ creekshed boundaries
Lakes and streams
Political boundaries
Highways
Huron River Watershed Council
Data Source: USDA Soil Survey

Figure 2.10

Dams of the Huron Chain of Lakes Watershed



Dams

Watershed/ creekshed boundaries

Lakes and streams

Political boundaries

Highways

Data Source: National Inventory of Dams

Huron River Watershed Council

2.2 Communities and Current Land Use

2.2.1 Political Structure

With an area of 253 square miles, the Huron Chain of Lakes Watershed encompasses portions of 20 communities in three counties. 69% of the watershed is located in all or part of 11 communities in southeast Livingston County; 20% of the watershed is in five communities in southwest Oakland County; and the remaining 11% of the watershed is in four townships in northern Washtenaw County.

Each local government in the Huron Chain of Lakes is zoned and holds regularly scheduled meetings of township governmental bodies where rulings are made on policy additions and changes, budgets, land use issues, and other important local business. Working with the guidance of statewide procedures, townships and other local governments have power to formulate land use and development policy, among other important activities. Drains, including roadside ditches, pipes, bridges, and culverts under state highways and county roads that are not designated county drains are maintained by the county Road Commissions.

Political jurisdictions regarding the Huron River and its tributaries, riparian zones, and land are controlled by federal and state laws, county and township ordinance, 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. The State of Michigan defines that:

> "'Surface waters of the state' means all of the following, but does not include drainage ways and ponds used solely for wastewater conveyance, treatment, or control:
>
> (i) The Great Lakes and their connecting waters.
>
> (ii) All inland lakes.
>
> (iii) Rivers.
>
> (iv) Streams.
>
> (v) Impoundments.
>
> (vi) Open drains.
>
> (vii) Wetlands.
>
> (viii) Other surface bodies of water within the confines of the state."[9]

The Huron River and its tributaries are public and subject to public trust protection. The Michigan Natural Rivers Act (PA 231, 1970) designated a 27.5-mile stretch of the Huron River from Kent Lake Dam and Barton Pond in Washtenaw County as a "country-scenic river." All of the Huron River within the Huron Chain of Lakes Watershed is part of this stretch . A stretch of Davis Creek between Sandy Bottom Lake and its confluence with the Huron River also bears this designation. The Natural Rivers District includes 400 feet on either side of the ordinary watermark where development is severely limited. On private lands, zoning requires 125 feet building setbacks on the mainstem and 50 feet setbacks on tributaries. Minimum lot width for new construction is 150 feet, with 125 feet septic setback, and 50 feet natural vegetation strip along the river. All restrictions apply to public lands yet the natural vegetation strip increases to 100 feet. In the District, no new commercial, industrial or extractive development is permitted within 300 feet of the river or tributaries.

County government assumes responsibility for carrying out certain state policies. In most cases, the 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 are typically self-regulaging in terms erosion control. The City of Novi and Dexter Township are the only local governments in the Huron Chain of Lakes Watershed that currently administer their own soil erosion and sediment control programs.

Designated county drains in the watershed may be an open ditch, stream or underground pipe, retention pond or swale that conveys stormwater. The Drain Commissioner Offices of Livingston, Oakland, and Washtenaw Counties are responsible for operation and maintenance of these storm water management systems ("county drains"). These systems are designed to provide storm water management, drainage, flood prevention, and stream protection for urban and agricultural lands. The Drain Code gives the Drain Commissioners authority for construction or maintenance of drains, creeks, rivers and watercourses and their branches for flood control and water management.

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

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 woodland and wetlands, establish watershed-friendly development standards and lawn care and landscaping practices, and so forth. Local governments oversee enforcement of their policies.

2.2.2 Growth Trends

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

The watershed area is experiencing tremendous economic growth and development pressures due to it's proximity to suburban Detroit. Eastern portions of the watershed in Novi, Lyon Township, and South Lyon are rapidly becoming urbanized and assimilated into the metro Detroit area. These growth pressures continue to radiate westward through the Huron Chain of Lakes Watershed, reflecting a trend in growth from Detroit to more outlying areas spurred by highway improvements, infrastructure, and a desire for open space.

A discussion of growth trends in the watershed is challenged by the fact that readily available demographic data is based on political, rather than hydrologic boundaries. Furthermore, for several of the watershed's 21 communities, only small portions of their areas are located in the watershed. As such, growth trends in these peripheral communities are not necessarily indicative of growth trends in the watershed as a whole. Therefore, this section focuses on seven communities in Livingston County, as well as South Lyon and Lyon Township in Oakland County, which cumulatively represent 74% of the watershed area. Growth and development trends in these core communities are generally indicative of the watershed as a whole.

In examining growth and land use trends in the Huron Chain of Lakes Watershed, it is helpful to place it in the larger context of trends in the five-county area of southeast Michigan. SEMCOG has combined U.S. Census data and land use data to determine changes in growth and land use that have occurred in the region between 1990 and 2000. Among the key findings are the following[10]:

- Developed land in the region increased by 17.7% (163,634 acres), which equates to an 8.1% decrease in undeveloped land. Residential development accounted for 76% of all developed land.
- The region's population grew by 5% (243,000 people), a major factor in land use change.
- Residential housing development saw a dramatic decrease in density. In 1990, housing density averaged 2.86 units per acre. Residential units built between 1990 and 2000 averaged 1.23 units per acre
- Average household size has decreased and average home size has increased
- The average number of persons per household decreased from 2.66 in 1990 to 2.58 in 2000.

In summary, much of the undeveloped land in southeast Michigan is being developed to accommodate new housing demands from an increasing population. The average home in southeast Michigan is increasing in size and consuming more land while housing fewer people. These trends, which have serious implications for environmental impacts in the region and can be expected to continue, are also evident in the communities comprising the Huron Chain of Lakes Watershed.

Livingston County has been the fastest growing county in the state for the last decade. According to U.S. Census data, the county's population increased between 1990 and 2000 by over 35%. From 2000 to February 2005, SEMCOG estimates that the County's population increased by 15.4%, from just under 157,000 to just over 181,000. By comparison, the population in southeast Michigan increased during this same period by 1.6%, while Washtenaw County saw an increase of 7.4% and Oakland County increased by 1.8%[11]. From 2005 to 2030, SEMCOG projects that Livingston County's population will increase over 56% to 282,552, an increase of over 101,000[12]. Population changes for communities that are located primarily in the Huron Chain of Lakes Watershed are listed below in Table 2.3. Note that these data are for the entire communities, not just their areas within the Huron Chain of Lakes Watershed.

Table 2.3. 1990-2030 Population Changes for Core Communities in the Huron Chain of Lakes Watershed[13]

	1990 Census	2000 Census	Change 1990-2000	2005 SEMCOG estimate	Change 2000-2005	2030 SEMCOG forecast	Change 2005-2030
Brighton City	5,686	6,701	17.9%	7,231	7.0%	7,365	1.9%
Brighton Twp.	14,815	17,673	19.3%	18,454	3.9%	24,409	32.3%
Genoa Twp.	10,820	15,901	47.0%	19,768	23.0%	29,083	47.1%
Green Oak Twp.	11,604	15,618	34.6%	17,792	10.8%	34,104	91.7%
Hamburg Twp.	13,083	20,627	57.7%	22,638	8.4%	36,331	60.5%
Lyon Twp.	8,828	11,041	25.1%	12,683	14.9%	49,076	286.9%
Pinckney Village	1,603	2,141	33.6%	2,426	13.3%	2,792	15.1%
Putnam Twp.	4,580	5,359	17.0%	5,916	9.6%	8,403	42.0%
South Lyon City	6,479	10,036	54.9%	11,149	11.1%	13,871	24.4%
TOTAL	77,498	105,097	35.6%	118,057	12.3%	205,434	74.0%

Not surprisingly, the urbanized areas represented by the City of Brighton, Pinckney, and South Lyon show the smallest projected population gains through 2030 because they have less land available for new development. Lyon Township shows by far the largest projected populations gains, nearly tripling its 2005 population. The combined population of these core communities is projected to be over 87,000 people by 2030, an increase of 74%.

Table 2.4 illustrates the relation of the number and density of housing units in the watershed's core communities between 1990 and 2000. All communities show increases of 23%-58% in the number of housing units between 1990 and 2000. With the exception of Brighton City, the vast majority of the building permits issued during this period for these communities were for single family detached homes, a trend which continues through the most current data available in 2005[14].

The change in average density of these housing units is less dramatic, but the general trend is in keeping with the rest of southeast Michigan. With the exception of Genoa Township, all township areas show a decrease in density. In the Village of Pinckney and Brighton City, where less land is available, housing densities show marked increases in the number of units per acre.

Table 2.4. Housing Units and Densities for Communities in the Huron Chain of Lakes Watershed[15]

	Housing Units in 2000	Increase in Housing Units, 1990-2000	Average Density of All Housing Units in 2000 (units per acre)	Density of Housing Units Built 1990-2000 (units per acre)
Brighton City	3,206	27.8%	3.70	4.07
Brighton Twp.	6,207	27.3%	.72	.62
Genoa Twp.	6,334	55.8%	.92	.94
Green Oak Twp.	5,780	35.8%	1.05	.99
Hamburg Twp.	7,687	51.0%	1.01	.99
Lyon Twp.	4,047	29.3%	.68	.65
Pinckney Village	764	41.0%	1.98	3.66
Putnam Twp.	2,130	23.7%	.62	.58
South Lyon City	4,467	58.1%	3.80	3.45

2.2.3 Land Use and Development

As the Huron Chain of Lakes communities develop, the potential for negative environmental impacts increases, including water *quality* impacts from erosion, sedimentation, and increased inputs of stormwater pollutants. Potential impacts on water *quantity* also increase as wetlands, woodlands, floodplains and other natural features that regulate water quantity are altered or replaced with impervious surfaces. (See Chapter 4 for analysis of present and future impervious surface cover of the watershed).

Prior to permanent European settlement, grasslands of oak barrens and openings and forests of several species of oak, beech, and maples dominated the landscape of the Huron Chain of Lakes Watershed. Multiple types of wetlands, such as emergent, forested, and wet prairie were also found throughout the low-lying areas (Figure 2.11).

Upon permanent settlement, the land began to be used for human benefit. Initial activities on the land centered on the clearing of grasslands for agricultural production and the use of forested areas for wood and wood by-products. By 2000, SEMCOG aerial photographic data indicates the significant changes to the landscape (2.12). Permanent mixed density residential land use is the single largest use of the watershed (29%), followed by open grass and shrub (16%), agriculture (15%), wetlands (14%), and forest (11%). Prairie and grasslands, forested lands, and to a lesser extent, wetlands, experienced moderate to significant reductions in coverage as the area was developed from the mid-1800s to late-1900s. The remainder of the land is either commercial/industrial (6%), water (6%), or actively maintained recreational land (3%).

The watershed also contains several large land areas for public recreation (Figure 2.14). The State of Michigan is a major landowner, which includes Island Lake and Brighton State Recreation Areas. The Huron-Clinton Metropolitan Authority owns the Huron Meadows Metropark, and small portions of Kensington and Hudson Mills Metroparks are also located in the watershed. The University of Michigan owns significant land parcels for research in the south and western-most areas of the watershed.

Table 2.5 shows the percentage increases for selected land uses in the watershed between 1990 and 2000. With few exceptions, the land use categories of single family and multi-family, commercial, and industrial show moderate to significant percentage increases. With the exception of a small increase in active agriculture in Putnam Township, the land use categories of active agriculture, grassland and shrub, and woodland and wetland all showed moderate to substantial decreases in all core communities.

Table 2.5. Land Use Change, 1990-2000 for Core Communities in the Huron Chain of Lakes Watershed[16]

	Single Family	Multi-Family	Commercial	Industrial	Active Agriculture	Grassland and Shrub	Woodland and Wetland
Brighton City	13.7%	65.7%	18.7%	61.8%	-87.9%	-40.9%	-14.6%
Brighton Twp.	33.2%	19.8%	50.4%	0.3%	-38.7%	-29.8%	-15.4%
Genoa Twp.	52.4%	183.2%	137.5%	73.6%	-27.6%	-18.9%	-14.0%
Green Oak Twp.	39.3%	6.3%	47.6%	88.2%	-30.6%	-19.8%	-1.2%
Hamburg Twp.	52.6%	n/a	22.4%	49.5%	-36.4%	-24.6%	-9.5%
Lyon Twp.	31.2%	16.1%	60.5%	88.7%	-23.5%	-29.2%	-17.9%
Pinckney Village	18.7%	0.0%	4.5%	0.0%	-43.0%	-7.5%	-.4%
Putnam Twp.	25.9%	0.0%	134.8%	0.0%	4.3%	-3.6%	-11.5%
South Lyon City	64.6%	84.4%	3.5%	0.0%	-82.5%	-52.1%	-10.3%

Future land use trends in the Huron Chain of Lakes Watershed can be predicted by studying each community's master plan. A master plan is a community's comprehensive guide for all aspects of future development. This future development is also known as a "build-out" scenario, as it displays what a community's land use would look like if it were fully developed according to its master plan. (Build-out scenarios can also be constructed using a community's zoning ordinances). The Huron Chain of Lakes Watershed's build-out scenario according to community master plans is shown in Figure 2.13.

All land use types expand in the future build-out scenario at the expense of open land and agriculture. The most notable change is the expansion of residential areas into areas that currently are actively farmed or are open; residential use is projected to double from 29% to 57% of the total land area of the Watershed, while agriculture is projected to go from 14% of current land use to 1%. Commercial/industrial land use is projected to increase from 5% to 9%. The combined current land uses of forest (17%), open space (16%) and public/recreation (3%) account for 36% of the Watershed area. In the build-out scenario, these land uses will account for only 14% of the Watershed area. The remaining open/public and forest lands are either municipal parks, Metroparks, or state game or state recreation areas.

2.2.4 Existing Point Sources

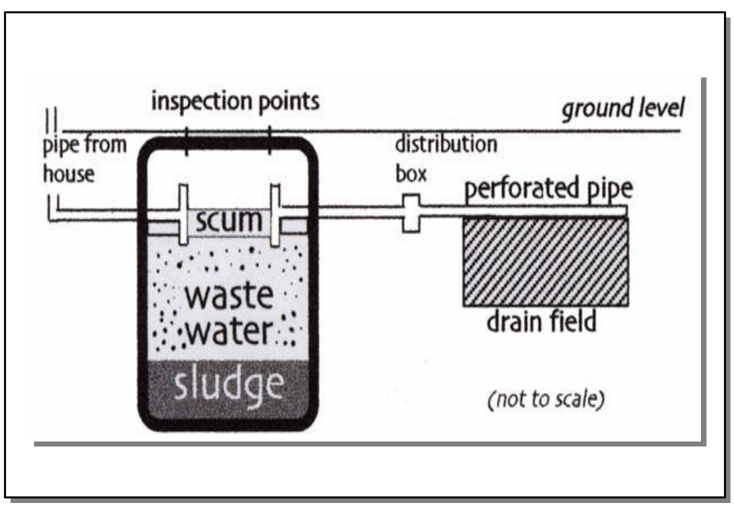
There are several point source facilities in the watershed that hold NPDES permits issued by the State of Michigan (Figure 2.15). The number of permitted point sources is not static due to expiring old permits and activation of new permits. At the writing of this document, fifty-one permits were in issuance[17]. Four point sources in the Huron Chain of Lakes Watershed are considered major contributors for the amount of discharge they emit. These facilities are the General Motors Milford Proving Grounds, the City of Brighton Waste Water Treatment Plant, the South Lyon Waste Water Treatment Plant, and Michigan Seamless Tube, LLC. in South Lyon.

The remaining permittees are considered minor point source discharges and are privately owned, with the exception of the wastewater treatments plants owned by Brighton Township, Northfield Township, and South Lyon. Receiving waters for the permitted pollution drain to the Huron River, all major tributaries (except Chilson Creek), numerous secondary streams or drains, and impoundments along these water bodies. Thirty-seven of the permits are issued for the purpose of conveying stormwater to local waterways, nine are for discharge of various types of industrial pollutant wastewater, one for discharge from a municipal separate storm sewer, and four are for discharge from municipal wastewater treatment plants.

Due to the nutrient TMDLs in Brighton, Ore, and Strawberry Lakes, waste load allocations for Phosphorus contributions from permitted point sources have been established in all upstream contributing portions of the Huron River Watershed. These waste load allocations place restrictions on the total amount of phosphorus that can be discharged into waters flowing to these TMDL areas. Such restrictions have implications for determining the amount of phosphorus that may be discharged by existing NPDES permittees. Waste load allocations also factor into determining whether additional phosphorus-discharging facilities may be permitted to locate in a TMDL area. For additional information on phosphorus load allocations in the three established phosphorus TMDLs in the watershed, refer to Appendix A.

2.2.5 Sanitary Sewer Service Areas and Privately Owned Septic Systems

The Huron Chain of Lakes Watershed has a mix of households whose waste discharges are treated by publicly owned wastewater treatment plants (WWTP) or on-site decentralized wastewater systems (privately-owned septic systems). Sanitary sewers rely on the connection of pipes from residential, commercial, and industrial sites that ultimately are received at a wastewater treatment plant where treatments are applied before discharge.



Privately owned on-site septic systems, or septic tanks, allow wastewater from a single (sometimes multiple) entity to be treated via biological and infiltration processes. Both technologies are effective methods of wastewater treatment if maintained and operated properly; however, impairments do occur. Households currently served by sanitary sewers are located in the urbanized areas of the watershed, while remaining areas are served by on-site septic systems (Figure 2.16).

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

If either system is designed, constructed, or maintained improperly, it can be a significant source of water pollution and a threat to public health. The health departments of Livingston, Oakland, and Washtenaw Counties regulate the design, installation, and repair of privately owned septic systems. However, only Washtenaw County currently requires regular maintenance and inspection to assure proper functioning of these systems, which occurs at time of property sale. Through implementation of the time of sale program, Washtenaw County has determined that 20% of privately owned septic systems in the county are failing and require repair.

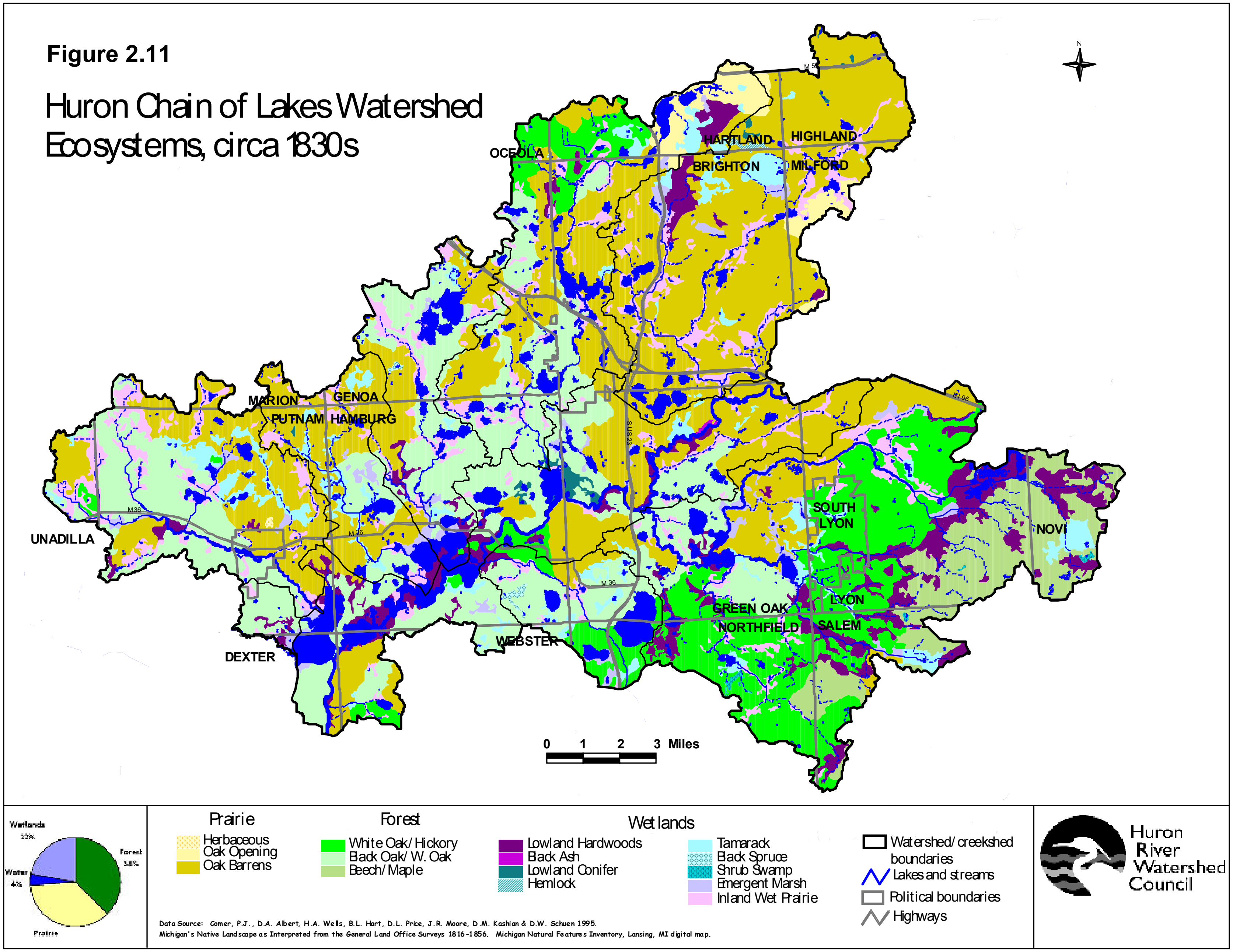
Sanitary sewer systems can suffer from improper installation and maintenance. For instance, in many older developments sanitary sewer pipes can be inadvertently connected to stormwater drainage systems, causing what is termed an "illicit discharge." These discharges can have an even greater impact on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

Recent legislation has facilitated the ability of new development projects to utilize community wastewater systems, also known as decentralized wastewater systems, which provide on-site wastewater treatment for multiple homes much a giant septic system. Community wastewater systems are increasingly being used to build high density developments in un-sewered areas where soils are not suitable for individual septic systems.

A drawback of these large septic systems is the potential discharge of large quantities of septic waste into a localized groundwater area. Conversely, community wastewater systems can also be a tool for mitigating the impacts of individual septic systems over a larger area; rather than locating several individual septic systems in close proximity to a lake or waterway where they could pose a greater risk to surface waters or groundwater, a community wastewater system could allow the homes to be built near the waterbody, while the community septic system would be located at a greater distance from the waterbody. Due to the potential impacts of community wastewater systems, communities should be aware of their complexities and plan accordingly for their location, construction, and operation.

Figure 2.11

Huron Chain of Lakes Watershed Ecosystems, circa 1830s



Data Source: Comer, P.J., D.A. Albert, H.A. Wells, B.L. Hart, D.L. Price, J.R. Moore, D.M. Kashian & D.W. Schuen 1995. Michigan's Native Landscape as Interpreted from the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI digital map.

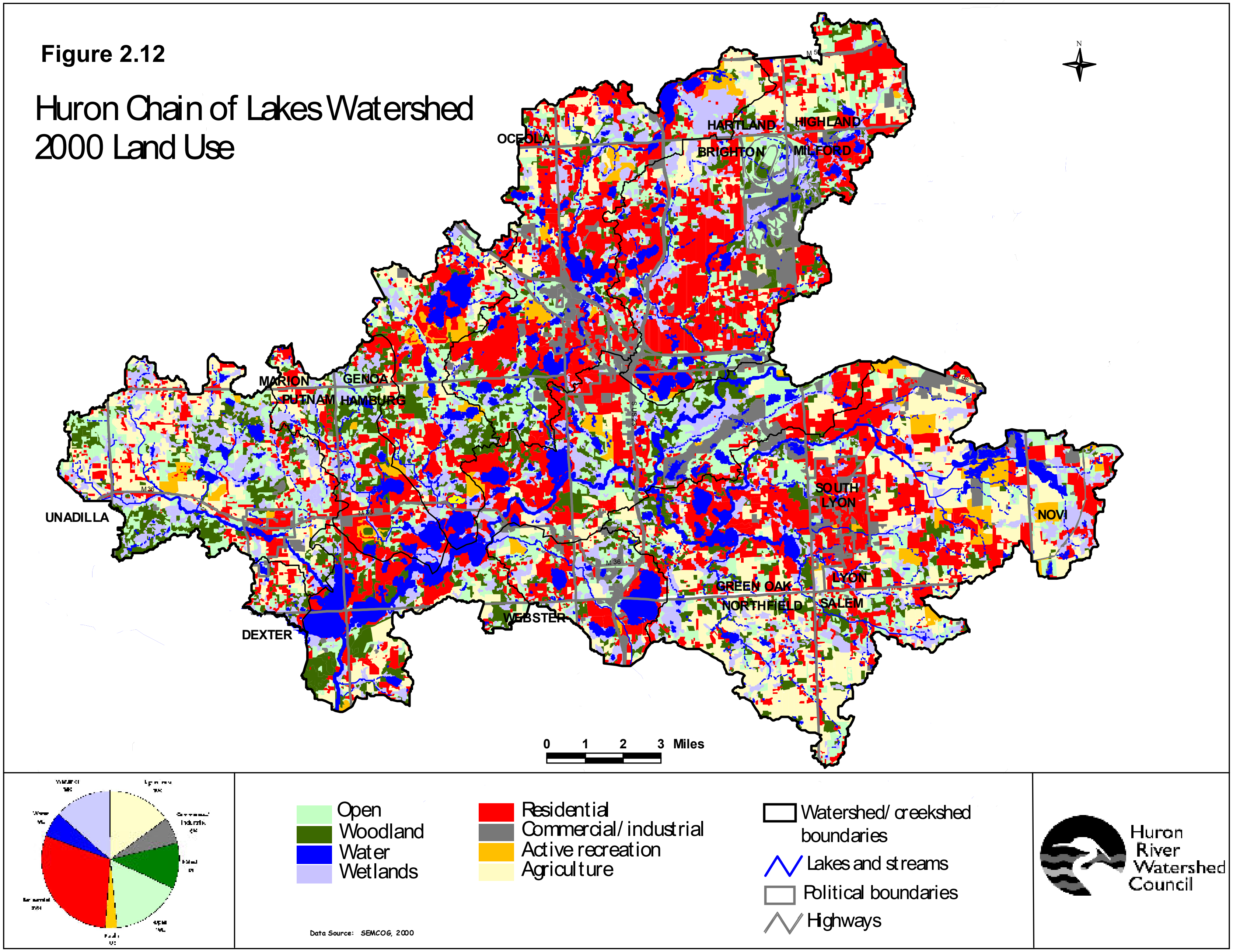


Figure 2.12

Huron Chain of Lakes Watershed 2000 Land Use

Figure 2.13

Huron Chain of Lakes Watershed Land Use at Buildout According to Master Plans

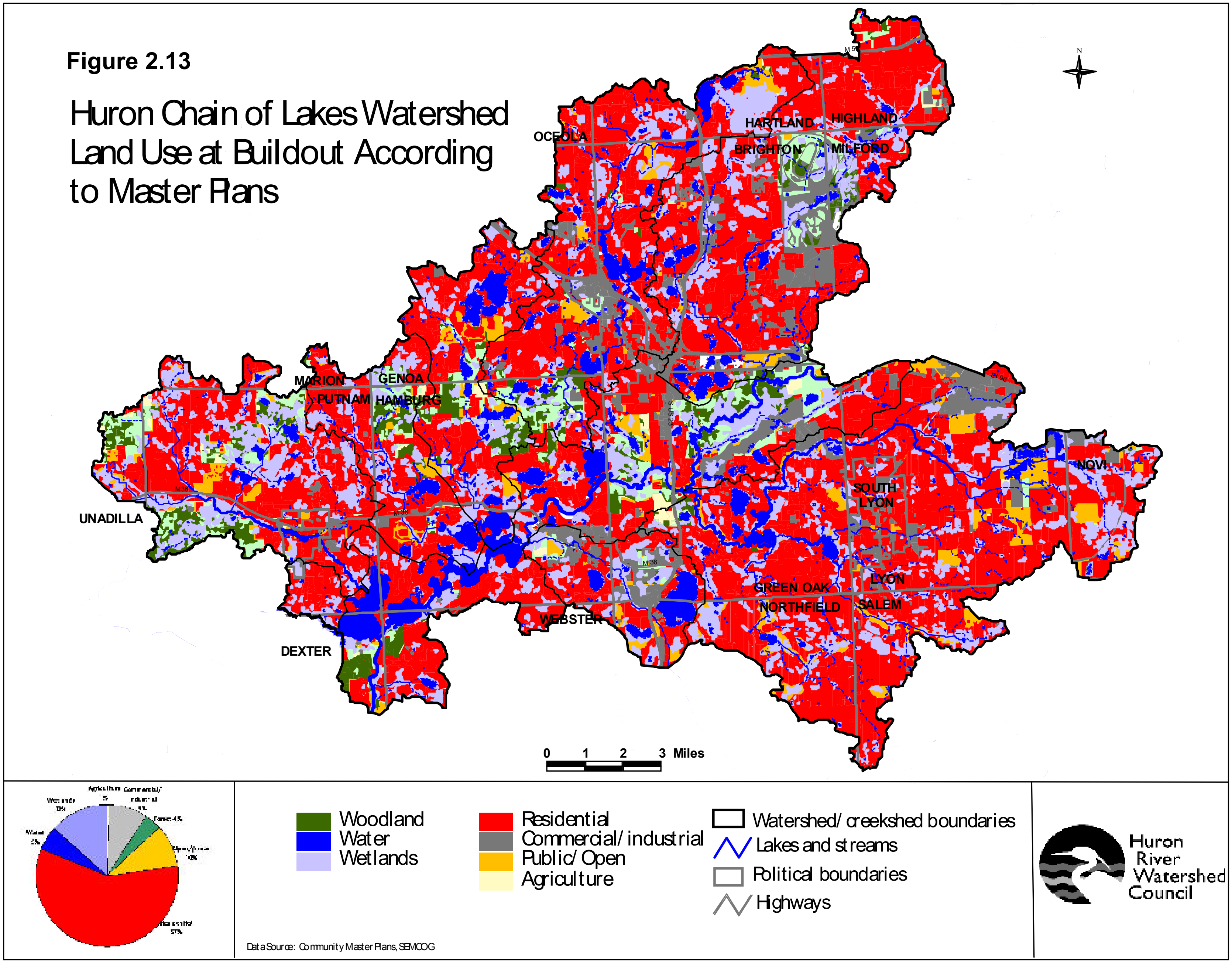


Figure 2.14

Huron Chain of Lakes Watershed Major Public Lands

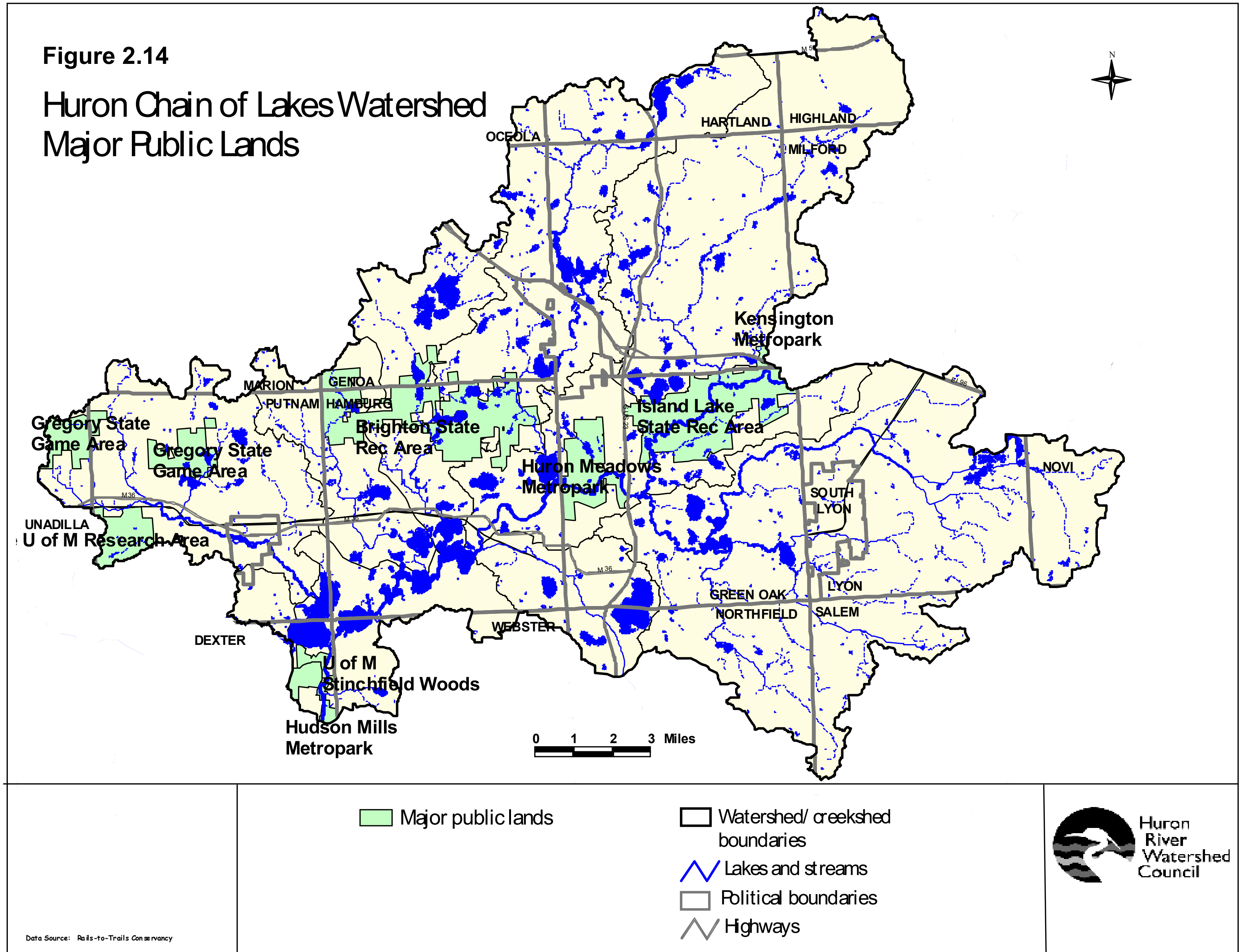
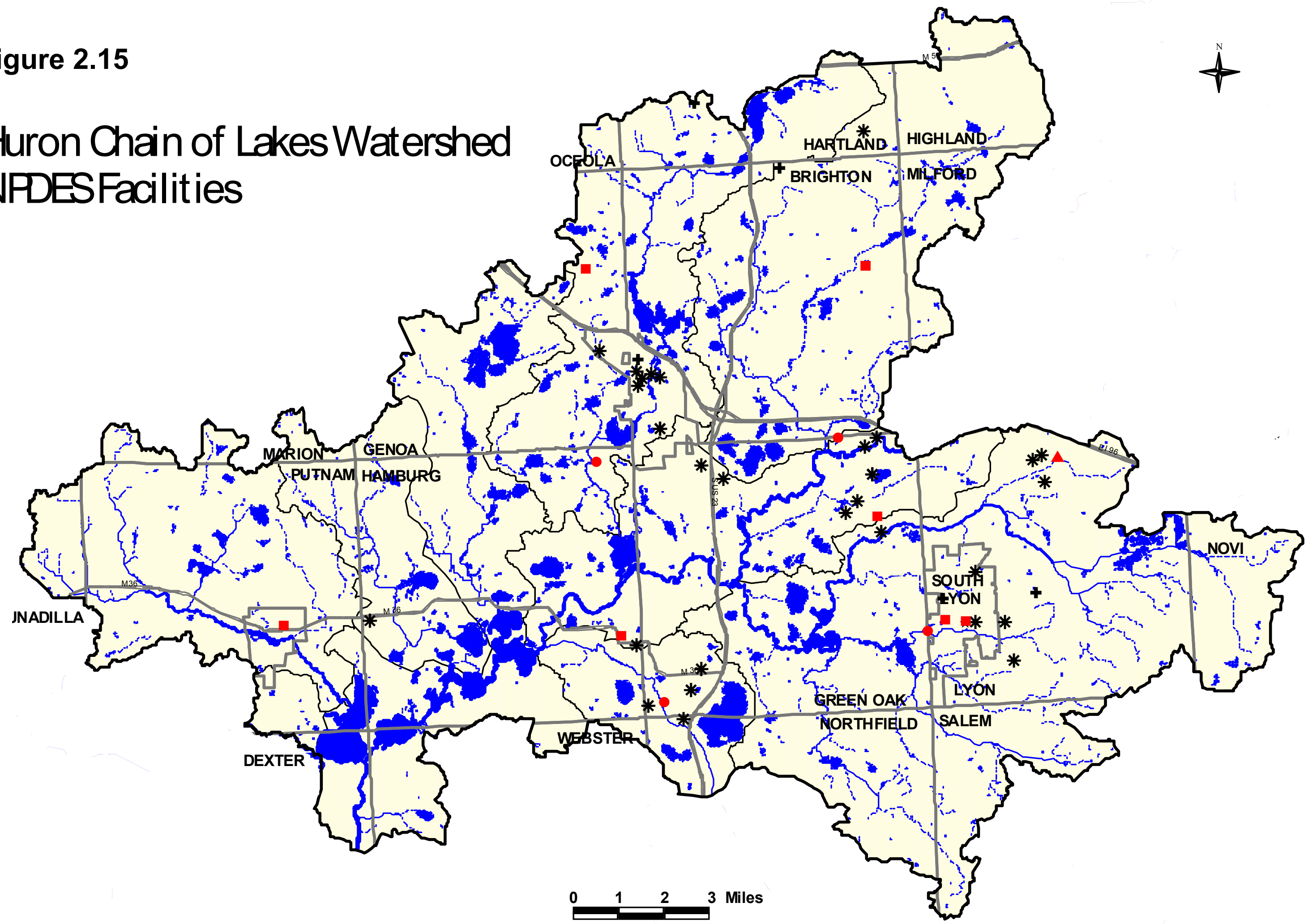


Figure 2.15

Huron Chain of Lakes Watershed NPDES Facilities



Npdes permits
- ▲ Municipal Separate Storm Sewer - 1
- ● Non-Industrial Sanitary Wastewater - 4
- ■ Standard (All others) - 9

Npdes stormwater permits
- ✚ Construction Sites - 4
- ✱ Industrial Storm Water - 32
- ☆ Standard (All others) - 1

Watershed/ creekshed boundaries
Lakes and streams
Political boundaries
Highways

Huron River Watershed Council

Data Source: MDEQ

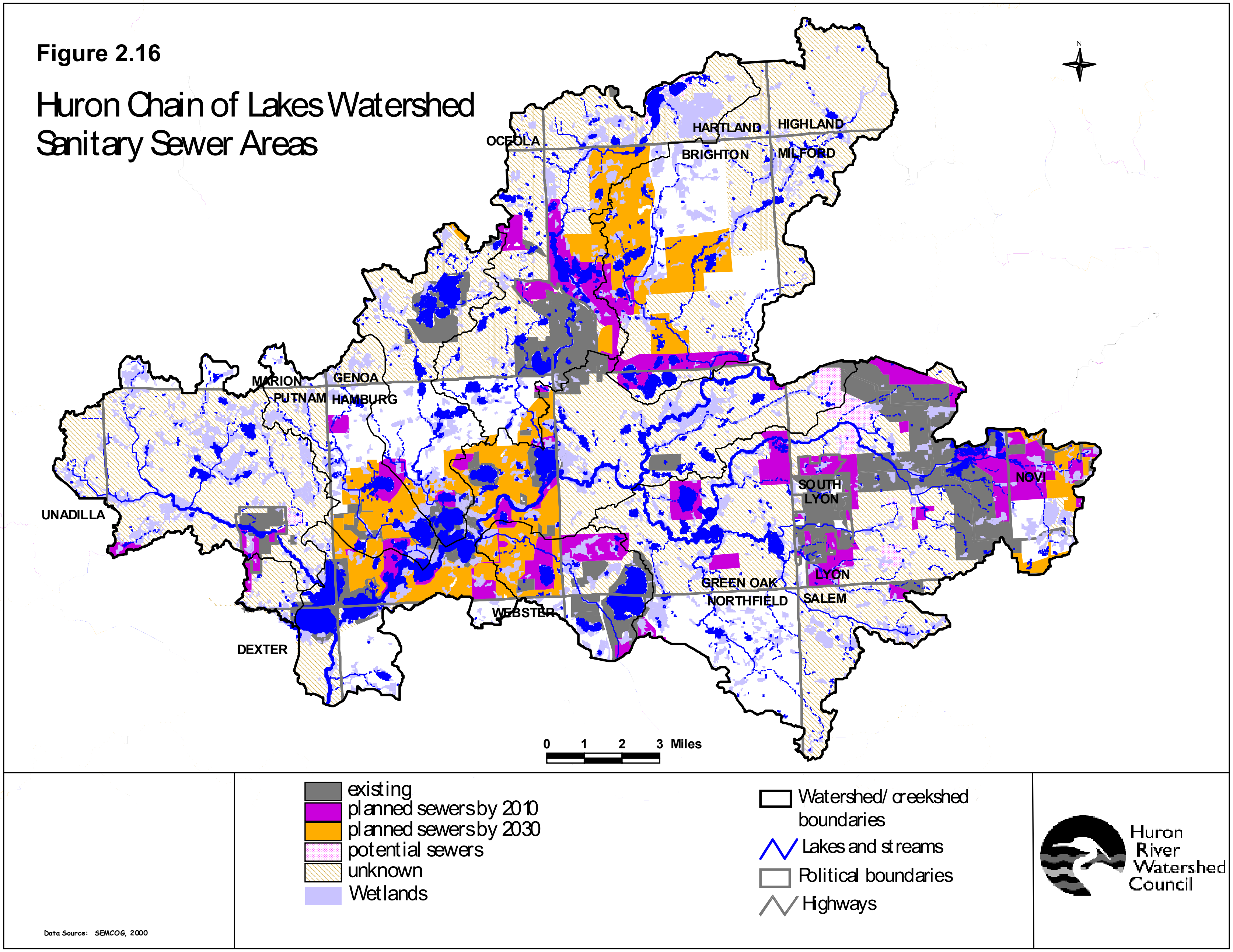


Figure 2.16

Huron Chain of Lakes Watershed Sanitary Sewer Areas

2.3 WATER QUALITY INDICATORS

This section provides a synopsis of common indicators for gauging water quality. These water quality parameters include phosphorus, nitrogen, sediment, turbidity and dissolved/suspended solids, conductivity, dissolved oxygen, bacteria, temperature, and benthic macroinvertebrate assessments (aquatic insects and mussels). A general discussion of basic limnology (lake behavior) is also presented. While these indicators are important and useful in evaluating overall water quality, data for all of these parameters were not readily available for all creeksheds in the watershed.

2.3.1 Chemical and Physical Indicators

Phosphorus

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

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

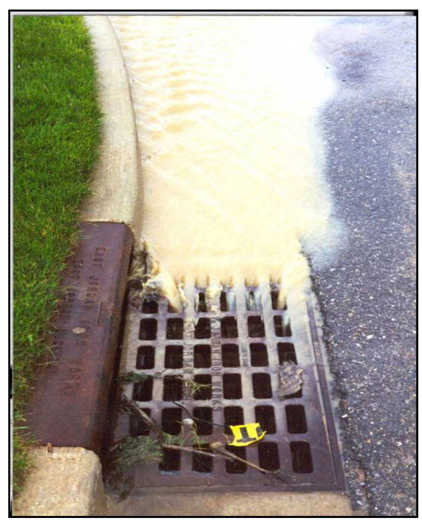
Nonpoint sources of phosphorus include human, natural, and animal sources. Because phosphorus has a strong affinity for soil, stormwater runoff from activities that dislodge soil or introduce excess phosphorus (such as conversion of land to urban uses and over-fertilization of lawns) is frequently considered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

Nitrogen

Nitrogen is also considered essential in determining algae growth in lakes and is found in a number of forms, including molecular nitrogen, ammonia, nitrates, and nitrites. Nitrogen is often found in waterbodies at higher concentrations than phosphorus. Consequently, nitrogen is often not considered the limiting nutrient to detrimental growth. Additionally, unlike phosphorus loading, nitrogen loading is often difficult to reduce due to the high water solubility of nitrogen. Therefore, concerns regarding nitrogen and its role in eutrophication often are considered secondary to phosphorus in southeast Michigan. However, studies have shown that high nitrate concentrations, even without Phosphorus limitations, can promote eutrophication. Typical sources of nitrogen in surface waters include human and animal wastes, decomposing organic matter, and runoff from fertilizers. Improperly operated wastewater treatment plants and septic systems, as well as sewer pipeline leaks also can act as additional sources of nitrogen to waterbodies. MDEQ considers total nitrogen levels greater than 1 to 2 mg/L to have the potential to cause eutrophic conditions[18]. Nitrate levels above 10 mg/L are considered unsafe for drinking water[19].

Sediment

Silt, which is fine-grained sediment, is an important factor when considering a creek's quality. Silt in riffles can limit the number of creatures living in a creek because it fills the spaces between surfaces and reduces oxygen in the substrate. Erosion also degrades water quality because soil binds pollutants, like phosphorus, which helps to create nuisance algae blooms. Silt is smaller than sand and larger than clay. Many streambeds in the Huron River system are sandy naturally, but a problem arises when a dramatic shift from gravel and rocks to more fine sediments occurs. Erosion is a natural process, but dramatic fine sediment increases suggest unnaturally high erosion rates.



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

Turbidity and Total Dissolved/Suspended Solids

Turbidity is the measure of the relative clarity of water and is an approximation of suspended solids in the water that reduce the transmission of light. The relationship depends on several factors including the size and shape of the suspended particles and their density. Turbidity should not be confused with color since darkly colored water can be clear without being turbid. Total suspended solids (TSS) include all particles suspended in water that will not pass through a filter. Suspended solids are any particles/substances that are neither dissolved nor settled in the water. Total Dissolved Solids (TDS) include anything present in water other than the pure water (H_20) molecule and suspended solids such as minerals, salts, metals, cations or anions dissolved in water.

High turbidity and TSS directly result from soil erosion, stormwater runoff, algal blooms and bottom sediment disturbances that may be caused by boat traffic and large populations of bottom feeders such as carp. Turbid water absorbs heat from the sun. Warmer water holds less oxygen than cooler water, resulting in less oxygen in the water. Water with high turbidity loses its ability to support diverse aquatic biology. Suspended solids range from clay, silt and plankton to industrial wastes and sewage. Suspended solids can clog fish gills, reduce growth rates and disease resistance, decrease photosynthesis and reduce DO levels, and prevent egg and larval development. Settled particles can accumulate on the stream bottom and smother fish eggs and aquatic insects including larvae of benthic macroinvertebrates.

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

A simple, though somewhat subjective, method of measuring water clarity in lakes is with a Secchi disk, an 8-inch diameter plate with alternating quadrants painted black and white that is lowered into water until it disappears from view. It is then raised until just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. Nearly all Secchi disc measurements on Michigan inland lakes will be between one and forty feet. MDEQ classifies Secchi disk readings greater than 16 feet as indicative of oligotrophic (nutrient poor) conditions. Secchi disk readings between 6.5 and 16 feet indicate mesotrophic conditions, and Secchi disk readings less than 6.5 feet indicate eutrophic or hypereutrophic conditions. [21]

Conductivity

Conductivity, a measure of general water quality, increases with the amount of dissolved ions, such as salts or metals. If the average conductivity measured at a site is 800 microSiemens (μS) or less, then it is considered natural for stream water in the Huron River Watershed.[22] Conductivity over 800 μS may indicate the presence of toxic substances; however many toxins are not measured by conductivity. A high conductivity measurement signals a need for further investigation of what is dissolved in the water.

Salts

Salt is composed of two compounds: sodium (Na) and chloride (Cl_2). Salts typically enter waterways from road salting (de-icing) operations or from water softener backwash discharge into the environment. De-icing product, primarily sodium chloride, is used locally by MDOT, county road commissions, homeowners, and business/commercial establishments. Most highway and road commissions have specific policies and procedures regarding salt application, salt/sand mixtures, and storage. The Livingston

County Department of Public Health prohibits the discharge of water softener backwash from on-site septic systems.

There are several environmental concerns regarding the use of de-icing salts and water softener backwash discharge. Salts are highly soluble in water and easily wash off pavement into surface waters and leach into soil and groundwater. High concentrations of salt can damage and kill vegetation, disrupt fish spawning in streams, reduce oxygen solubility in surface water, interfere with the chemical and physical characteristics of a lake, and pollute groundwater making well water undrinkable.

However, Michigan has no water quality standards for salt concentrations and little is known about "how much salt is too much." Furthermore, the ecological impacts of salt in freshwater systems vary considerably according to localized site conditions, making it difficult to establish general limits for acceptable quantities of salt application or environmental concentrations.

Although very little data exists for salt concentrations in the Huron Chain of Lakes Watershed, several citizens have expressed concern with salts entering their lakes from road runoff. Best management practices to reduce salt inputs may include the use of alternative road de-icers such as calcium carbonate or calcium acetate that are not as detrimental to water quality. In addition to salt alternatives, proper calibration of salt dispensing equipment and optimizing the timing of de-icing applications can reduce over-use of salt and alternative de-icers.

Dissolved Oxygen

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

The amount of oxygen an organism requires varies according to species and stage of life. DO levels below 1-2 mg/L do not support fish. DO levels below 3 mg/L are stressful to most aquatic organisms. Minimal DO levels of 5-6 mg/L usually are required for growth and activity. Low DO levels encourage the growth of anaerobic organisms and nuisance algae. The accumulation of organic wastes and accompanying aerobic respiration by microorganisms as they consume the waste depletes DO in freshwater systems. High levels of bacteria from sewage pollution and high levels of organic matter can lead to low DO levels. Michigan Water Quality Standards states that surface waters protected for warmwater fish and aquatic life must meet a minimum dissolved oxygen standard of 5 mg/l.[23]

Bacteria

Bacteria are microorganisms that are found everywhere. Coliform bacteria are a group of bacteria that includes a smaller group known as fecal coliforms, which are found in the digestive tract of warm-blooded animals. Their presence in freshwater ecosystems indicates that pollution by sewage or wastewater may have occurred and that other harmful microorganisms may be present. A species of fecal coliform known as *Escherichia coli* or *E. coli* is analyzed to test for contamination.

Rule 62 of the Michigan Water Quality Standards (Part 4 of Act 451) limits the concentration of microorganisms in surface waters of the state and surface water discharges. Waters of the state that are protected for total body contact recreation must meet limits of 130 *Escherichia coli* (*E. coli*) per 100 milliliters (ml) water as a monthly geometric mean of five sampling events (3 samples per event) and 300 *E. coli* per 100 ml water for any single sampling event during the May 1 through October 31 period. The limit for waters of the state that are protected for partial body contact recreation is a geometric mean of 1000 *E. coli* per 100 ml water for any single sampling event at any time of the year.[24]

Monitoring of public bathing beaches in the watershed is performed by the County Health Departments. Starting in 2003, state law requires that monitoring results from public beaches must be reported to MDEQ, which publishes the data on its web site.[25] Beach monitoring results for 2003 and 2004 show only one water quality violation for E. *coli* exceedances in the Huron Chain of Lakes Watershed during one day in July 2004. On July 14, 2004, the Camp Innisfree beach on Bentley Lake in Putnam Township (Honey Creekshed) registered a one-time reading of 570 E. *coli* per 100 ml water. The next testing date of July 20 was, showed a reading of 53 E. *coli* per 100 ml water, well under the 300 *E. coli* per 100 ml trigger level. No other public beaches have reported closings or water quality violations in recent years. Several private beaches in the watershed also test for E. coli levels, but this data is not readily available to the public. Steering Committee members recalled instances of beach closings on Chilson Pond and Bishop lake due to elevated *E. coli* levels. However, no data was available to document these instances.

Temperature

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

An average summer temperature of about 72º F is the warmest water that will support coldwater fish, such as sculpin and trout. Fish that can survive in warmer waters up to 77º F include smallmouth bass, rockbass, sunfish, carp, catfish, suckers, and mudminnows. Average summer temperatures above 77º F exclude many fish and cool water insects[26]. Fluctuations in temperature also affect biodiversity. Extreme fluctuation in summer temperature, as defined by a difference of more than 18º F between the average maximum and average minimum stream temperature, have been found to decrease fish diversity at warm sites.[27]

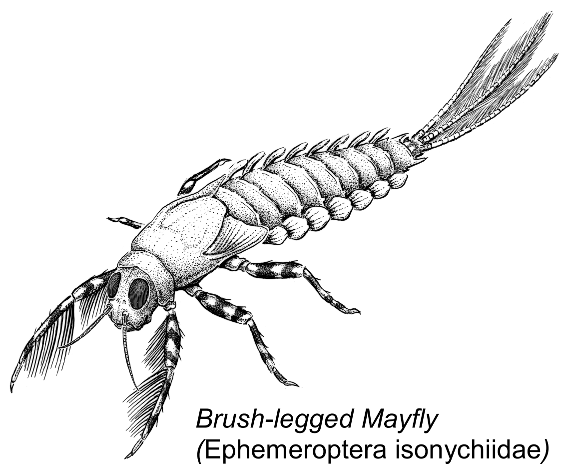
Thermal pollution, the discharge of heated water from industrial operations, dams, or stormwater runoff from hot pavement and other impervious surfaces often cause an increase in stream temperature. The Michigan Water Quality Standards specify that the Great Lakes and connecting waters and inland lakes shall not receive a heat load that increases the temperature of the receiving water more than 3º F above the existing natural water temperature (after mixing with the receiving water). Rivers, streams and impoundments shall not receive a heat load that increases the temperature of the receiving water more than 5º F for warmwater fisheries. These waters shall not receive a heat load that increases the temperature of the receiving water above monthly maximum temperatures (after mixing).[28]

2.3.2 Aquatic Biological Communities

Aquatic insects

Insects living in the creek compose the benthic macroinvertebrate (no backbone) population, along with clams and crayfish. Since the benthic population depends on the physical conditions of the stream as well as water quality, its composition indicates the overall stream quality. Insect diversity indicates good stream quality, and is measured by the number of different insect families. 87 benthic insect families are found in the Huron River Watershed.[29]

Much of the benthic macroinvertebrate data in this document is from Huron River Watershed Council's Adopt-A-Stream Program, which relies on trained volunteers to monitor more than 65 sites in the watershed, including 19 in the Huron Chain of Lakes Watershed (see Figure 2.5). Monitoring data has been gathered since as early as 1994 at some sites through annual spring and fall collection days, and a winter stonefly search each January. Not all sites have been monitored at each collection event, but all sites have been monitored at least once per year since monitoring began at the site.



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

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

Sensitive insect families, such as Perlidae (Perlid stonefly) and Brachycentridae (log-cabin caddisfly), are highly sensitive to organic pollution; 19 of the 87 benthic insect families living in the Huron River Watershed are sensitive.[30]

The presence of winter stoneflies, which are active in January and require high levels of oxygen, are indicators of good stream quality. Absence of winter stoneflies suggests that toxic pollutants may be present. This is because organic pollutants, such as fertilizer and human or animal waste, are associated with stormwater runoff in warmer months. Because there is usually little or no stormwater runoff in January, there is a greater likelihood that any pollutants in the stream are persistent (long-lasting) toxic substances are present in the bottom of the streambed. Conversely, at a site where insect diversity is lower than expected but winter stoneflies are present, organic pollutants are more likely to be the problem.

The Adopt-A-Stream Program also rates the “ecological conditions” at each site, which is determined by both the biological and physical conditions of the site. Biological conditions include the diversity of insect families, EPT families, and sensitive families. Physical conditions are determined by conductivity results and “measuring and mapping” assessments of habitat. These assessments involve examining characteristics such as the stream banks, stream widths and depths, and bed material (such as sand, gravel, or muck). When interpreting the biological and physical conditions, more diversity is generally expected at larger sites or sites with cooler summer stream temperatures.

Fish

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

No information is available on the pre-European settlement fish community in the Huron Chain of Lakes system. The headwaters and most tributaries of the Huron River had fairly stable flows. Summer water temperatures remained cool due to substantial water volumes, shaded banks, and local inflow of additional groundwater. Diverse habitats existed, including extensive gravel and cobble riffles, deep pools with cover, channel-side marshes, and flood plain wetlands. A 1938 survey of the headwaters and tributaries upstream of Ann Arbor found about 25 species.[32] Higher-gradient stretches with extensive gravel riffles and pools held mudminnow, hornyhead chub, silver shiner, rosyface shiner, common shiner, lake chubsucker, northern hog sucker, golden redhorse, black redhorse, yellow bullhead, stonecat, tadpole madtom, brindled madtom, longear sunfish, rock bass, smallmouth bass, rainbow darter, fantail darter, and greenside darter. Vegetation-dependant mud pickerel, northern pike, blackstripe topminnow, and least darter were also present. Most common in the faster flowing, low gradient stretches connecting natural lakes were white sucker, largemouth bass, bluegill, pumpkinseed, Johnny darter, logperch, and yellow perch. Neither muskellunge nor walleye were found in the 1938 survey. These may have been originally present but extirpated during early settlement.

In general, a 1977 study of fish communities in the upper Huron and four major tributaries (including Davis Creek) showed good diversity and indicated relatively healthy systems.[33] The species present indicated that fairly cool, clear water with some gravelly substrates persisted. However, two major fish groups had declined and many species dependant on clear and heavily vegetated water had disappeared or decreased in number. These species were often associated with natural lake outlets that have been replaced with lake-level control structures. Species that are dependant on clean gravel substrates had similarly declined sharply or disappeared, while species tolerating silt and sand substrates became more abundant during this time[34].

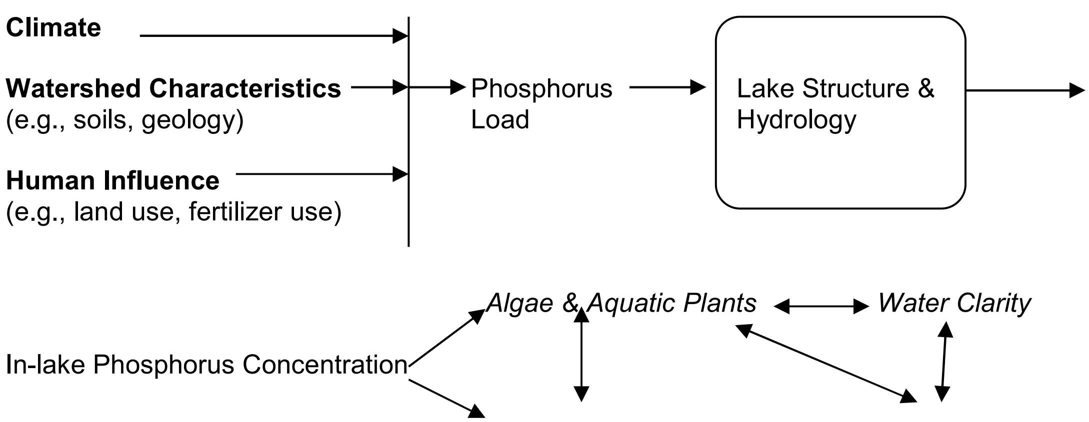
The Huron River and its tributaries in the Huron Chain of Lakes Watershed are considered warmwater fish habitat, mostly of second quality. Second quality warmwater feeder streams (tributaries of the mainstem of the Huron River) are those that contain significant populations of warmwater fish, but game fish populations are appreciably limited by such factors as pollution, competition, or inadequate natural reproduction. Small streams are often difficult to fish because of their small size; typically less than 15 feet wide.[35]

2.3.3 Lake Behavior (Limnology)

The presence of many lakes in the watershed makes a general review of lake behavior in response to nutrients useful when considering conditions of natural and manmade lakes in the watershed. Limnology is the physical, chemical, and biological science of freshwater systems, including lakes.

While numerous water quality parameters are studied to determine the trophic status and water quality status of lakes, in-lake phosphorus concentrations are often the determining factor. Trophic status is a useful means of assessing the water quality of a lake since it affects the productivity or growth of the system. While many factors influence the overall trophic status of a lake, the interaction of climate, watershed characteristics (e.g., soils), and human influences are the most dominant (Figure 2.17).

Figure 2.17: Illustrative Schematic of Phosphorus Load Determinants and Lake Response.[36]



Dissolved Oxygen ⟷ *Fish Population*

Ordinarily, a lake with concentrations of phosphorus less then .01 mg/L is often considered oligotrophic. A lake is considered mesotrophic at concentrations of .01 mg/L to .02 mg/L and eutrophic to hypereutrophic at or greater than .02 mg/L to .03 mg/L.[37] Oligotrophic and mesotrophic lakes normally support uses such as coldwater fisheries (e.g., trout, various species of bass) and numerous recreational activities. The water in these lakes is also often suitable for drinking water supply. Eutrophic lakes often support warm water fisheries (e.g., carp) and have limited recreational value compared to oligotrophic or mestrophic lakes because of periodic nuisance algal blooms. Hypereutrophic lakes, which experience frequent and intense nuisance algal blooms, do not ordinarily support cold or warm water fisheries and offer little or no recreational value. In addition, these lakes often exhibit decrease in open water surface areas because of layers of algal and aquatic plant masses.

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

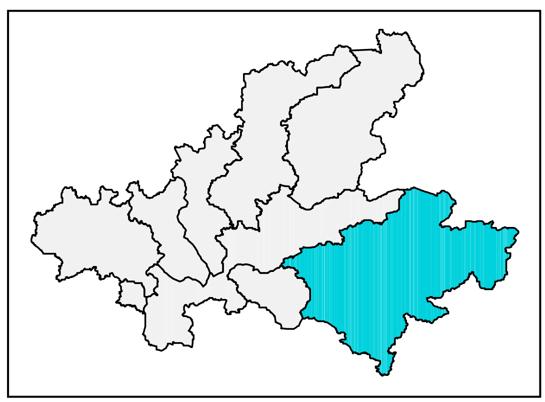
2.4 CREEKSHED REVIEWS

In order to gain a perspective on the past and present general water quality conditions in the watershed, efforts were made to compile and summarize relevant and readily available existing water quality data. This effort included, but was not limited to acquisition of studies conducted by state researchers, as well as requests to Workgroup members and researchers in the area. A visual assessment survey of water quality conditions at road stream crossings was also conducted.

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

This Watershed Management Plan focuses on the sources and distribution patterns of nonpoint source pollution throughout the watershed. Therefore, rather than attempting to present data on the many lakes throughout the watershed, emphasis was placed on water quality conditions in the Huron River, its major tributaries, and directly connected major lakes and impoundments. In addition, the large number of lakes and their widely varying characteristics and conditions make a meaningful analysis of lakes within the watershed impractical for the scope and purpose of this document. Because the large size of the watershed, an effort was made to categorize the analysis based on drainage areas in the watershed. Eight hydrologically distinct drainage areas, or creeksheds, were delineated and their water quality summaries are reviewed below.

2.4.1 Davis Creek



At 43,557 acres (68 mi.^{2}) Davis Creek is the largest creekshed in the Huron Chain of Lakes Watershed. Davis Creek, a second order stream, and a group of connected tributary creeks and drains flow west from Novi and Lyon townships in Oakland County, and northwest from Northfield and Salem Townships in Washtenaw County into Sandy Bottom Lake in Green Oak Township. From Sandy Bottom Lake, Davis Creek continues on to its confluence with the Huron River just east of Highway 23. This segment of the creek is one of only three tributaries of the Huron River that holds special status as a state Natural River Zone.

Davis Creek is a considered one of the highest quality streams in the Huron River Watershed, and it's gentle slope of 6 feet per mile provide for excellent canoeing on the lower stretches, where sensitive species of fish, mussels, and aquatic insects are present. The lower reaches are mostly run (low gradient) habitat with no pools and bottom substrate is composed largely of sand and gravel[38]. However, much of this large creek lies in the rapidly developing areas of South Lyon and Lyon and Green Oak Townships. Some parts of the creek are deteriorating, and one branch – Yerkes Drain – suffers from a chronic history of pollution.

The Davis Creek area consists primarily of outwash sand/gravel mix and postglacial alluvium with pockets of medium-textured end-moraine and glacial tills. These soils generally provide moderate to slow permeability, especially in the south and eastern portions of the creekshed, and the area generally lacks significant groundwater recharge. Housing development has been rapid in the past 25 years and has been accelerating since the 1990s, especially in the suburbs of South Lyon and along the lakes and branches of Davis Creek.

Water Quality Data

Much of the water quality data in Davis Creek has been collected in response to a history of problems associated with Yerkes Drain and Limekiln Lake. Yerkes Drain provides drainage for the South Lyon area and flows due west where it empties into Nichwagh Lake, which in turn, empties into Limekiln Lake and Sandy Bottom Lake.

Yerkes Drain has suffered through several episodes of pollution and its flow is substantially augmented by effluent discharges from the South Lyon Wastewater Treatment Plant and a metal fabricating plant (formerly Michigan Seamless Tube, then Quantex, now Vision Metals, Inc.). During a 1970s oil spill at Michigan Seamless Tube, fuel oil seeped both into and under Yerkes Drain, surrounding it on both sides. While much contaminated soil was excavated, the oil was never totally removed and it continued to spread for years afterward. As recently as 2003 oil could still be seen oozing from the bottom of portions of the Drain when walking in the channel.[39]

The flow of Yerkes Drain is substantially augmented by discharges from these two point sources. Between April 2002 and April 2003, flow upstream from these two point sources averaged .5 cfs, while flow downstream from these point sources averaged 2.6 cfs. Monitoring data of the total point source flows for this same period demonstrate that this flow increase can be attributed to effluent discharges from the point sources.[40] Despite the significant effluent inputs from these point sources, a 1985 study by MDEQ classified the segment of Yerkes drain from Dixboro Road (downstream of the South Lyon WWPT) to Nichwagh Lake as having "moderate use potential." This classification qualified Yerkes Drain as a warmwater stream, making it subject to State water quality standards established to protect its designated use as a warmwater stream.[41]

A 1992 chronic toxicity test of Yerkes Drain indicated that fathead minnow survival was significantly reduced at a testing station located immediately downstream from the South Lyon WWPT, and daphnia (water fleas) reproduction was significantly reduced immediately downstream from Vision Metals. However, the toxicity was not explained by a limited chemical analysis.[42]

A TMDL for water quality standard exceedences for dissolved oxygen is required to be established by 2013 for the .7 mile stretch of Yerkes Drain from Dixboro Road to Nichwagh Lake. Studies conducted from July 31 to August 5, 1998 show that D.O was below water quality standards for warmwater streams every morning. The lowest reading was 3.02 mg/L, with 35% of all 290 data points below 5 mg/L[43]

As previously mentioned, Limekiln Lake is located downstream of Nichwagh Lake, which receives water from Yerkes Drain. Limekiln Lake is currently meeting designated uses. However, it was listed in 1998 as threatened on the Michigan 303(d) list of waterbodies requiring TMDL development in 2004. The primary issue identified as threatening the lake was phosphorus enrichment due to the significant increased development pressure in the Huron River Watershed and the accompanying requests for new and increased discharges of phosphorus from point source discharges.[44]

Limekiln Lake experienced periodic fish kills and nuisance algae blooms in the late 1970s, and was subsequently classified as a eutrophic lake in which phosphorus was identified as the most appropriate nutrient for controlling algae growth.[45] A fish kill in 1977 was attributed to the lowering of the Nichwagh Lake level. Sediments were released when the outlet was opened, which were carried into Limekiln Lake. These sediments released un-ionized ammonia, which stressed the fish. Sediment deposits also covered Limekiln Lake's sandy swimming area and the stream bottom between Nichwagh and Limekiln Lake.[46]

Limekiln experienced another fish kill in early June, 1978. This kill was most likely caused by oxygen depletion associated with a blue-green algae bloom. Total phosphorus levels were measured at .08 mg/L.[47] Data collected in 1980 found total phosphorus concentrations in the lake of .052 mg/L.[48] The most recent algal bloom occurred in November 1998, theorized to be associated with a nutrient flux associated with fall turnover and unusually warm weather. This event was considered an isolated incident, since no other dense algal blooms were reported in the few years prior to 1998 or have been since.[49]

Total phosphorus concentrations remained relatively stable between 1981 and 1999. Phosphorus concentrations in 1981 were estimated at .036 mg/L. Additional data collected in 1994 and 1998 showed phosphorus concentrations at .039 mg/L, and .036 mg/L in 1999. Summer oxygen and temperature data for these years showed distinct temperature stratification in the water column, with little oxygen in the deeper, cooler layers and higher nutrient concentrations along the bottom sediments, which is commonly found in eutrophic lakes. [50]

The total phosphorus load to Limekiln Lake from April 1998 to March 1999 was calculated to be 5,618 pounds. Of that load 475 pounds (8%) was from the South Lyon WWTP (307 pounds) and Vision Metals (168 pounds) discharging into Yerkes drain upstream of Nichwagh Lake. (The sum of the phosphorus loads from these two point sources also represents 40% of the annual phosphorus loading in Yerkes Drain). Thirty-one homes with septic systems contributed an estimated 31 pounds (1%) to Limekiln Lake. The remaining 5,112 pounds (91%) was from upstream nonpoint source contributions in the Davis Creekshed.[51]

A nutrient monitoring study was conducted in the Davis Creekshed from April 2003 through March 2003 to estimate nutrient load estimates for the Limekiln Lake TMDL development process[52]. Ten stations were monitored on 25 different days throughout the creekshed, including Davis Creek, Yerkes Drain, and several points along the series of lakes between Nichwagh and Sandy Bottom Lakes. Concentrations and loadings of several nutrient parameters, including total phosphorus and total nitrogen (nitrate +

nitrite) were estimated. Total Suspended Solids concentrations and loads were also estimated.

For all parameters, the greatest concentrations were found in the Yerkes Drain station at Dixboro Road downstream from the two major point sources. Phosphorus concentrations ranged from below the detection limit of .004 mg/L to 1.1 mg/L at all sampling stations. Yerkes Drain at Dixboro Road had the highest average phosphorus concentration of .29 mg/L, compared to an overall average of .073 mg/L for all stations[53]. Phosphorus concentrations in Limekiln Lake were estimated in 2002 and 2003 at .034 mg/L and .032 mg/L respectively[54]. This lead the MDEQ to conclude in 2004 that nutrient-related conditions have continually improved and that the lake was meeting state Water Quality Standards. Limekiln Lake was subsequently removed from the Michigan 303(d) list, but phosphorus waste load allocations are still in place for NPDES permitted facilities in Limekiln Lake's drainage areas. This is because the drainage area of Limekiln Lake is part of the larger Strawberry Lake drainage area, which remains under a TMDL for phosphorus.

Total nitrogen concentrations for all stations ranged from below the detection limit to 9.7 mg/L. Yerkes Drain at Dixboro Road had the highest average total nitrogen concentration of 4.6 mg/L, compared to an overall average of .89 mg/L for all stations. TSS concentrations ranged from below the detection limit of 4 mg/L to 200 mg/L at all sampling stations. Yerkes Drain at Dixboro Road had the highest average TSS concentrations of 27 mg/L, compared to an overall average of 11 mg/L.[55]

As with concentration levels, the greatest net loadings for all parameters occurred at Yerkes Drain at Dixboro Road. For total phosphorus, total nitrogen and TSS, net annual loads declined with distance downstream through the series of lakes[56], indicating that the lakes are retaining these nutrients and suspended solids. Residents and volunteers with the Huron River Watershed council have noted that the segment of Davis Creek between Rushton Road and Doane Road (upstream of Crooked Lake) is often muddy brown in color, particularly after rain events[57]. Deposits of sand, clay, slit, and muck cover much of the creek near Doane Road[58].

Since the mid 1990s, the Huron River Watershed Council's Adopt-a-Stream volunteer monitoring program has gathered data at four sites along Davis Creek: Rushton Road (between Nichwagh and Limekiln Lakes), Pontiac Trail (on the north branch of Davis Creek in Lyon Township), Doane Road (downstream of the Pontiac trail site), and Sliver Lake Road (just upstream of Davis Creek's confluence with the Huron River). Using data collected up until 2003, average conductivity at all four sites was over 800 µS, indicating possible toxins and a need for further research. Average conductivity at Pontiac Rd. was 862 µS (n=12). Average conductivity at Doane Rd was 877 µS (n=11). The highest average conductivity was at Rushton Rd at 1356 µS (n=10). Davis Creek at Silver Lake Rd. was 899 (n=12).[59]

Average summer temperatures were relatively cold at Pontiac Trail (66º F) and Doane Rd. (65º F) with moderate average monthly fluctuations of 11º F. Rushton Road was significantly warmer, averaging 77º F with a monthly fluctuation of 9º F, making it the only warm water study site the Huron Chain of Lakes Watershed. The Sliver Lake site averaged 73º F with a slightly higher monthly fluctuation of 14º F.[60]

Biological Communities

Much of Davis Creek offers a good variety of habitat to aquatic animals. The creek meanders through the shade of woodlands. The trees and shrubs that line the bank resist erosion during strong storm flows. Some areas of the stream are slow, forming deep pools, while other portions flow quickly, offering shallow riffles. This mixture of stream depths and velocities provides habitat for animals that require the high oxygen of a riffle, as well as those that require the slow refuge of a pool. Undercut branches and fallen trees and branches offer shelter for fish, crayfish, aquatic insects, mussels, and other aquatic animals.

Table 2.6 shows biological monitoring data by the Huron River Watershed Council through 2003 at the four Davis Creek sites. Data represents 6-8 collections between 1998 and 2003. Aquatic insects living in the stream show that the north branch and the downstream portion of the creek have much higher quality than the areas near Nichwagh Lake on the creek's south branch.

Table 2.6. Ecological Conditions and Aquatic Insect Families at HRWC Adopt-A-Stream Program Monitoring Sites in the Davis Creekshed[61]

Study Site	Ecological Conditions*	Population Diversity	Avg. Insect Families	Avg. EPT Families	Avg. Sensitive Families	Winter Stonefly
Pontiac Trail	Acceptable	Stable	13	5	2	Present all 6 years
Doane Road	Acceptable	Declining	12	5	1	Present all 5 years
Rushton Road	Poor	Stable	6	2	0	Absent all 5 years
Silver Lake Road	Exceptional	Stable	18	7	2	Present all 4 years

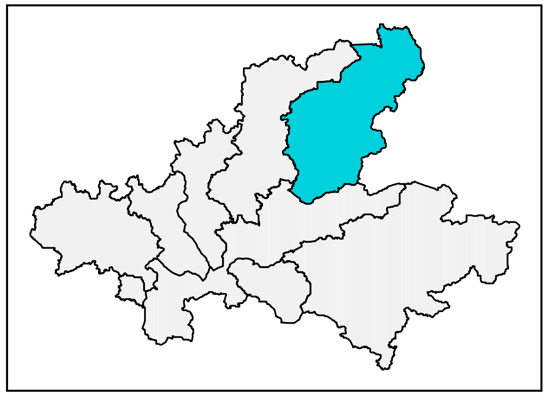
** categories: exceptional, acceptable, good, and poor*

Between 1998 and 2003, eight different sensitive families were identified at the Silver Lake Road site (average of 2 per year). Seven different sensitive families were recorded at Pontiac Trail (average of 2 per year), and five were recorded at Doane Rd. (average of 1 per year). At the Rushton site, there was one sensitive family in 1998 and one in 1999, but none in the six collections since then.

The trend in population diversity over the years sampled is stable at all sites except at Doane Road, which is declining. Stoneflies have been found during each collection event in all sites except at Rushton Rd., where their repeated absence is indicative of the poor ecological quality and suggests that toxic pollutants may be present. Ecological conditions ratings, which range from "poor" at Rushton Road to "exceptional" at Silver Lake Road, are determined by the biological and physical conditions of the site. Biological conditions include the diversity of insect families, EPT families, and sensitive families. Physical conditions are determined by conductivity results and measuring and mapping assessments of habitat, such as characteristics of stream banks, stream widths, and material (such as sand or gravel).

A 1992 biological survey by MDEQ of the north branch of Davis Creek at Dixboro Road (on the border between Livingston and Oakland Counties) found that the fish community rated as fair, the macroinvertebrate community rated as good, the overall biotic community rated as fair, and habitat was rated excellent. Results for Davis Creek at Silver Lake Road showed the fish community rated as excellent, while the macroinvertebrate, overall biotic, and habitat were all rated “good”.[62]

2.4.2 Woodruff Creek



The Woodruff Creekshed drains 41 square miles (26,485 acres) of the Huron Chain of Lakes Watershed. Woodruff Creek drains the western portion of the creekshed, beginning in northern Brighton Township and flowing south into Green Oak Township where it joins the Huron River approximately one mile downstream of the Kent Lake dam.

The eastern portion of the creekshed is drained by Mann Creek, whose headwaters drain an area around the intersection of Milford, Highland, Hartland, and Brighton Townships. Mann Creek flows southwest until it joins Woodruff Creek in south-central Brighton Township.

A significant portion of the watershed, in northeast Brighton Township and Milford Township, is occupied by the General Motors Milford Proving Grounds, one of three major NPDES holders in the watershed. The facility discharges process water and assorted wastewaters to Mann Creek. The Brighton Township Waste Water Treatment Plant discharges to Woodruff Creek.

Both Woodruff and Mann Creeks (alternately referred to as Woodruff-Mann Creek) are second quality warmwater fish habitat streams. The dominant channel type in Mann creek is run (low gradient) habitat. Woodruff Creek is comprised of riffles and fast run habitat with no pools. Bottom substrate of both creeks is primarily gravel and sand.[63]

Water Quality Data

Little water quality data was found for either creeks. However, between March and September of 1992, MDEQ conducted studies of Mann Creek at Spencer Road (STORET ID #470462) in Brighton Township, downstream from the General Motors Proving Grounds and just upstream of Mann Creek’s confluence with Woodruff Creek. Total phosphorus (n=8) ranged from .016 mg/L to .056 mg/L with a mean of .038 mg/L. Total nitrogen (N=8) ranged from .152 mg/L to .4 mg/L with a mean of .246 mg/L. Conductivity (n=8) were high, ranging from 971 µS to 1340 µS with a mean of 1158 µS,[64] indicating the possible presence of toxic pollutants in the stream.

Conductivity readings gathered between 1995 and 2003 by the Huron River Watershed Council’s Adopt-A-Stream program at VanAmburg Road on Mann Creek (just downstream from the Spencer Rd. site) were also high, ranging from 1092 µS to 1670 µS with an average of 1436 µS (n=11). Conductivity measurements during the same time period near the headwaters of Woodruff Creek at Maxfield Rd. were much lower, ranging from 378 µS to 705 µS with an average of 599 µS (n=10). Conductivity was also measured at Buno Road on Woodruff Creek, just downstream from where the creek passes under Interstate 23. Average conductivity at the site was slightly excessive at 815 µS (n=9) ranging from 644 µS to 936 µS.[65]

Average summer temperature at the VanAmburg site was 74º F with a relatively low monthly fluctuation of 5º F.[66] The headwaters area at Maxfield Rd. was quite cold, averaging 64º F, but average monthly temperature fluctuation was 16º F. The Buno Road site was considerably warmer, averaging 74º F with a fluctuation of 12º F.[67]

Water quality of several lakes in the creekshed has been monitored by Dr. Wallace Fusilier. Reports on water quality studies conducted between 1994 and 2004 for School Lake , Pickerel Lake, and Lake of the Pines indicate generally good water quality. Conductivity tends to be gradually rising, but is still within acceptable limits. Dissolved Oxygen levels are generally near saturation, and phosphorus and nitrogen concentrations are acceptable. Overall water quality indices for these three lakes remains fairly stable and favorable over the years, ranging from the upper 80s to low 90s.[68, 69, and 70] Relevant data on other lakes in the creekshed was not readily available, and the data collected at these three lakes are not necessarily indiciative of other lake conditions in the creekshed.

Biological Communities

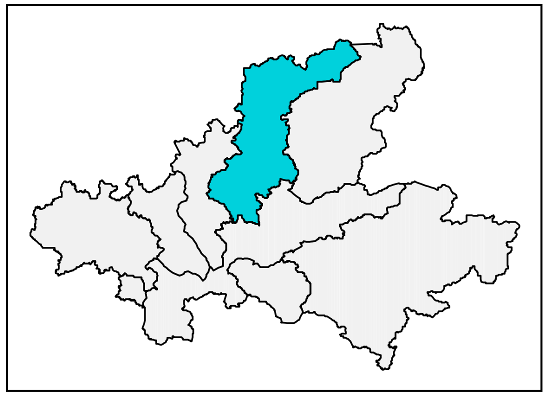
Table 2.7 shows biological monitoring data collected through 2003 by the Huron River Watershed Council's Adopt-A-Stream Program at the three sites in the creekshed. Data have been collected at these sites once or twice a year since monitoring began. The Mann Creek site at VanAmburg Road is located just upstream of Mann Creek's confluence with Woodruff Creek and shows overall good ecological quality and a strong representation of insect families, including EPT and sensitive families and consistent presence of winter stoneflies.

Table 2.7. Ecological Conditions and Aquatic Insect Families at HRWC Adopt-A-Stream Program Monitoring Sites at Woodruff Creek and Mann Creek[71]

Study Site	First Year Monitored	Ecological Condition*	Population Diversity	Avg. # Insect Families	Avg. # EPT Families	Avg. # Sensitive Families	Winter Stonefly
Mann Cr. At VanAmburg	1995	Good	Stable	13	6	3	Present all 5 years
Woodruff at Maxfield	1996	Good	Stable	12	4	1	Absent 4 of 5 years
Woodruff at Buno	2000	Acceptable	Stable	14	6	1	Absent 2 of 3 years

The data for Woodruff Creek at Maxfield Road in the creek's headwaters area also show good overall ecological conditions, but insect diversity is lower than at the Mann Creek site and winter stoneflies are generally absent. Given the cold temperatures and low conductivity at the site, the general absence of winter stoneflies at this site is unexplained. Possible concern for upstream pollution has been reported by nearby property owners, although no further investigations have been conducted[72]. Ecological conditions downstream at the Buno Road site are acceptable, with slightly better insect diversity than the headwaters area.

2.4.3 South Ore Creek



This 34 square mile (21,544 acres) creekshed extends from the headwaters of South Ore Creek in southern Hartland Township downstream to Ore Lake in eastern Hamburg Township. The creekshed comprises portions of Hartland, Oceola, Genoa, Brighton, and Hamburg Townships and all of the City of Brighton. Land use in the South Ore Creekshed ranges from heavily commercial and residential settings in the south to small rural farms and housing in the north. The Nature Conservancy has deemed the exceptional value of a portion of this creekshed an "Aquatic Priority."

From its headwaters northeast of Maxfield Lake to Brighton Lake, South Ore Creek is a narrow channel of mostly low-gradient run habitat and silty substrates. Substrate consists mostly of sand, gravel and rubble substrates. Fish cover, in parts, is sparse and the stream has very few pools or riffles. Portions of the creek exhibit the narrowing effects of historical flow alteration (e.g., dredging) while other areas show widening effects due to fluctuating flow or sedimentation.[73]

The geomorphology and habitat of the South Ore Creek appears fairly stable. However, slight evidence of erratic flows, undercut and eroding streambanks, and sedimentation was observed. Such observations were particularly evident in the portion of the creek between the Mill Pond in the City of Brighton and Brighton Lake[74].

Water Quality Data

Analysis of readily available water quality data in the South Ore Creekshed is organized according to three major features of the creekshed: South Ore Creek; Brighton Lake; and the major impoundments of Long Lake and Woodland Lake. Much of the South Ore Creekshed data presented in this section was derived from the Brighton Lake Subwatershed Management Plan[75], which was developed by the Huron River Watershed Council and approved by MDEQ in 2002 as a watershed management plan to meet the phosphorus TMDL for Brighton Lake. A more detailed account of the major characteristics, water quality conditions, and management recommendations for the South Ore Creekshed may be found in this document.

South Ore Creek
The water quality of South Ore Creek greatly impacts the integrity of its lakes and impoundments. Much of the water quality data on the creek is focused on phosphorus loading due to the Phosphorus TMDL for Brighton Lake. According to MDEQ data reported to the U.S Environmental Protection Agency Storage and Retrieval Water Quality Database (STORET)[76], the total phosphorus concentrations for South Ore Creek in Brighton Township from 1977-78 at Interstate 96 ranged from .009 to .046 mg/L (n=12), with a mean of .028 mg/L. The average flow for this period was not reported for the 1977-78 period; therefore, loading estimates are not feasible. However, a sampling station of South Ore Creek at North Street in the City of Brighton and performed by the

MDNR with reported values in 1977-78, indicates an annual total phosphorus load of 584 lbs/yr.[77]

At the mouth of South Ore Creek entering Brighton Lake, a 1975 USEPA study established a total phosphorus load of approximately 700 pounds per year (lbs/yr),[78] all of which was from nonpoint source loading. A more recent MDEQ loading study for the creekshed determined the monthly phosphorus load for the same site to be approximately 1,070 lbs/yr, again all attributed to nonpoint sources[79].

Readily identifiable and available total nitrogen measurements were limited for South Ore Creek. The 1975 USEPA study found a total nitrogen load of 25,950 lbs/yr, all of which is attributed to nonpoint sources. No other relevant total nitrogen data for the creek was obtained.

STORET data for the creek indicate dissolved oxygen levels averaged near saturation for the 1977-78 sampling stations.

Suspended sediment and other water quality indicator data either were not collected, not reported, or not readily available.

Brighton Lake

Water quality data for Brighton Lake is significant in the South Ore Creekshed and the Huron Chain of Lakes Watershed because of the TMDL established for the lake in 2000. In April of 1998, a 12-month phosphorus loading analysis was initiated by the MDEQ to investigate the water quality of Brighton Lake and its upstream sources. The analysis showed that despite greatly improved water quality in the lake as a result of upgrading and relocating the Brighton Wastewater Treatment Plant (WWTP) downstream from Brighton Lake in 1988, Brighton Lake still threatened to fail to meet water quality standards due to phosphorus enrichment. Based on water quality sampling and accepted mathematical models, a phosphorus TMDL of .03 mg/L for Brighton Lake was established. Based on three years of scheduled monitoring, the TMDL estimates that the current annual phosphorus load is 973 pounds/year, all of which is from nonpoint sources. Therefore, MDEQ prescribes a 10% reduction (approximately100 pounds/year) of nonpoint source phosphorus loading to the lake to meet the TMDL. See Appendix A for the federally approved Brighton Lake TMDL.

Brighton Lake's immediate drainage area, which is the land area that contributes water directly to the lake, is estimated at 1.32 square miles (844 acres). The lake has an average depth of approximately 2 meters, a maximum depth of 6.1 meters, and a hydraulic residence time of 40 days or 0.11 years.[80]

Michigan State University conducted water quality studies in several locations in Brighton Lake during the summers of 1970 and 1971. During October 1970 sampling, investigators observed instances of total fecal coliform exceeding 11,300 counts per 100 ml of water in some locations of the lake,[81] well in excess of state standards of 300 *E. coli* per 100 ml water for full body contact or 1000 *E. coli* per 100 ml water for partial body contact. However, other study points in the lake during April and July of 1971, showed lower but still potentially problematic average count concentrations for total fecal coliform.

Water chemistry samples taken in October 1970 and April 1971 yield contradictory information. Ortho-phosphate, often considered the most biologically available form of total phosphate, concentrations for the two sampling events ranged from 0 to 1 mg/L (n=12) with a mean of .223 mg/L. Nitrate concentrations ranged from 0 to .129 mg/L (n=12) during the study period and a mean of .013 mg/L.[82]

As part of the National Eutrophication Survey, in 1975 the U.S. EPA, with the cooperation of the Michigan DNR and the Michigan National Guard, performed a water quality assessment of Brighton Lake. The study concluded that the lake was eutrophic. The authors noted that algae blooms were reported to have been frequent and intense for the lake. Of particular note, results indicated that nitrogen was the limiting nutrient in June and September 1975 while phosphorus was limiting in November of 1975. This was attributed to the Brighton WWTP discharge, which now releases below Brighton Lake.

Determination of total loads and load source from this study indicated that 1,280 lbs/yr (59%) of the phosphorus load to Brighton Lake was from the WWTP. Nonpoint source loads comprised approximately 720 lbs/yr (34%) of the total phosphorus load, while septic systems, immediate drainage area, and precipitation contributed the remaining for a total yearly phosphorus load of 2,150 lbs/yr. The mean total phosphorus concentration for the period of study was found to be .11 mg/L.[83]

The USEPA determined that the total load of nitrogen to the lake in 1971 was 53,140 lbs/yr. Load sources for nitrogen were found to be dominated by nonpoint sources with a load of 25,950 lbs/yr (48%). The Brighton WWTP was determined to contribute 18,590 lbs/yr (34%) of the total. Septic systems, immediate drainage area, and precipitation contributed the remaining nitrogen load.[84]

A 1978 water quality study of Brighton Lake by MDNR concluded the lake was in very poor condition, primarily due to the WWTP discharge. The researchers noted frequent and intense algae blooms, persistent anaerobic conditions (lack of oxygen), failure to meet state standards for total fecal coliform, and moderately contaminated sediments. During May 1977 and April 1978, MDNR determined the nonpoint source load to the lake to be 584 lbs/yr (19%), which is less than the 1975 USEPA conclusion. Loading from the WWTP was determined to be 2336 lbs/yr (76%) with remaining from septic systems, immediate drainage area, and precipitation. This represents a phosphorus concentration of .126 mg/L.[85]

The MDNR report suggests that increased regulation and improvement to the WWTP would reduce nutrient loading to Brighton Lake. The magnitude of this reduction, the authors contended, will allow phosphorus to become the limiting nutrient and reduce algae bloom frequency. However, given that the lake is shallow, reintroduction of phosphorus bound in lake sediments could impact the lake water quality for an extended period of time. As noted earlier, the WWTP point source was removed from discharge to the lake in the late 1970s and has resulted in no authorized point source activity discharging to the lake.

A major conclusion of a 1978 SEMCOG survey, which investigated several water quality indicative biological and chemical parameters, determined Brighton Lake to have the worst overall water quality of 78 lakes sampled in southeast Michigan. In the SEMCOG study, Brighton Lake had the highest concentrations of total phosphorus, ammonia, second highest concentration of total nitrogen, and the lowest average Secchi depth of all the lakes studied.[86]

From April 1998 to April 1999, the MDEQ Great Lakes and Environmental Assessment Section (GLEAS) conducted a phosphorus loading and lake quality analysis of Brighton Lake. With an average annual total phosphorus concentration in 1998 of .029mg/L and .039 mg/L in 1999 Brighton Lake shows vast improvement from 1970s levels.[87] During the period of study, the average annual phosphorus load to Brighton Lake was 1,070 lbs/yr, all of which is attributed to nonpoint source loading from South Ore Creek, surface runoff from the immediate drainage area (land area surrounding the lake), and precipitation. Approximately 96% of the total phosphorus load to the lake can be attributed to pollution from nonpoint sources entering South Ore Creek upstream of the lake.

Long Lake and Woodland Lake
Long Lake is 171 acres with a maximum depth of 75 feet, a mean depth of just over 48 feet, and a hydraulic residence time of 3.4 years. The drainage area of the lake, including the lake itself, is 3035 acres.[88] Little relevant information regarding the historical water quality of Long Lake was found. Nonetheless, a limited bacteriological analysis of the lake in 1971 by Michigan State University found total fecal coliform ranges from 0 to 16 counts per 100 milliliters,[89] well within state standards. In addition, the Michigan Department of Natural Resources reported that from 1974-76, Long Lake was classified as mesotrophic.

Studies of the Long Lake performed by Dr. Wallace Fusilier between 1994 and 2003 show an average total phosphorus concentration of .015 mg/L with a range of .003 to .037 mg/L (n=54) and an average nitrate concentration of 13 with a range of 3 to 34 μg/L (excluding an unexplained outlier sample of 32.36 mg/L.). Secchi depths hovered around 10 feet during the period of study and routinely the DO level of Long Lake was near saturation. Conductivity readings ranged from a 340 μS to 430 μS.

A unique aspect to Dr. Fusilier's methodology of assessing lake water quality is the assignment of "grade" based the results of parameter analysis and known lake characteristics such as hydraulic residence time. On average, Long Lake was determined by Dr. Fusilier to be fairly stable and have a grade of "B" or above average.[90]

Woodland Lake is a 309-acre impoundment to South Ore Creek in Brighton Township. The immediate land surrounding the lake has been dominated by residential development beginning in the 1940s and intensifying in subsequent years. The lake exhibits an average depth of around 7.6 feet and a maximum of approximately 38 feet.[91]

Several studies outlining various attributes of the water quality status of Woodland Lake were found. The Michigan Water Resources Commission (MWRC) performed the earliest study found in 1965.[92] The study found phosphorus concentrations averaging around .2 mg/L and nitrogen concentrations around .8 mg/L, indicating possible hypereutrophic status. Total suspended solids in the lake were found to be approximately 6 to 8 mg/L in concentration. Analysis by MSU in 1971[93] revealed an average phosphorus concentration, of .162 mg/L (n=5), confirming the range of phosphorus concentrations found in 1965. Average nitrogen concentrations, in the form of nitrate, were found to be .3 mg/L.

During a 1977 water quality study of inland lakes in Southeast Michigan, SEMCOG found an average phosphorus concentration of .5 mg/L, .6 mg/L of total nitrogen, and a Secchi depth of 5 feet[94]. Of particular note, the report indicates that swimmer's itch, a condition caused by blood fluke (trematode) larvae in which larva bore into the skin causing irritation, had occurred at Woodland Lake. The larvae of swimmer's itch are found naturally in most lake systems. However, when growth conditions are enhanced via anthropogenic (human induced) pollution or natural means, outbreaks can occur.

Dr. Wallace Fusilier for Brighton Township performed numerous studies assessing Woodland Lake. For the periods of study from 1994 to 2004, annual average total phosphorus concentrations ranged from .023 mg/L in 1999 and 2003 to .046 mg/L in 2004. Annual average concentrations of Nitrogen as nitrate ranged from .009 mg/L in 1996 to .16 mg/L in 2000. Secchi depths hovered around six feet during the period of study and routinely the DO level of the lake was near saturation. On average, Woodland Lake was determined by Dr. Fusilier to have a grade of "B" or above average. However, on several occasions the lake did receive both "D" and "E" grades, below average and failing, respectfully[95].

A Fish Consumption Advisory has been issued by MDEQ for Polychlorinated Biphenyls (PCBs) in Woodland Lake, and a TMDL for PCBs is scheduled for development in 2010. PCBs are a synthetic, organic chemical once widely used in electrical equipment and other industrial products. PCBs have been shown to cause cancer in animals, as well as a number of serious non-cancer health effects in animals, including effects on the immune system, reproductive system, nervous system, endocrine system and other health effects. Studies of PCBs in humans provide supportive evidence for potential carcinogenic and non-carcinogenic effects.[96]

The Michigan Department of Community Health (MDCH) advises against eating more than one meal of fish per week when concentrations in more than 10% of fish samples from a particular species of fish of a given length exceed the trigger level. When 50% of fish samples exceed a trigger level, MDCH advises against eating any fish.[97] Different trigger levels are set for the general population and for women of childbearing age and children under age 15. Ten carp were collected from Woodland Lake in 2000. The median total PCB concentration in carp less than 22 inches was .009 mg/L and .046 in carp greater than 22 inches. Total PCB concentrations in one carp were .091 mg/L, which is above the trigger level of .05 mg/L set for women of childbearing age and children under age 15.[98] The Fish Consumption Advisory for Woodland Lake recommends that women of childbearing age and children under 15 should eat no more than one meal per week of carp over 26 inches.[99]

Biological Communities

Table 2.8 shows biological monitoring data collected through 2003 by the Huron River Watershed Council's Adopt-A-Stream Program at the three sites on South Ore Creek. Data have been collected at these sites once or twice a year since monitoring began.

Table 2.8. **Ecological Conditions and Aquatic Insect Families at HRWC Adopt-A-Stream Program Monitoring Sites on South Ore Creek[100]**

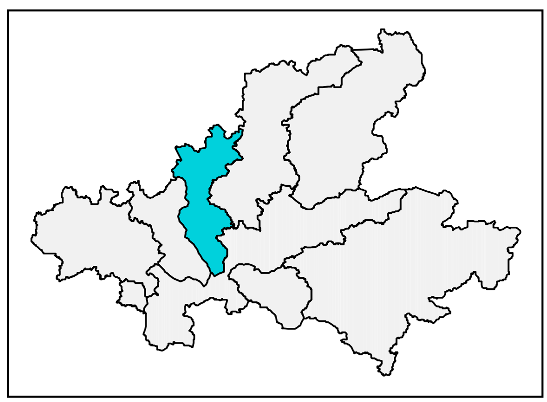
Study Site	First Year Monitored	Ecological Condition*	Population Diversity	Avg. # Insect Families	Avg. # EPT Families	Avg. # Sensitive Families	Winter Stonefly
Lake Ridge Road	1998	Poor	Stable	7	3	0	Absent all 4 years
Bauer Rd	1998	Acceptable	Stable	13	6	2	Present 3 of 4 years
Hamburg Road	1994	Good	Stable	15	6	2	Present all 6 years

** categories: exceptional, acceptable, good, and poor*

All sites are located on the creek between Brighton Lake and Ore Lake. The site at Lake Ridge Rd. is located just downstream of the Brighton Lake outlet and shows overall poor ecological quality and a general absence of sensitive families or winter stoneflies. The data for the Bauer Road site, which is downstream from the Lake Ridge site, indicate better overall water quality conditions, showing acceptable ecological conditions, significantly greater aquatic insect diversity, and the presence of stoneflies. The Hamburg Road site, downstream from Bauer Road, shows good ecological conditions and insect diversity that is similar to Bauer Road.

A 1992 biological survey by MDEQ of the north branch of South Ore Creek at Hamburg Road rated the fish, macroinvertebrate, and overall biotic communities as good, while habitat was rated excellent.[101]

2.4.4 Chilson Creekshed



The Chilson Creekshed encompasses approximately 17 square miles (10,868 acres) in Genoa and Hamburg Townships. The uppermost reaches of Chilson Creek are located in central Genoa Township. The creek flows south through the Chilson Pond impoundments on the Genoa/Hamburg Township border, and continues south where it drains into Oneida Lake, then Zukey Lake which is connected to Strawberry Lake and the Huron River.

Water Quality

Unfortunately, little data was found on chemical or physical parameters for Chilson Creek. A one–day sampling (n=3) of upper and lower Chilson Ponds collected by MDEQ in 1980 showed average total phosphorus levels of .018 mg/L (n=3); total nitrogen was very low, averaging .004 mg/L (n=3), and average conductivity was 400 µS.[102] Total phosphorus, as measured by volunteers with Michigan's Cooperative Lakes Monitoring Program (CLMP) in 2002, was .015 mg/L during the pond's spring turnover and .020 mg/L in the fall turnover, both indicative of mesotrophic conditions.[103]

Water quality data gathered by CLMP for Oneida Lake in 2002, which is fed by Chilson Creek, are also indicative of mesotrophic conditions. Spring and fall turnover phosphorus readings were .013 and .009 respectively. 2002 CLMP Secchi disk readings (n=14) of Oneida Lake also indicate mesotrophic conditions, ranging from 7 to 15 feet with an average of 11.7 feet.[104] Slightly lower Secchi disk readings were gathered at Zukey Lake, which is downstream of Oneida Lake and connected by Chilson Creek. Measurements ranged from 5 to 9 feet with an average of 7.1 feet (n=9), which is still indicative of mesotrophic conditions.[105]

According to the 2003 Lake Water Quality Assessment of Michigan's public access lakes, the trophic status of the three public access lakes in the Chilson Creekshed (East and West Crooked Lakes and Bishop Lake) were all assessed as mesotrophic.[106]

The creek is a designated County Drain, and the uppermost portions of the Creek, as well as a section above Oneida Lake, have been channelized and dredged. A 1984 interoffice memo from a MDNR fisheries biologist conveyed concerns for potential impacts on fish populations in Chilson Creek and Chilson Pond, from increased sedimentation during and following construction of a proposed golf course (now the Oak Point Golf Course). The memo also cited potential problems associated with increased nutrient loading from operating the golf course and filing in of wetlands that served as a nutrient filter to the Creek.[107]

Conductivity and temperature in Chilson Creek have been measured by the Huron River Watershed Council at crossings at Brighton Road, north of Chilson Ponds in Genoa Township, and at Chilson Road, directly west of Bishop Lake in Hamburg Township. Conductivity readings at the Brighton Road were within normal limits, ranging from 500 µS to 840 µS with an average of 688 µS (n=12). Summer temperatures at this site are cold, averaging 66º F, but monthly fluctuations were relatively high at 17º F. Conductivity at the Chilson Road site were also good, averaging 566 µS with a range of 433 µS to 771µS. Temperature was warmer than at the upstream Brighton Road site, averaging 70º F, but with lower monthly fluctuations of 10º F.[108]

Bishop Lake, a 19-acre kettle lake located in Brighton State Recreational Area, Hamburg Township, is under a fish consumption advisory for mercury. Mercury is a naturally occurring element that is found in air, water and soil. Coal-burning power plants are the largest human-caused source of mercury emissions to the air in the United States, accounting for about 40 percent of all domestic mercury emissions. Burning hazardous wastes, producing chlorine, breaking mercury products, and spilling mercury, as well as the improper treatment and disposal of products or wastes containing mercury, can also release it into the environment. Mercury in the air may settle into water bodies and affect water quality and ecosystems. Mercury accumulates in fish at levels that may harm the fish and animals that eat them. Effects of mercury exposure on wildlife can include death, reduced fertility, slower growth and development and abnormal behavior that affects survival, depending on the level of exposure.[109]

Samples of largemouth bass and northern pike collected in Bishop Lake by MDEQ staff in 1987 and 1989 detected average mercury concentration levels that exceeded .35 mg/kg. This concentration represents a numeric equivalent of 1.8 nanograms per liter (ng/L), the water quality standard for mercury in water that is protective of human health.[110] A TMDL is scheduled for 2010 to bring Bishop Lake into compliance with state water quality standards of 1.3 nanograms per liter.

Biological Communities

Chilson Creek provides second quality warm water fish habitat, but no data on fish populations was available. Ecological quality and insect diversity of Chilson Creek have been measured at Brighton Road and Chilson Road since 1998 through the Huron River Watershed Council's Adopt-A-Stream Program (Table 2.9).

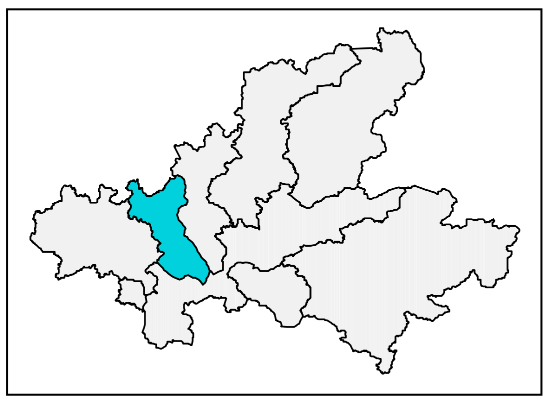
Table 2.9. Ecological Conditions and Aquatic Insect Families at HRWC Adopt-A-Stream Program Monitoring Sites in the Chilson Creekshed[111]

Study Site	First Year Monitored	Ecological Condition*	Population Diversity	Avg. # Insect Families	Avg. # EPT Families	Avg. # Sensitive Families	Winter Stonefly
Chilson at Brighton Rd	1998	Poor	Stable	10	5	0	Absent all 5 years
Chilson at Chilson Rd.	1995	Good	Stable	13	5	3	Present all 5 years

** categories: exceptional, acceptable, good, and poor*

Ecological conditions are generally rated as poor at the Brighton Road site, with a general absence of sensitive families and no records of winter stoneflies. Water quality indicators downstream at Chilson Road are better, with good overall ecological conditions, an average of three sensitive species per collection date and presence of winter stoneflies at all five annual collection events.

2.4.5 Hay Creekshed



Hay creek is a rural second quality warmwater stream that drains an area of 13 square miles (8,568 acres) in Marion, Genoa, Putnam, and Hamburg Townships. The stream flows unimpeded by dams or major lakes in a south/southeast direction through most of the creekshed until reaching Mohican and Bass Lakes in south Hamburg Township. After passing through the lake control structure at the outlet of Bass Lake, the creek flows into Gallager Lake, an impoundment of the Huron River.

Historic or current data for nutrients and other parameters of concern for this small creekshed were lacking, preventing even a basic assessment of water quality conditions in Hay Creek. However, samples of total phosphorus in two lakes in the creekshed were collected through the Cooperative Lakes Monitoring Program. Cordley Lake, a small kettle lake that drains to Hay Creek between Bass and Gallagher Lakes, had an average total phosphorus concentration in 1999 of .011 mg/L (n=2). Total phosphorus concentrations for Bass Lake taken in 2002 and 2003 averaged .008 mg/L (n=4).[112]

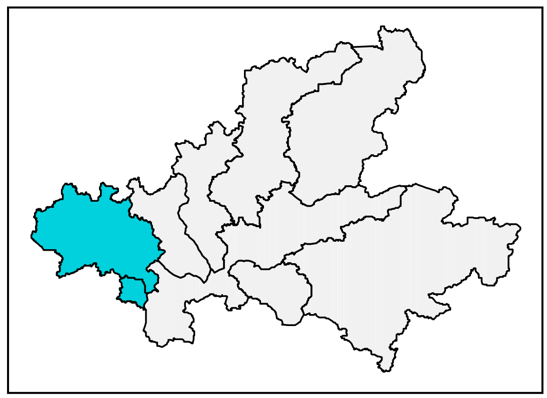
One site has been monitored since 1996 by the Huron River Watershed Council at M-36 Highway in Hamburg Township, which provides data on temperature and conductivity, ecological quality, and aquatic insect diversity. Temperature at the site averages 70º F with a significant monthly fluctuation of 20º F. Conductivity averages 539µS (n=12), ranging from 457µS to 600µS. Ecological conditions at this site are considered good (Table 2.10). An average of 13 insect families, including seven EPT families and two sensitive families, have been found at the spring and fall collection days. Winter stoneflies have been found during all four annual searches.[113]

Table 2.10. Ecological Conditions and Aquatic Insect Families at HRWC Adopt-A-Stream Program Monitoring Site in Hay Creekshed[114]

Study Site	First Year Monitored	Ecological Condition*	Population Diversity	Avg. # Insect Families	Avg. # EPT Families	Avg. # Sensitive Families	Winter Stonefly
Hay Cree k at M-36	1996	Good	Stable	13	7	2	Present all 4 years

** categories: exceptional, acceptable, good, and poor*

2.4.6 Honey and Portage Creeksheds



The Honey and Portage Creeksheds are reviewed together because only a small portion of the Portage Creek drainage area (about 2 square miles, or 1,338 acres) is considered part of the Huron Chain of Lakes for the purposes of this Plan.

The Honey Creekshed covers 27 square miles (17,416 acres) in the far western part of the Huron Chain of Lakes Watershed. Small parts of the creekshed are in Unadilla and Marion Townships, while the majority is located in Putnam Township. Honey Creek flows east/southeast through Pinckney before entering Portage Lake. Honey creek varies from a first order stream in the headwaters (which are channelized county drains) to a third order stream at Portage Lake. Past land use practices have resulted in sedimentation and agricultural runoff in the headwater areas.[115] Sections of Honey Creek near Pinckney were dredged by 1920. The creek is now characterized by low gradient flow habitat with no pools. Lower reaches have sand and gravel substrates and upper reaches have silty substrates.[116] As discussed below, a TMDL for poor macroinvertebrate communities is scheduled for development in 2007 for a 16 mile stretch of Honey Creek from the headwaters to the Mill Pond in Pinckney.

While Portage Creek (also called the Portage River) drains an area of 82 square miles west through Unadilla Township into Stockbridge Township in Ingham County, the small section of Portage Creek considered part of the Huron Chain of Lakes Watershed begins in Putnam Township approximately 2 miles upstream from the Creek’s outlet into Little Portage Lake in Dexter Township, Washtenaw County. Little Portage Lake drains to Portage Lake on the border between Washtenaw and Livingston Counties. Therefore, although only a very small portion of the Portage Creekshed is in the Huron Chain of Lakes study area, water quality and quantity in this area is certainly affected by the large upstream portion not included in this Plan. Habitat of Portage Creek is predominantly low gradient with sand and gravel substrate. Flow fluctuations due to the operation of lake-level control structures are a major problem.[117]

Water Quality Data

Relevant water quality data was lacking for both Honey Creek and Portage Creek. However, an MDEQ biological survey of five stations on Honey Creek was conducted in 1991 to qualitatively evaluate nonpoint source inputs and land use practices on the aquatic macroinvertebrate and fish communities.[118] While the report indicates that water samples were collected for chemical analyses, no data were presented in the report. However the report states that water chemistry results for nutrients indicated little difference between the upstream and downstream stations. Total phosphorus levels were not elevated. Data collected by the Huron River Watershed Council where the creek is crossed by Darwin Road (between the Mill Pond and the inlet to Portage Lake) show an average conductivity of 578µS (n=11) and an average summer temperature of 66º F with a monthly fluctuation of 24º F – the largest temperature fluctuation found at all monitoring sites in the Huron Chain of Lakes Watershed.

The Michigan Department of Natural Resources conducted an investigation of Portage Creek and Little Portage Lake in 1972 following complaints of accelerated aquatic weed growth in Portage Lake that extended into all areas of Little Portage Lake. No abnormal quantities of phosphorus or nitrogen in Portage Creek or Little Portage Lake were detected. The study concluded that nutrient and other water chemistry parameters were indicative of normal mesotrophic lake conditions and that the amount of weeds present was due to natural inputs of nutrients from the watershed and the nature of the lake basin rather than the result of recent human activities.[119] More recent water quality studies of Little Portage Lake by Dr. Wallace Fusilier between 1997 and 2003 show an overall relatively stable water quality index ranging from 70 to 93 out of a possible 100. Using Dr. Fusilier's rating scale, this corresponds to a water quality grade ranging from "C" to "A" for Little Portage Lake. Dr. Fusilier also concludes that water quality may be improving and that summer water quality is generally better than spring water quality in the lake.[120]

Biological Communities

MDEQ's 1991 biological survey of Honey Creek included a habitat evaluation with results ranging from excellent (non-impaired) on Putnam Drain (which drains Putnam Lake into Honey Creek) to "poor" (severely impaired) at the uppermost sampling station on Honey Creek above the Mill Pond in Pinckney. This station scored particularly low in the rating categories of bottom substrate, embeddedness, and bottom deposition; all of which suggest that excessive sediment from the upper reaches of the creek and its tributaries are a major source of pollution and stream degradation. The stream quality was observably poor and heavily impacted by sedimentation in the headwaters upstream of Putnam Drain, but deep muck deposits and overhanging brush were so extensive that sampling could not be conducted in this area.[121]

The three downstream sites located between the Mill Pond in Pinckney and Portage Lake were rated either "fair" (moderately impaired) or "good" (slightly impaired). The better habitat ratings for the three downstream sites is attributed to the numerous small tributaries and springs that drain into the creek, and the fact that the Millpond impoundment in Pinckney acts as a sediment trap for these downstream sites.

Evaluation of macroinvertebrate communities at four of the five sites were rated “good” (slightly impaired) except for the most downstream site at Darwin Road, which was rated “excellent” (nonimpaired). As mentioned above, a TMDL for Honey Creek is scheduled for development in 2007. The area applies to 16 miles of Honey Creek from the headwaters down to the Millpond. While the TMDL is for poor macroinvertebrate communities, the root cause of the poor rating appears to be tied to heavy sedimentation and stream embeddeness.

Evaluation of fish communities at the sites on Putnam Drain and at the middle site below the Millpond rated “excellent” while fish communities at the remaining three sites were “good.”[122]

Table 2.11 summarizes the results of monitoring efforts by the Huron River Watershed Council in Honey Creek and Portage Creek. Sites in both creeks show the same average numbers of insect families, EPT families, and sensitive families, which represent the greatest diversities found in any of the 19 Adopt-A-Stream monitoring stations in the Huron Chain of Lakes Watershed. The high population diversity on Honey Creek at Darwin Road is consistent with MDEQ’s 1991 biological survey of the same site, which was rated “excellent” for macroinvertebrate communities. The “good” average ecological condition at this site is also in keeping with MDEQ’s assessment of the site as having a habitat rating of “good.”

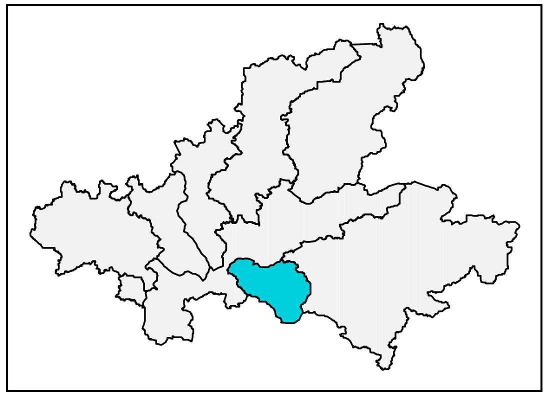
Table 2.11. Ecological Conditions and Aquatic Insect Families at HRWC Adopt-A-Stream Program Monitoring Sites on Honey Creek and Portage Creek[123]

Study Site	First Year Monitored	Ecological Condition*	Population Diversity	Avg. # Insect Families	Avg. # EPT Families	Avg. # Sensitive Families	Winter Stonefly
Honey Cr. at Darwin Rd.	1996	Good	Stable	19	8	3	Present all 5 years
Portage Cr. at Dexter-TownHall Rd.	1996	Exceptional	Declining	19	8	3	Present all 5 years

** categories: exceptional, acceptable, good, and poor*

The monitoring site on Portage Creek at Dexter Town Hall Road, just upstream of Little Portage Lake, shows exceptional ecological condition – one of just two such sites in the watershed. However, despite this status and the strong diversity of macroinvertebrates, more recent data shows that the overall population diversity has declined in more recent collection years.

2.4.7 Horseshoe Lake Creekshed



Horseshoe Lake Drain, also called Horseshoe Creek, is a first order stream that drains from Horseshoe Lake in Northfield Township, Washtenaw County. The stream, which is a County Drain in both Washtenaw and Livingston Counties, flows northwest and empties into the Huron River just upstream of Strawberry Lake. For the purposes of this Watershed Management Plan, the most downstream point in the creekshed has been defined by the outlet of Horseshoe Lake into Horseshoe Creek. However, Horseshoe Lake, which is technically outside of the creekshed, drains a much larger land area that extends to the southern boundary of Northfield Township with Ann Arbor Township. Therefore, the 6,621acres (10.3 square miles) of Horseshoe Lake Creekshed belies the true size of the land area that actually feeds into the creek.

Water Quality

Despite the fact that the Horseshoe Creek is on the MDEQ's 303(d) list of impaired water bodies due to poor macroinvertebrate communities, little relevant water quality data was found. In 1986, the Huron River Watershed Council conducted bacteriological sampling at four stations in Hamburg Township. The purpose was to determine the amount and possible sources of fecal contamination present and its public health significance. Fecal coliform densities were in compliance with state standards partial body contact. An analysis of the types of fecal bacteria strongly indicated pollution by warm-blooded animals other than humans.[124] The report also concluded that low and inconsistent flows, as well as animal waste runoff at Hamburg Road, made Horseshoe Lake Drain unsuitable for total body contact recreation. Animal waste runoff and agricultural waste runoff in the area were noted as problematic nonpoint sources of pollution. The report also concluded that log jams and accumulated bottom mud were hindering the Drain's flow patterns, causing stagnant pools containing mats of algae.

Temperature and conductivity data for Horseshoe Lake Drain at Hamburg Road in Green Oak Township have been collected through HRWC's Adopt-A-Stream Program since 1995. Conductivity was generally excessive, ranging from 630 µS to 1487µS with an average of 1020 µS (n=9). Average summer temperature was 69º F with a monthly fluctuation of 10º F.[125]

As with Woodland Lake on South Ore Creek, a Fish Consumption Advisory has been issued by MDEQ for PCBs in Whitmore Lake, a 677-acre lake on the border between Livingston County and Washtenaw County. The Lake has no outlet and no natural inlet; however, water is pumped into the lake from nearby Horseshoe Lake Drain. A TMDL for PCBs is scheduled for development in 2010. Ten carp were collected from Whitmore Lake in 1992. Total PCB concentrations in three of the samples were above the trigger level of .05 mg/L set for women of childbearing age and children under age 15.[126] The Fish Consumption Advisory for Whitmore Lake recommends that women of childbearing age and children under 15 should eat no more than one meal per week of carp from the lake that exceed 26 inches in length.[127]

Biological Communities

In 1988, MDNR conducted a biological survey of Horseshoe Lake Drain at two stations between Main Street and Barker Road in Whitmore Lake. Macroinvertebrate abundance at the sites was sparse to moderate, consisting of species tolerant of slow flow conditions. The channel was wide and shallow with water depths between two and six inches. Flow velocities were estimated to range from .5 feet per second to .1 feet per second. Overall habitat quality was rated low for both sites.[128]

Based on MDNR's 1988 assessment and a 1997 field survey data (which was not readily accessible), MDEQ concluded that the poor macroinvertebrate community is due to habitat loss from sedimentation and siltation.[129] A target date of 2009 has been set for development of the TMDL to address Horseshoe Lake Drain's poor macroinvertebrate community.

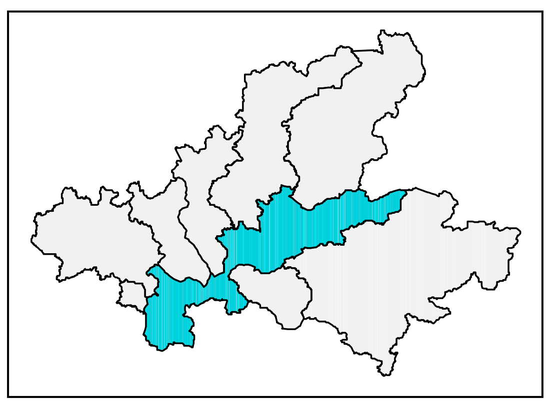
Table 2.12. Ecological Conditions and Aquatic Insect Families at the HRWC Adopt-A-Stream Program Monitoring Site on Horseshoe Lake Drain [130]

Study Site	First Year Monitored	Ecological Condition*	Population Diversity	Avg. # Insect Families	Avg. # EPT Families	Avg. # Sensitive Families	Winter Stonefly
Horseshoe Lake Dr. at Hamburg Rd.	1995	Poor	Stable	11	5	0	Present 6 of 7 years

** categories: exceptional, acceptable, good, and poor*

Horseshoe Lake Drain is monitored in Green Oak Township at Hamburg Road, which is approximately 3 miles downstream (north) of Horseshoe Drain's TMDL area.
As shown in Table 2.12, the site shows poor ecological conditions and low aquatic insect diversity, with 5 EPT families and no sensitive families present. The general presence of winter stoneflies and lack of sensitive families both indicate that organic pollutants, such as fertilizers or animal or human waste, are a more likely pollutant than persistent toxic chemicals in the drain.

2.4.8 Huron River (Direct Drainage)



Portions of the Huron Chain of Lakes Watershed that drain directly to the Huron River instead of one of the eight tributaries comprise the Huron River drainage area – the equivalent of a "creekshed" for this segment of the Huron River. The Huron's direct drainage area in the Huron Chain of Lakes Watershed is 40 square miles (25,556 acres) and begins in the northeast corner of Green Oak Township, flowing southwest past Ore Lake into Hamburg Township and through the chain of lakes, which includes Strawberry, Gallagher, Whitewood, Baseline, and Portage Lakes. Below the Flook dam at the outlet of Portage Lake, a small portion of Dexter and Webster Townships drains directly to the Huron River.

The Huron direct drainage area consists primarily of outwash sand/gravel and postglacial alluvium mix, which allow rapid infiltration of surface water to groundwater aquifers, providing relatively stable baseflow. Small pockets of fine-textured glacial till and some medium-textured end moraine till in the southern portions of the subbasin are more conducive to surface runoff than providing baseflow.

Most of the river in Green Oak Township runs through Island Lake State Recreation Area and Huron Meadows Metropark, both of which provide excellent river access and recreational opportunities, as well as protecting large amounts of upland and riparian land under public management. The Strawberry to Baseline chain of lakes provides excellent swimming, boating, and fishing, but these lakes are ringed with homes and access is private except for one public site on Portage Lake.[131]

Water Quality

Phosphorus TMDLs for Strawberry and Ore Lakes
Because of the history of eutrophic and hypereutrophic conditions in the lakes and impoundments along the Huron River, phosphorus is generally identified as the most appropriate nutrient for controlling algae and aquatic plant growth. Therefore, many of the water quality studies along the Huron River have focused primarily on phosphorus concentrations and loads. MDEQ has established two TMDLs for phosphorus in the direct drainage area of the Huron River; in Ore Lake and Strawberry Lake. Both lakes are currently meeting designated uses, but are listed as threatened on the Michigan 2004 Section 303(d) list of impaired water bodies. The primary threat to these lakes is nutrient (phosphorus) enrichment due to the significant increased development pressure in the Huron River Watershed and the accompanying requests for new and increased discharges of phosphorus from point sources.[132] [133]

Ore Lake is a 192 acre natural lake fed by South Ore Creek, about 2.5 miles downstream from Brighton Lake, which also has an established TMDL for phosphorus. In the 1970's, Ore Lake was classified as a highly eutrophic to hypereutrophic lake with occasional fish kills and frequent nuisance algae blooms. Phosphorus was identified as the most controllable nutrient for reducing eutrophic conditions in the Lake. In 1978, the phosphorus concentration was .055 mg/L with a total load of 3,900 pounds per year to the lake. 59% (2,300 pounds) of this load was attributed from the Brighton Publicly Owned Treatment Works (POTW) and the remaining 41% (1,600 pounds) was from nonpoint source contributions. [134]

In 1998, the Brighton POTW was upgraded with a more effective phosphorus removal system and the discharge was moved downstream of Brighton Lake. Subsequent to the upgrade of the WWTP, overall water quality in Ore Lake was significantly improved.[135] This improvement can be attributed to the dramatic reduction in the point source phosphorus loading, since nonpoint source contributions have increased since 1978. Results from water quality sampling conducted in Ore Lake during April 1998 and April 1999 showed phosphorus concentrations of .013 mg/L and .021 mg/L respectively. The data show distinct temperature stratification, with little oxygen in the deeper, colder waters and higher nutrient concentrations in the bottom sediments. Such water chemistry characteristics are classic indications of eutrophic conditions.[136] More recent data collected through the 2003 Cooperative Lakes Monitoring Program show spring turnover phosphorus concentrations of .017 mg/L and .02 mg/L and an average Secchi Disk reading of 17 feet (n=4).[137]

Average phosphorus concentration from 1997-1999 was .025 mg/L, which equates to 1,375 pounds of phosphorus to Ore Lake per year. Of this amount, point source contributions from the Brighton POTW from 1997-1999 averaged 117 pounds per year- a significant improvement over the 2,300 pounds per year in 1978. The remaining 1,257 pounds of phosphorus was from nonpoint sources.[138]

Based on the data collected from 1997-1999, a TMDL was established in October 1999 that allocates 1,300 pounds of phosphorus to nonpoint source loads, 600 pounds to point source loads, and 40 pounds to a margin of safety. These loads are established to meet the goal of 1,940 pounds per year and an in-lake phosphorus concentration of .025 mg/L, which is generally accepted in the majority of available literature to be the middle range of eutrophic lakes.[139] Based on the 1997-1999 data for phosphorus concentrations and loads, no reductions in point source or nonpoint source phosphorus loading is currently required to meet the goals established in the TMDL. However, having an established TMDL serves to place limits on additional point source inputs, as well as keep nonpoint source contributions near current levels, even as development increases.

Strawberry Lake is a 257-acre inland lake along the Huron River. It is downstream of three other lakes that have established phosphorus TMDLs, which are Kent Lake, Brighton Lake, and Ore Lake. Strawberry Lake was classified in the 1970s as a eutrophic lake with frequent nuisance algae blooms, and phosphorus was identified as the most controllable nutrient for reducing such conditions. In 1978, the phosphorus load to Strawberry Lake was 16,700 pounds per year to the lake. 54% of this load was from point source contributions and 46% was from nonpoint source contributions.[140]

Average phosphorus concentration from 1997-1999 was .021 mg/L, which equates to 13,760 pounds of phosphorus to Strawberry Lake per year. Of this amount, phosphorus contributions from the seven upstream point sources accounted for 13% (2,067 pounds per year). These seven point sources included the WWTPs for Wixom, Milford, South Lyon, Brighton, and Northfield, as well as Vision Metals in South Lyon and the General Motors Proving Ground in Brighton Township. The remaining 87% (12,878 pounds) of phosphorus was from nonpoint sources.[141]

Based on the data collected from 1997-1999, a TMDL was established in May 2000 that allocates 11,000 pounds of phosphorus to nonpoint source loads, 5,877 pounds to point source loads, and 223 pounds to a margin of safety. These loads are established to meet the goal of 17,100 pounds per year and an in-lake phosphorus concentration of .025 mg/L, which will allow the lake to meet the requirements of the Water Quality Standards for plant nutrients. This load allocation equates to a reduction of 15% (1,878 pounds per year) from the average nonpoint source contributions.[142] In order to reach this phosphorus reduction goal of 15%, and to do so in the face of increasing growth and development, best management practices for reduction of nonpoint source contributions must be implemented in contributing areas of the Huron River Watershed.

Hamburg/Ore Lake Flooding and Weed Growth in River
Another problem area is a segment of the river downstream from Ore Lake between Hamburg Road and Highway M-36. In May 2004, Ore Lake and surrounding areas of the Huron River in Hamburg and Green Oak Townships experienced historically significant flooding. Data collected at the USGS gage station at Hamburg Road indicated that the river's discharge rate (or flow in cubic feet per second) should not have caused a flood of such magnitude. Rather, the disproportionate severity of the flood was determined to be caused primarily by an unusually dense mat of curly-leaf pondweed (*Potamogeton crispus*), an exotic nuisance plant, that had formed in the river between Hamburg Road and M-36.[143] This large and dense weed mass significantly slowed down the flow of the river, much like a partially clogged drain, causing the river to overflow its banks and back up into Ore Lake and surrounding areas in the river's floodplain.

The Huron River flooded homes near Ore Lake in May 2004. Photo: LCDC

According to data collected by at the USGS gage station, the river's peak flow rate on May 27, 2004 was 744 cubic feet per second. If the river were flowing freely without the weed obstruction, this peak flow rate should have caused the river to crest at 6.93 feet, resulting in relatively minor flooding. (This segment of the Huron reaches bankfull at 6 feet, and the flood stage is set at 6.5 feet). However, because of the weed obstruction, the actual flood stage reached a height of 8.13 feet, the third highest stage on record since data collection began 54 years ago.[144]

Factors leading to the establishment of the weed mass in the river are not fully understood, but this segment of the Huron River has a very low gradient, averaging only .77 feet per mile between Kensington Road and Strawberry Lake. This low gradient translates to very slow flow, which may allow for accumulation of sediment and/or convenient establishment of plants. The substrate along this portion of the Huron has historically been characterized as primarily gravel and cobble. While no data exist to document how the substrate has changed over time, residents and township officials have noted that the bottom of the river now appears to be dominated by sand and fine sediment. Input of nutrients (phosphorus) and sediment from upstream sources of stormwater runoff are also potential contributors to the weed growth.

In June 2005, a mechanical weed harvester was deployed in the river to harvest the weeds as a short-term preventative measure against potential future flooding events. This initial weed harvest appears to have been at least partially successful in temporarily mitigating the weed growth, and future harvesting is planned for spring 2006 and possibly future years. A comprehensive strategy for controlling and preventing future weed growth in the river has not yet been established, and additional studies will be required to determine the sources and causes of the weed growth and the options for their long-term control and prevention.

While the weed growth in the river has clearly exacerbated the potential for flooding in this area, eliminating the weed blockage would reduce but not eliminate future flooding events. Flooding is a natural process that can never be entirely prevented. Altered hydrology, as a result of lake control structures and increasing stormwater runoff from urbanization and new development in upstream portions of the Huron River Watershed, are also major factors contributing to increased flood events throughout the watershed.

Other Huron River Water Quality Data

In 1977-1978, MDNR collected water quality data at three stations along the Huron River in the Chain of Lakes Watershed as part of an intensive biological inventory. Samples were collected monthly between May 1977 and April 1978 at Kensington Road, just below the Kent Lake Dam, at Winans Lake Road downstream of Ore Lake, and at McGregor Road downstream of Flook Dam at Portage Lake. Emphasis of the chemical sampling was placed primarily on parameters indicative of, or pertaining to, plant growth.

For all three stations, biological oxygen demand levels were consistently low and there was no violation of state water quality standards for dissolved oxygen. Conductivity levels were also within acceptable levels at all three stations, ranging from 455 µS to 710 µS. Total Phosphorus concentrations were highest at Kensington Road, just below the Kent Lake Dam, with a yearly average of .044 mg/L and a summer average of .049 mg/L. Winans Lake Road was slightly lower with a yearly average of .036 mg/L and a summer average of .046 mg/L. McGregor Road was significantly lower with a yearly average of .024 mg/L and a summer average of only .013 mg/L. This lowering of phosphorus levels as the river moves downstream indicates that the Chain of Lakes act as a phosphorus sink by retaining the phosphorus as the water moves through the lakes.[145] Nitrate values for the summer were extremely low at all three stations when compared to other river systems, and yearly fluctuations of nitrate below the stations followed typical lake nitrate levels with low concentrations in the summer and highest levels at spring and fall overturns.[146] Kensington Road had an average summer nitrate level of .017 mg/L and a yearly average of .01 mg/L. Winans Lake Road had an average summer nitrate level of .120 mg/L and a yearly average of .183 mg/L. McGergor Road had an average summer nitrate level of .006 mg/L and a yearly average of .216 mg/L.

Average monthly Water Quality Index (WQI) values for all three locations indicated “good” water quality in the Huron River. Kensington Road ranged from 70 to 82 with an average of 78. Winans Road ranged from 68 to 82 with an average of 76. McGregor Road ranged from 68 to 84 with an average of 80.

Water chemistry data was also collected in 2002 by MDEQ as part of the Michigan Water Chemistry Monitoring Report. One site on the Huron River, at Whitmore Lake Road (Old U.S.-23) just downstream of the Davis Creek confluence in Green Oak Township, was selected as one of five “minimally impacted” sites among 31 tributary watersheds throughout the state in the 2002 monitoring cycle. These minimally impacted sites were selected to represent the best water quality conditions that can be expected and to allow for a comparison of water chemistry data collected at downstream, potentially impacted sites. Data were collected at 4 events between February and October 2002. Contaminants of interest included a wide variety of base/neutral organic compounds, trace metals, heavy metals, PCBs, nutrients, and suspended solids.

Contaminants at the Whitmore Lake Rd. station that are covered under Michigan Rule 57 water quality values were in compliance with water quality values with the exception of PCBs, which were exceeded at all 35 monitoring stations throughout the state. PCBs were found at an average of 2.236 ng/L, well above the exceedance level of .026 ng/L.[147] With an average Mercury concentration of .86 ng/L, the site was one of only five sites in the state that did not exceed the Michigan Rule 57 water quality value of 1.3 ng/L of Mercury. Total dissolved solids ranged from 4 mg/L to 20 mg/L with a mean of 10.3 mg/L. Total Nitrogen ranged from .087 mg/L to .385 mg/L with a mean of .194 mg/L. Total phosphorus ranged from .014 mg/L to .035 mg/L with a mean of .027 mg/L.[148] Data collected at this site by through HRWC's Adopt-A-Stream Program between 1995 and 2003 show slightly excessive conductivity with an average of 854 µS (n=13).[149]

Baseline Lake is a 265-acre natural kettle lake located on the Huron River on the border between Hamburg Township and Webster Township in Washtenaw County. According to surveys conducted by MDNR in 1974, the lake was considered to have good water quality and was considered a mesotrophic lake. A study by SEMCOG in 1977 reached the same conclusion.[150] Water quality monitoring was conduced on Baseline Lake in 1984 by the Huron River Watershed Council, which concluded that the lake was trending toward eutrophic conditions. Total phosphorus concentration samples were taken monthly for 6 months at three different stations on the lake. Total phosphorus concentrations ranged from less than .010 mg/L to .041 mg/L.[151]

Water quality monitoring of Baseline Lake has also been conducted by Wallace Fusilier between 1994 and 2003. Fusilier's summary report of data collected during this time shows that the Water Quality Index ranged from a low of 77 in 1995 to a high of 94 in 1999, averaging in the 80s which corresponds to a "grade" in the B range.

Just downstream from Baseline is Portage Lake, the most downstream lake in the chain of lakes. Portage Lake, also called Big Portage Lake, is a 725-acre natural kettle lake located in parts of Putnam, Hamburg, and Dexter townships. The lake is fed through two inlets from Honey Creek and Portage Creek (via Little Portage Lake). The Flook dam on the Huron River below Portage Lake causes water from the river to flow both in and out of the lake through the Gulf Canal and the Portage River outlet, depending on water volume and time of year.

Water quality samples conducted by MDEQ in spring and summer of 1997 show an average total phosphorus concentration of .030 mg/L (n=4). A single Secchi Disk reading in April 1997 showed a depth of 12 feet, generally indicative of mesotrophic conditions. Dissolved Oxygen levels were good, ranging from 11.8 mg/L at 30 feet deep to 13.1 mg/L at the surface and conductivity was a uniform 460 µS at four depth readings from the surface to 30 feet.[152] Studies of Portage Lake by Wallace Fusilier from 1994-2003 show a Water Quality Index range from 74 in summer 1995 to 96 in spring of the same year with typical WQIs in the low to mid 80s, corresponding to a grade of B.

Biological Communities

In 1977-1978, the Michigan Department of Natural Resources conducted an intensive biological survey of the Huron River that included the stretch between Kent Lake Dam and Flook Dam. Phytoplankton levels were relatively low and found to be primarily related to levels within Kent, Portage, and Baseline Lakes. Aquatic plants were found to be particularly abundant between Kent Lake and Strawberry Lake. Macroinvertebrate collections at four stations between Kent Lake and Strawberry Lake indicated a steady increase in water quality as the Huron flows downstream. The insect family diversity and EPT diversity at the uppermost station on Kensington Road, just downstream of Kent Lake Dam, were limited by profuse plant growth, high water temperatures, and probably diurnal oxygen fluctuations. The three stations downstream from the Kensington Road site showed increasing species diversity and biotic indices.[153]

Another survey by MDNR in 1993 looked at three stations on the Huron River in the Huron Chain of Lakes Watershed and rated the biotic community and habitat. The uppermost site at Kensington Road had a "good" rating for the fish community, a rating of "fair" for the macroinvertebrate and overall biotic communities, and "excellent" habitat. Two other sites, at Rickett Road midway between the Davis Creek confluence and Ore Lake, and at M-36, upstream of Strawberry Lake, both had identical ratings: "good" fish, macroinvertebrate, and overall biotic ratings; and "excellent" habitat.[154]

Two sites are monitored through HRWC's Adopt-A-Stream Program in the Huron's direct drainage area (table 2.12). The Huron River is monitored in Green Oak Township at U.S.-23 just below Davis Creek's confluence with the Huron River, and in Dexter Township at Bell Road, south of Portage Lake.

Table 2.13. Ecological Conditions and Aquatic Insect Families at HRWC Adopt-A-Stream Program Monitoring Sites on the Huron River in the Huron Chain of Lakes Watershed [155]

Study Site	First Year Monitored	Ecological Condition*	Population Diversity	Avg. # Insect Families	Avg. # EPT Families	Avg. # Sensitive Families	Winter Stonefly
Huron R. at U.S.-23	1998	(not assessed)	Stable	14	6	2	Present 3 of 4 years
Huron R. at Bell Road	2000	Acceptable	Stable	14	6	1	Present all 3 years

** categories: exceptional, acceptable, good, and poor*

The ecological condition for the Huron River at U.S.-23 has not been assessed due to a lack of temperature data, but the Bell Road site has acceptable ecological conditions. Both Huron River sites show similar average insect diversities.

2.5 Resident Values and Attitudes

While not a part of the Watershed's physical conditions, the values and attitudes of its residents play an important role in shaping the human-influenced conditions throughout the Watershed. During the summer of 2004, the primary partners in the Huron Chain of Lakes Watershed commissioned SEMCOG to conduct a Regional Public Education Survey of the Huron Chain of Lakes. The major findings of this survey as reported by SEMCOG are presented below.[156]

Perceptions and Value of Water Resources

Residents were asked to rate the quality of water in lakes, rivers, and streams in the community where they live. Twenty-nine percent of those surveyed thought water quality was remaining the same and twenty-six percent thought it was getting “somewhat worse.” Eighteen percent reported that they thought water quality was getting “somewhat better.”

The activities that households were most likely to have done in or near lakes and streams in the region during the past year were: hiking/walking (55%), boating (53%), and swimming (53%). Only sixteen percent (16%) of those surveyed indicated that they did not participate in activities in or near lakes and streams in the region during the past year.

74% of those surveyed thought the way they cared for their lawn and home affects the quality of water in lakes and streams in the community where they live; 26% did not.

47% of those surveyed indicated that their household had taken some type of action to protect water resources in the past two years; 45% had not, and 8% indicated that they “didn’t know” if they had done anything that would have helped protect water resources.

Connection of Stormwater Runoff and Water Resources
Fifty-one percent of those surveyed thought stormwater runoff was the greatest contributor of pollution to lakes, rivers and streams. Industrial discharges were second (27%), followed by sewage overflows (14%), and wastewater treatment plant discharges (8%).

Fifty-three percent of those surveyed indicated that they know that stormwater flows directly to lakes and streams without treatment. Thirty-six percent of those surveyed indicated that they “didn’t know” where stormwater goes after it enters a storm drain or roadside ditch.

Twenty-five (25%) of those surveyed knew that they lived in a watershed. Thirty-seven percent (37%) indicated that they did not know if they lived in a watershed.

Seventy-three (73%) of those surveyed agreed with the statement that the quality of local streams where they live affects the Great Lakes and Lake St. Clair.

Fifty-two (52%) percent of the respondents indicted that they had not seen road signs identifying rivers or watersheds in their community. Forty-six percent (46%) of those surveyed indicated that they had seen signs identifying rivers in their community.

Current Activities
Twenty-four percent of those surveyed indicated that they typically wash their vehicles at home in the driveway. Most (71%) of those surveyed indicated that they use a car wash.

Twenty percent of those surveyed indicated that members of their household usually change motor oil, transmission fluid or radiator fluid for a vehicle at their home.

Sixty-nine percent of those surveyed indicated that their household uses a community collection site to dispose of household hazardous waste, such as old oil, fluids from vehicles, batteries, and pesticides; 19% of those surveyed indicated that their household typically disposes of household hazardous wastes with their regular trash.

Forty-seven percent of those surveyed who were not using a community collection site for household hazardous waste indicated that the reason they did not use a community collection site was because they did not know where one was located.

Thirty-nine percent of those surveyed indicated that their household seldom uses fertilizers on their lawn. Thirty-two (32%) indicated they use fertilizer on their lawn at least once a year.

The types of fertilizer that households were most likely to use on their lawn were: weed and feed (38%), slow release nitrogen (17%), seasonal varieties (15%), and low phosphorous (11%).

The most common reason residents gave for selecting the type of fertilizer or pesticide they use was previous experience with a product (38%).

Thirty percent of those surveyed indicated that their household uses a lawn service for fertilizer and/or pesticide applications.

Willingness to Take Action to Help Reduce Pollution of Streams and Lakes
Residents were asked how willing they would be to perform various actions to help reduce pollution in lakes and streams. Residents were most willing to (1) change car care practices (85%), (2) dispose of hazardous waste at a community collection day (84%), (3) sweep excess fertilizer/grass clippings into their lawn (84%), and (4) have their septic system serviced every 3-5 years (78%). Residents were somewhat less willing to change lawn watering practices (63%).

Best Ways to Inform Residents About Ways to Protect Lakes and Streams
The top four ways residents preferred to receive information about what they can do to protect lakes and streams were from community newspaper (59%), television news (37%), major newspaper (37%), and municipal newsletter (30%).

The results of this survey are particularly useful in determining the types of educational messages that should be targeted to the Watershed's residents and the media/outreach tools that are likely to reach the greatest number of residents and have the greatest impact on increasing awareness and changing behavior. The survey also provides a baseline against which the results of future surveys can be measured.

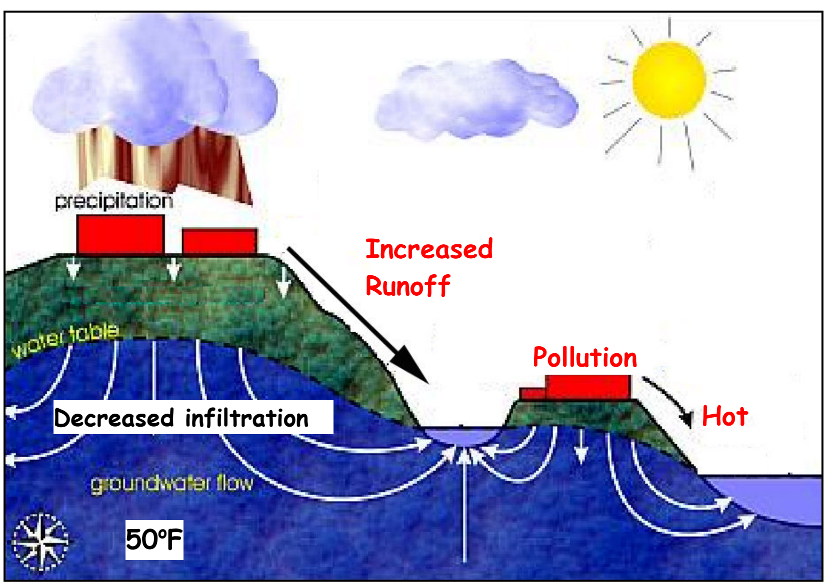
CHAPTER 3: LAND USE PLANNING AND WATERSHED ANALYSIS

Honey Creek near Darwin Rd. in Putnam Township *Photo: hrwc*

Land use planning and watershed analysis tools were employed in the Huron Chain of Lakes Watershed to provide information that is consistent across the watershed and provide comparisons among creeksheds, whereas the information in Chapter 2 is more site-specific. These analysis tools are the Impervious Cover model and the Long-Term Hydrologic Impact Assessment (L-THIA) model. These models are described below. The results of these models, along with other factors, were applied in the exercise of selecting critical areas in the Huron Chain of Lakes Watershed.

3.1 IMPERVIOUSNESS COVER MODEL

When natural open spaces are converted to residential, commercial, and industrial land uses, the result is an increase in the amount of impervious surfaces. Roads, parking lots, rooftops, and, to a lesser degree, managed lawns, all add to the amount of these surfaces in a watershed. Many impervious surfaces can be directly-connected—areas that drain directly to surface waters—without the benefit of water quality-improving treatment such as detention or infiltration. In general, as land is developed, stream flows become "flashy," with increased volume and velocity of flow, which impact water quality and can



Impervious surfaces reduce infiltration and increase runoff.

affect infrastructure and property (Table 3.1). Development also impacts groundwater hydrology by decreasing the amount of pervious area available for infiltration of rainwater. Less infiltration results in less recharge as baseflow for rivers and lakes, meaning lower lake levels and river flows. As described in Chapter 2.2, the hydrology of the Huron Chain of Lakes system is highly interconnected with groundwater.

Table 3.1. Impacts of Development on Hydrological Conditions[157]

	Storm Frequency (yr)	24-Hour Rainfall (in)	Estimated Runoff (in)	Runoff as Percentage of Rainfall
Half-acre Forest	2	2.8	0.14	5
	10	4.0	0.53	13
	100	5.0	1.4	24
Half-acre Residential	2	2.8	0.60	21
	10	4.0	1.33	33
	100	5.0	2.64	66

The amount of impervious surface in a watershed is directly related to its water quality. It is well documented that as the amount of these surfaces increases in a watershed the velocity, volume, and pollution of surface runoff also increases.[158] Subsequently, flooding, erosion, and pollutant loads in receiving waters also tend to increase while groundwater recharge areas and water tables decline, streambeds and flows are altered, and aquatic habitats are lost.

Table 3.2 presents typical pollutant concentrations from stormwater runoff in southeast Michigan. Developed land uses such as residential, commercial, and roads have noticeably higher concentrations of pollutants compared to managed and unmanaged open space.

Table 3.2. Typical Pollutant Concentration from Land Uses[159]

Land Use	Pollutant (mg/L)				
	Total Phosphorus	Total Nitrogen	Total Suspended Sediment	Biological Oxygen Demand	Lead
Road	0.43	1.82	141	24	0.014
Commercial	0.33	1.74	77	21	0.049
Industrial	0.32	2.08	149	24	0.072
Low Density Residential	0.52	3.32	70	38	0.057
High Density Residential	0.24	1.17	97	14	0.041
Forest	0.11	0.94	51	3	0.000
Urban Open	0.11	0.94	51	3	0.014
Pasture/Agriculture	0.37	1.92	145	3	0.000

Stream research generally indicates that certain zones of stream quality exist, most notably at about 10% impervious cover, where sensitive stream elements are lost from the system. However, the Huron River is slightly more sensitive; research of the Huron River Watershed reveals that water quality degradation is first notable as impervious surfaces achieve 8% of the total landscape.[160] When the watershed reaches this threshold, the impacts of incremental increases in surface runoff noticeably affect the aquatic macroinvertebrate and fish populations and, subsequently, water-based recreation activities. A second threshold appears to exist at around 25 to 30% impervious cover, where most indicators of stream quality consistently shift to a poor condition (e.g., diminished aquatic diversity, water quality, and habitat scores).

A simple urban stream classification scheme can be based on impervious cover and stream quality. This simple classification system contains three stream categories, based on the percentage of impervious cover. The model classifies streams into one of three categories: sensitive, impacted, and non-supporting.[161] Each stream category can be expected to have unique characteristics as follows:

Sensitive Streams: These streams typically have a watershed impervious cover of zero to 10%. Consequently, sensitive streams are of high quality, and are typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects. Since impervious cover is so low, they do not experience frequent flooding and other hydrological changes that accompany urbanization. It should be noted that some sensitive streams located in rural areas may have been impacted by prior poor grazing and cropping practices that may have severely altered the riparian zone, and consequently, may not have all the properties of a sensitive stream. Once riparian management improves, however these streams are often expected to recover.

Impacted Streams: Streams in this category possess a watershed impervious cover ranging from 11% to 25%, and show clear signs of degradation due to watershed urbanization. The elevated storm flows begin to alter stream geometry. Both erosion and channel widening are clearly evident. Streams banks become unstable, and physical habitat in the stream declines noticeably. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.

Non-Supporting Streams: Once watershed impervious cover exceeds 25%, stream quality crosses a second threshold. Streams in this category essentially become conduits for conveying stormwater flows, and can no longer support a diverse stream community. The stream channel becomes highly unstable, and many stream reaches experience severe widening, downcutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated and the substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Water quality is consistently rated as fair to poor, and water recreation is no longer possible due to the presence of high bacterial levels. Subwatersheds in the non-supporting category will generally display increases in nutrient loads to downstream receiving waters, even if effective urban BMPs are installed and maintained. The biological quality of non-supporting streams is generally considered poor, and is dominated by pollution tolerant insects and fish.

Using the Impervious Cover model, HRWC staff completed an analysis of current and future imperviousness in the Huron Chain of Lakes Watershed. The Impervious Cover Model correlates current land use (using SEMCOG 2000 aerial photography) with imperviousness rates for each land use category as determined through the Rouge River Project (Figure 3.1). Future imperviousness is determined by applying the same land use imperviousness rates to the Watershed's "build-out" scenario, as determined by each community's master plan (Figure 3.2).

The Impervious Cover model is designed for use in smaller urban streams from first to third order. This limitation reflects the fact that most of the research has been conducted at the subwatershed level (less than 10 square mile area), and that analyzing imperviousness at the sub-basin level provides a clearer connection between cause and effect than does analysis at the creekshed level, which is more useful for land use decision making. In larger watersheds and basins, other land uses, pollution sources, and disturbances often dominate the quality and dynamics of streams and rivers.

In order to apply the small scale needs of the Impervious Cover Model to the Huron Chain of Lakes Watershed, the nine creeksheds were further delineated into 35 sub-basins. The model was then applied to each of the 35 sub-basins in both the current and future scenarios; Table 3.3 and Figures 3.3 and 3.4 show the current and future imperviousness rates as averaged for each sub-basin.

Table 3.3. Percent Impervious Cover Based on Current Land Use (2000) and Build-out Based on Community Master Plans

Sub-basin	Current impervious surface %	Current category	Future Impervious surface %	Future category	Does category change?
Chilson #1	9	Sensitive	15	Impacted	yes
Chilson #2	13	Impacted	21	Impacted	no
Davis #1	17	Impacted	23	Impacted	no
Davis #2	9	Sensitive	18	Impacted	yes
Davis #3	17	Impacted	20	Impacted	no
Davis #4	5	Sensitive	9	Sensitive	no
Davis #5	16	Impacted	24	Impacted	no
Davis #6	11	Impacted	25	Impacted	no
Davis #7	7	Sensitive	13	Impacted	yes
Davis #8	9	Sensitive	15	Impacted	yes
Davis#9	16	Impacted	32	Non-supporting	yes
Hay #1	8	Sensitive	9	Sensitive	no
Hay #2	6	Sensitive	12	Impacted	yes
Hay #3	12	Impacted	17	Impacted	no
Honey (N) #1	7	Sensitive	17	Impacted	yes
Honey (N) #2	9	Sensitive	14	Impacted	yes
Honey (N) #3	5	Sensitive	8	Sensitive	no
Honey (N) #4	5	Sensitive	6	Sensitive	no
Honey (N) #5	5	Sensitive	10	Sensitive	no
Horseshoe #1	17	Impacted	34	Non-supporting	yes
Huron River #11	10	Sensitive	27	Non-supporting	yes
Huron River #12	20	Impacted	29	Non-supporting	yes
Huron River #15	16	Impacted	24	Impacted	no
Huron River #17	14	Impacted	18	Impacted	no
Huron River #7	9	Sensitive	14	Impacted	yes
Huron River #8	16	Impacted	24	Impacted	no
Portage #1	9	Sensitive	13	Impacted	yes
South Ore #1	9	Sensitive	17	Impacted	yes
South Ore #2	17	Impacted	28	Non-supporting	yes
South Ore #3	28	Non-supporting	36	Non-supporting	no
South Ore #4	11	Impacted	17	Impacted	yes
Woodruff #1	21	Impacted	29	Non-supporting	yes
Woodruff #2	15	Impacted	28	Non-supporting	yes
Woodruff #3	17	Impacted	23	Impacted	no
Woodruff #4	13	Impacted	26	Non-supporting	yes

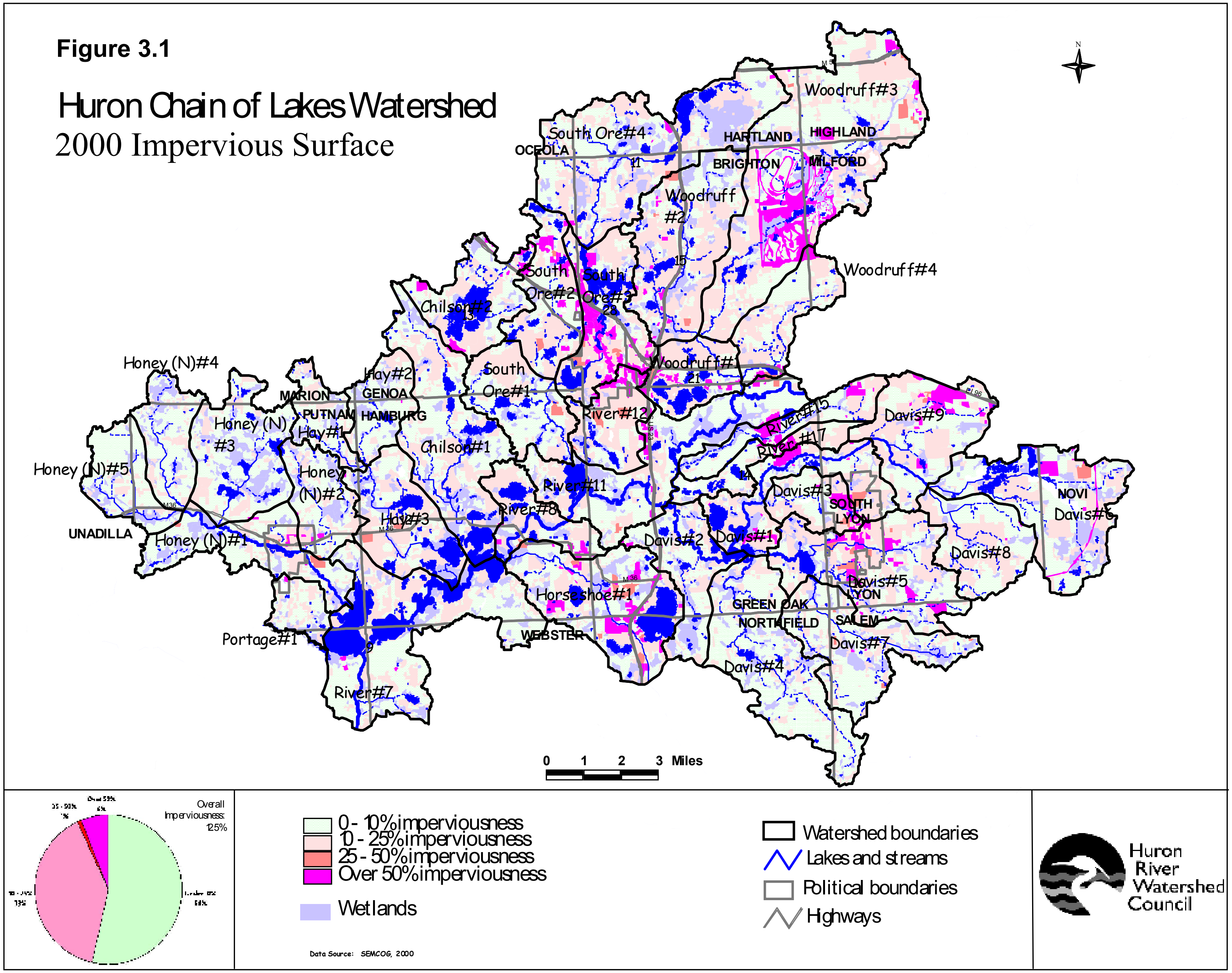
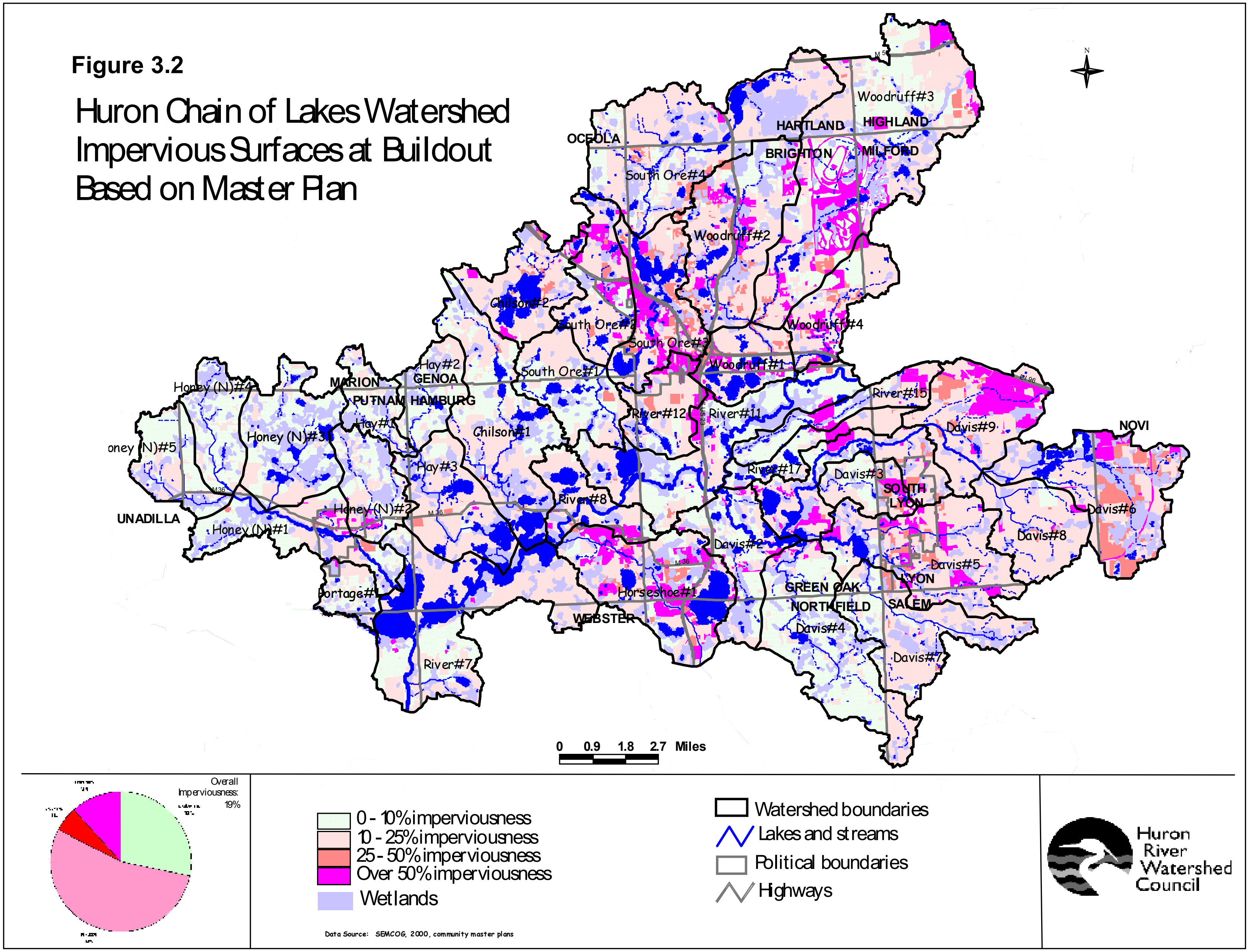


Figure 3.1

Huron Chain of Lakes Watershed
2000 Impervious Surface

Figure 3.2

Huron Chain of Lakes Watershed Impervious Surfaces at Buildout Based on Master Plan



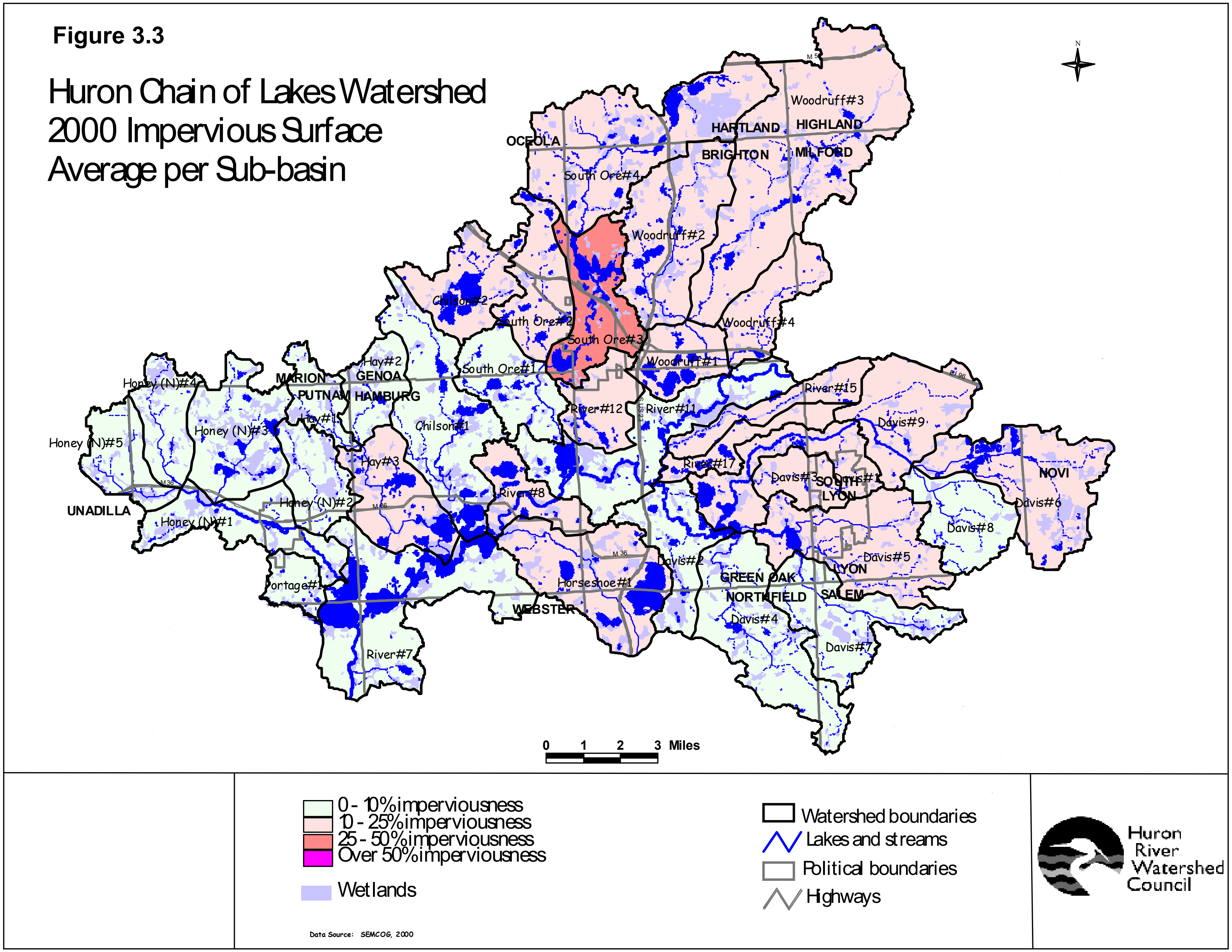


Figure 3.3
Huron Chain of Lakes Watershed
2000 Impervious Surface
Average per Sub-basin
N
OCEOLA
HARTLAND
HIGHLAND
BRIGHTON
MILFORD
MARION
GENOA
PUTNAM
HAMBURG
UNADILLA
WEBSTER
GREEN OAK
NORTHFIELD
SALEM
LYON
SOUTH LYON
NOVI
Woodruff#3
South Ore#4
Woodruff#2
Chilson#2
South Ore#2
South Ore#3
Woodruff#4
Woodruff#1
South Ore#1
Hay#2
Honey (N)#4
Honey (N)#3
Honey (N)#5
Hay#1
Chilson#1
Hay#3
River#12
River#11
River#15
Davis#9
River#17
Davis#3
Davis#1
Davis#6
River#8
Honey (N)#2
Honey (N)#1
Davis#8
Davis#2
Davis#5
Horseshoe#1
Portage#1
Davis#4
Davis#7
River#7
0 1 2 3 Miles
0 - 10% imperviousness
10 - 25% imperviousness
25 - 50% imperviousness
Over 50% imperviousness
Wetlands
Watershed boundaries
Lakes and streams
Political boundaries
Highways
Huron River Watershed Council
Data Source: SEMCOG, 2000

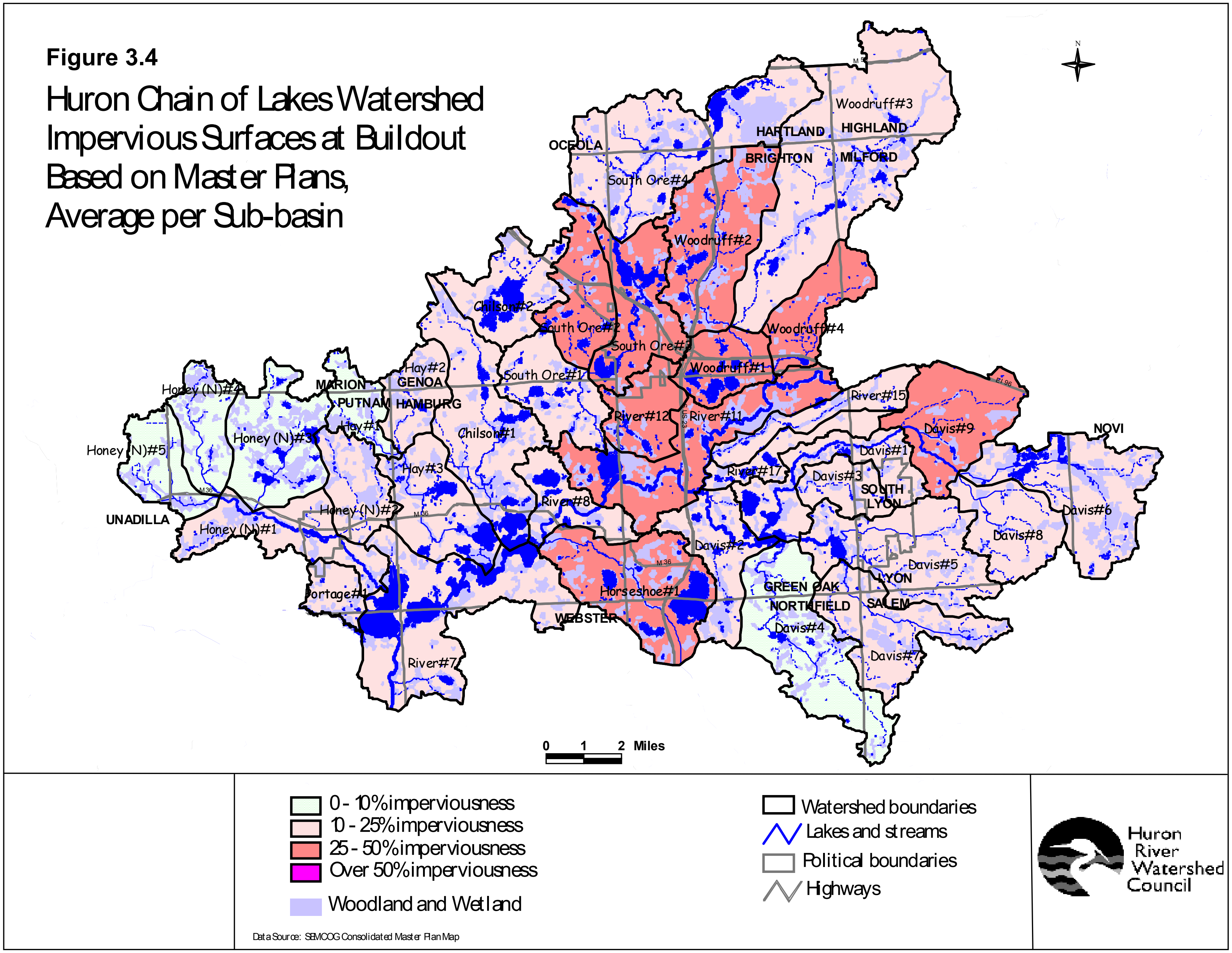


Figure 3.4

Huron Chain of Lakes Watershed Impervious Surfaces at Buildout Based on Master Plans, Average per Sub-basin

As of 2000, the Huron Chain of Lakes Watershed had an average imperviousness rate of 12.5%. sixteen sub-basins were classified as “sensitive” with impervious cover ranging from 6% to 10%. Only one sub-basin, South Ore #3, was classified as “non-supporting” with an impervious cover of 28%. The remaining 18 sub-basins were classified as “impacted.”

If the Huron Chain of Lakes communities fulfill their build-out scenarios as presented in their master plans, significant increases in impervious cover will occur. The overall imperviousness rate for the Watershed is expected to increase from 12.5% in 2000 to 19% if each community in the Watershed meets its build-out scenario as set forth in its master plan.

Eighteen of the 35 sub-basins will be downgraded to a lower stream category. Most of the change will come from ten of the sixteen “sensitive” sub-basins that will move into the “impacted” category. In fact, one sub-basin, Huron River #11, which includes over half of the Huron River in the Watershed, will surpass the “impacted” category altogether and become “non-supporting.” Seven of the “impacted” sub-basins will become “non-supporting.” Some of the largest changes in impervious cover percentage are in Horseshoe #1, which will double from 17% to 24%, and in Huron River #11, which will increase from 10% to 27%. Also, Davis Creek # 9 will double from 16% to 32% and Davis Creek # 6 will increase from 11% to 25%. Sub-basins #2 and #4 in Woodruff Creek will each increase by 13 percentage points to 28% and 26% respectively. Finally, South Ore Creek #3, which includes most of the City of Brighton, is expected to become more than 36% impervious at build-out, which is the highest percentage of any sub-basin in the Huron Chain of Lakes Watershed. However, future economic and population trends, and leadership, can alter the numbers presented here either by increasing or decreasing the impervious cover percentages. In addition, placement of stormwater Best Management Practices can partially mitigate the impacts of impervious surfaces. Since these predicted increases in impervious rates threaten to critically impact the quality of the Huron River and its tributaries, significant efforts to mitigate these effects should be a priority for the Huron Chain of Lakes communities.

Model Limitations

The Impervious Cover Model is intended to predict potential rather than actual stream quality, so an individual stream may depart from the model for various reasons. Also, it assigns one impervious surface percentage for each general land use, while the actual impervious surface percentage on any given piece of land may differ within the same land use category. For instance, for the 2000 impervious cover analysis, all single family residential areas receive an impervious surface coefficient of 20%, because the source data does not distinguish different densities of singly family residential. This level of impervious surface corresponds to a density of one density unit per acre, but there is a wide range of densities in the watershed, which would therefore have different levels of imperviousness.

3.2 LONG-TERM HYDROLOGIC IMPACT ASSESSMENT

The Long-Term Hydrological Impact Assessment, or L-THIA, models runoff and pollutant loading in the lower Huron River Watershed. Using GIS, the model combines land use and soil hydrological group grids with long term precipitation data to create grids estimating runoff depth and pollutant loads. Purdue University and the U.S. EPA developed L-THIA.

For the Huron Chain of Lakes Watershed, HRWC staff created land use grids from 2000 SEMCOG land use data and pre-settlement land use data from the Michigan Natural Features Inventory. The pre-settlement data is derived from notes made by land surveyors who walked the whole state of Michigan during the 1830s. The model allows use of eight land use classifications: water; forest; grass/pasture; industrial; commercial; agricultural; high density residential; and low density residential. The model overlays a grid of these land use classifications on a grid of soil hydrological groups (A, B, C, D) to give a grid of runoff curve numbers derived from the Soil Conservation Service TR 55 manual. Using the curve numbers grid, the model then computes a grid of the average runoff depth over a year, and from that, average runoff volume. Using a table of event mean concentrations (EMCs) of various pollutants developed by the Rouge River Wet Weather Demonstration Project for land uses in Southeast Michigan, the model then computes grids of various pollutant loads. The model was applied to the 35 sub-basins in the Huron Chain of Lakes Watershed.

The model was run for both land use conditions as of 2000 and conditions circa 1830s, before significant European settlement occurred. A series of six maps in Appendix E show the Watershed's pre-settlement and current (using 2000 data) conditions for runoff depth, total phosphorus, and total suspended solids. Figures 3.5 – 3.7 also show the Watershed's current conditions for the same factors, but displayed as the average load per acre for each sub-basin. Table 3.4 shows the average presettlement and current runoff, total phosphorus, and total suspended solids for each sub-basin.

Model Limitations

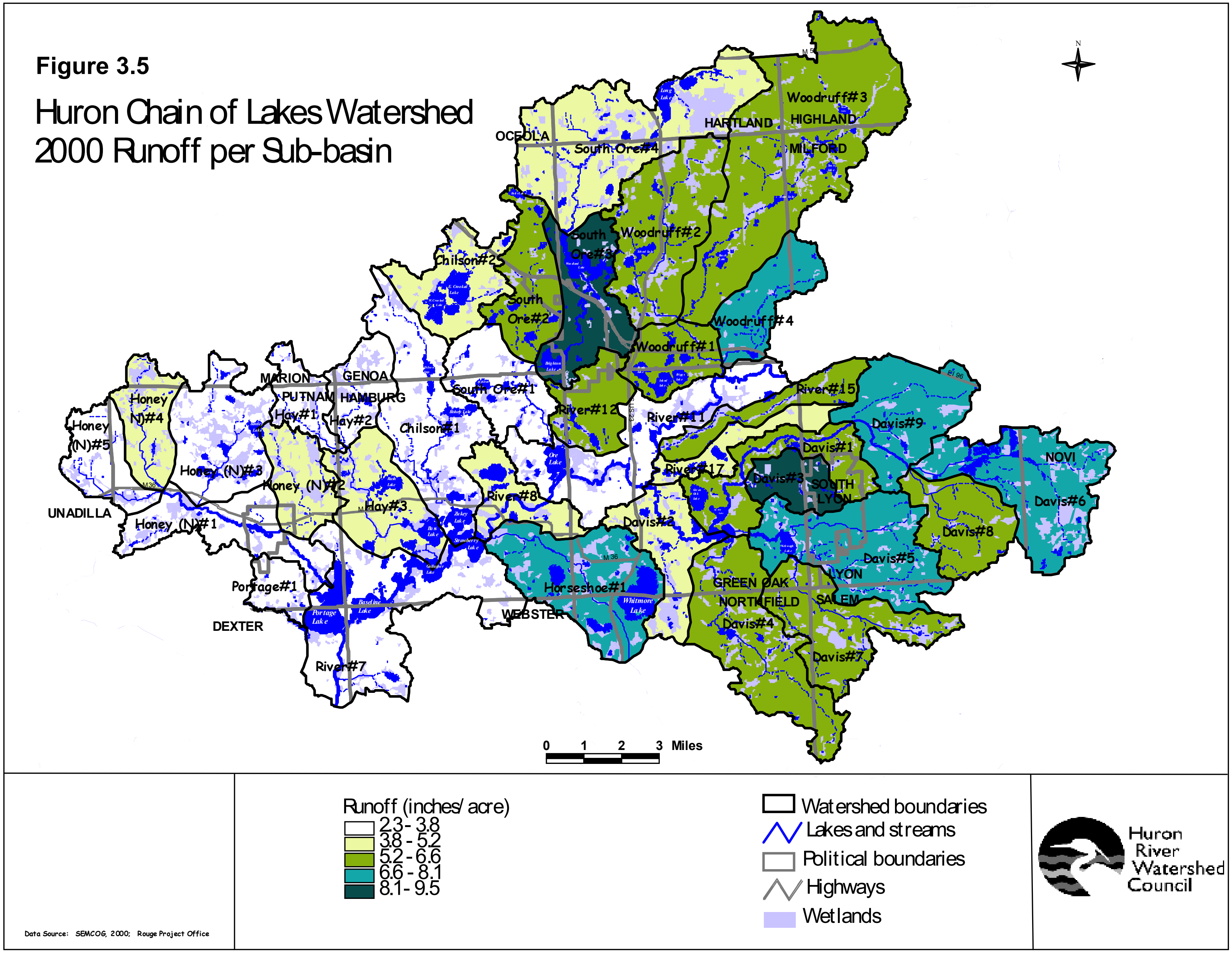
Note that the model is not calibrated to actual data, but relies on land use categories and the soil runoff curve number coefficients, which are based on field studies conducted several decades ago. Therefore, the L-THIA results should be considered only in relation from one sub-basin to another. However, the results do generally complement the results of the current imperviousness model and confirm general expectations of pollutant loads based on current land use patterns and urban/rural areas in the Watershed.

Table 3.4 Runoff and Pollutant Loads for Each Sub-basin for 2000 and Presettlement Land Uses/Cover

Subbasin	2000 Runoff per acre (inches)	1830s Runoff per acre (inches)	2000 TP per acre (lbs)	1830s TP per acre (lbs)	2000 TSS per acre (lbs)	1830s TSS per acre (lbs)
Chilson#1	3.12	0.89	0.060	0.005	11.67	2.35
Chilson#2	4.82	0.82	0.090	0.005	24.43	2.17
Davis#1	6.31	0.99	0.130	0.006	30.68	2.64
Davis#2	4.42	1.24	0.080	0.007	21.95	3.30
Davis#3	8.18	1.44	0.170	0.008	34.55	3.82
Davis#4	5.92	1.79	0.110	0.010	36.75	4.74
Davis#5	7.40	1.19	0.150	0.007	35.87	3.17
Davis#6	7.57	1.26	0.140	0.007	42.15	3.34
Davis#7	5.69	1.63	0.100	0.009	31.03	4.32
Davis#8	5.81	1.03	0.110	0.006	35.37	2.74
Davis#9	7.90	0.84	0.150	0.005	49.59	2.22
Hay#1	2.93	0.77	0.050	0.004	14.97	2.03
Hay#2	2.31	0.98	0.030	0.006	8.79	2.61
Hay#3	3.98	0.83	0.080	0.005	14.57	2.20
Honey #1	3.46	0.86	0.060	0.005	15.81	2.27
Honey #2	4.52	1.00	0.080	0.006	24.02	2.65
Honey #3	2.54	0.67	0.040	0.004	14.26	1.79
Honey #4	3.90	0.66	0.070	0.004	22.86	1.76
Honey #5	3.58	0.58	0.060	0.003	19.72	1.55
Horseshoe	7.56	0.97	0.140	0.006	38.87	2.56
Portage#1	3.30	0.80	0.070	0.005	17.61	2.12
River#11	3.57	0.77	0.060	0.004	17.59	2.04
River#12	6.44	0.59	0.120	0.003	28.67	1.57
River#15	6.55	0.77	0.120	0.004	40.04	2.03
River#17	4.97	0.97	0.100	0.006	30.94	2.56
River#7	3.62	0.84	0.070	0.005	16.39	2.24
River#8	4.41	0.71	0.090	0.004	21.48	1.87
South Ore#1	3.22	0.88	0.050	0.005	14.40	2.33
South Ore#2	6.57	0.94	0.120	0.005	32.77	2.50
South Ore#3	9.51	0.81	0.180	0.005	43.81	2.14
South Ore#4	4.28	1.38	0.080	0.008	20.75	3.66
Woodruff#1	6.25	0.76	0.120	0.004	32.08	2.01
Woodruff#2	5.25	0.76	0.110	0.004	26.01	2.01
Woodruff#3	5.74	0.61	0.110	0.003	35.03	1.61
Woodruff#4	7.49	0.76	0.140	0.004	44.59	2.01

Figure 3.5

Huron Chain of Lakes Watershed 2000 Runoff per Sub-basin



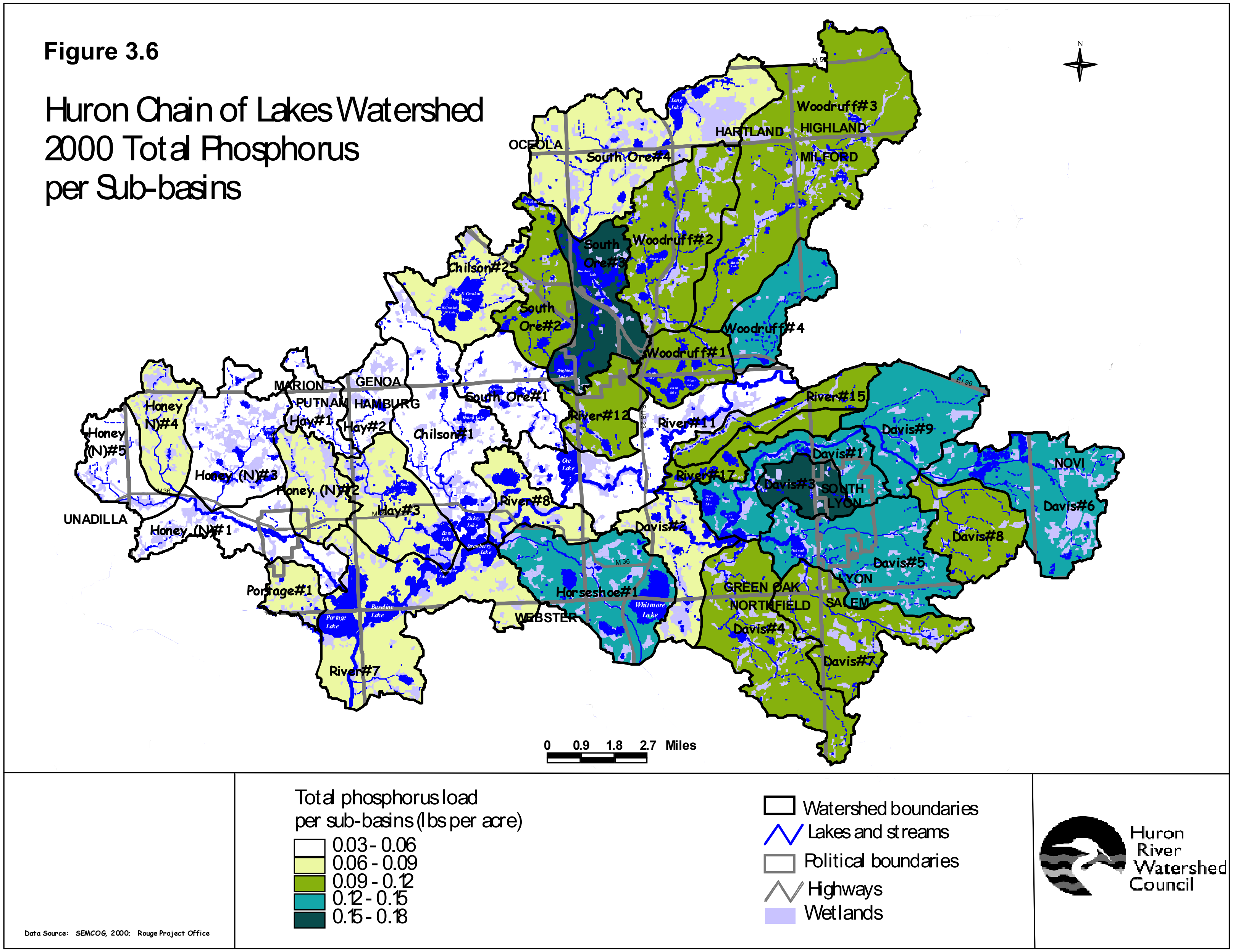


Figure 3.6
Huron Chain of Lakes Watershed
2000 Total Phosphorus
per Sub-basins
0 0.9 1.8 2.7 Miles
Total phosphorus load
per sub-basins (lbs per acre)
0.03 - 0.06
0.06 - 0.09
0.09 - 0.12
0.12 - 0.15
0.15 - 0.18
Watershed boundaries
Lakes and streams
Political boundaries
Highways
Wetlands
Huron River Watershed Council
Data Source: SEMCOG, 2000; Rouge Project Office

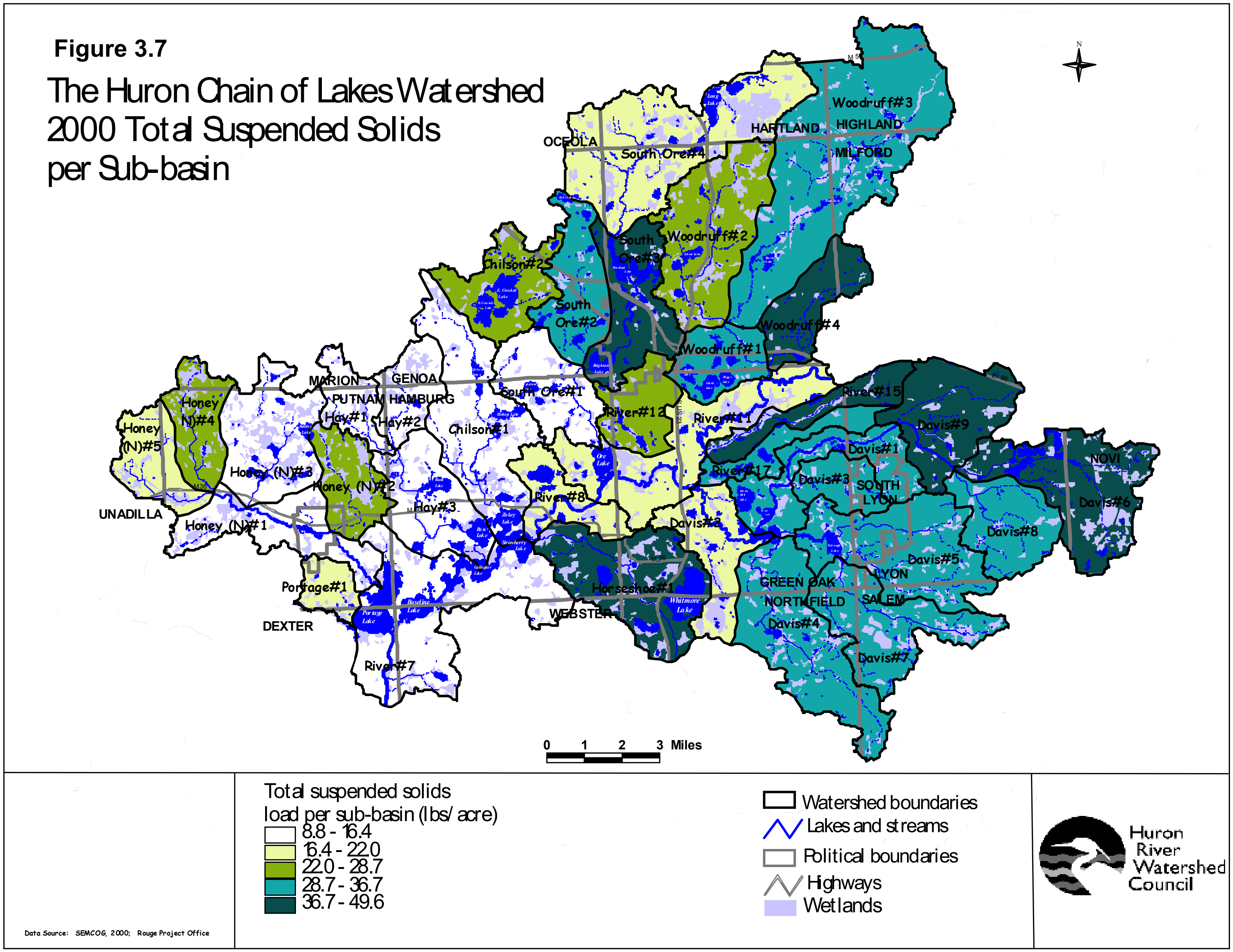


Figure 3.7

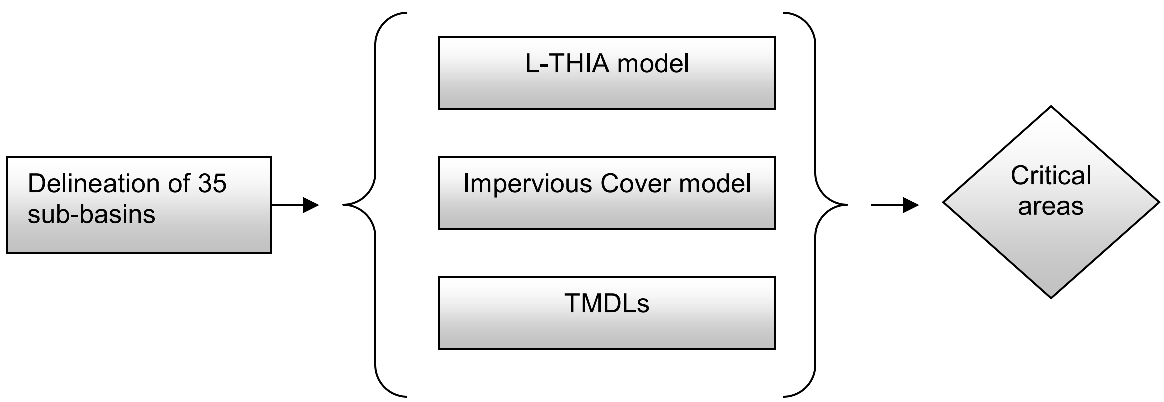
The Huron Chain of Lakes Watershed 2000 Total Suspended Solids per Sub-basin

3.3 IDENTIFICATION OF CRITICAL AREAS

A watershed's critical areas are those parts of the watershed that contribute higher amounts of pollutants to its waterways than other areas. Focusing on these critical areas targets management efforts on these "hot spots" rather than considering all parts of the watershed as equally important. Prioritization of critical areas is essential since staff and financial resources at the local level are limited.

The methodology employed to locate the critical areas in the Huron Chain of Lakes Watershed is based on the following factors: (1) current impervious cover and impervious cover at build-out of master plan; (2) relative nutrient, sediment and runoff output utilizing the L-THIA model; and (3) presence of a TMDL or upstream area contributing to a TMDL (Figure 3.17). These factors were weighted and applied to each of the 35 sub-basins to generate a score for each sub-basin. The eleven highest-scoring sub-basins were identified as the critical areas of the Watershed, as the numbers provided a natural break from the rest of the field. In future updates of this plan, methods should be employed to model pollutant pathways and include these factors in the critical area analysis.

Figure 3.8. Components of the Critical Area Methodology



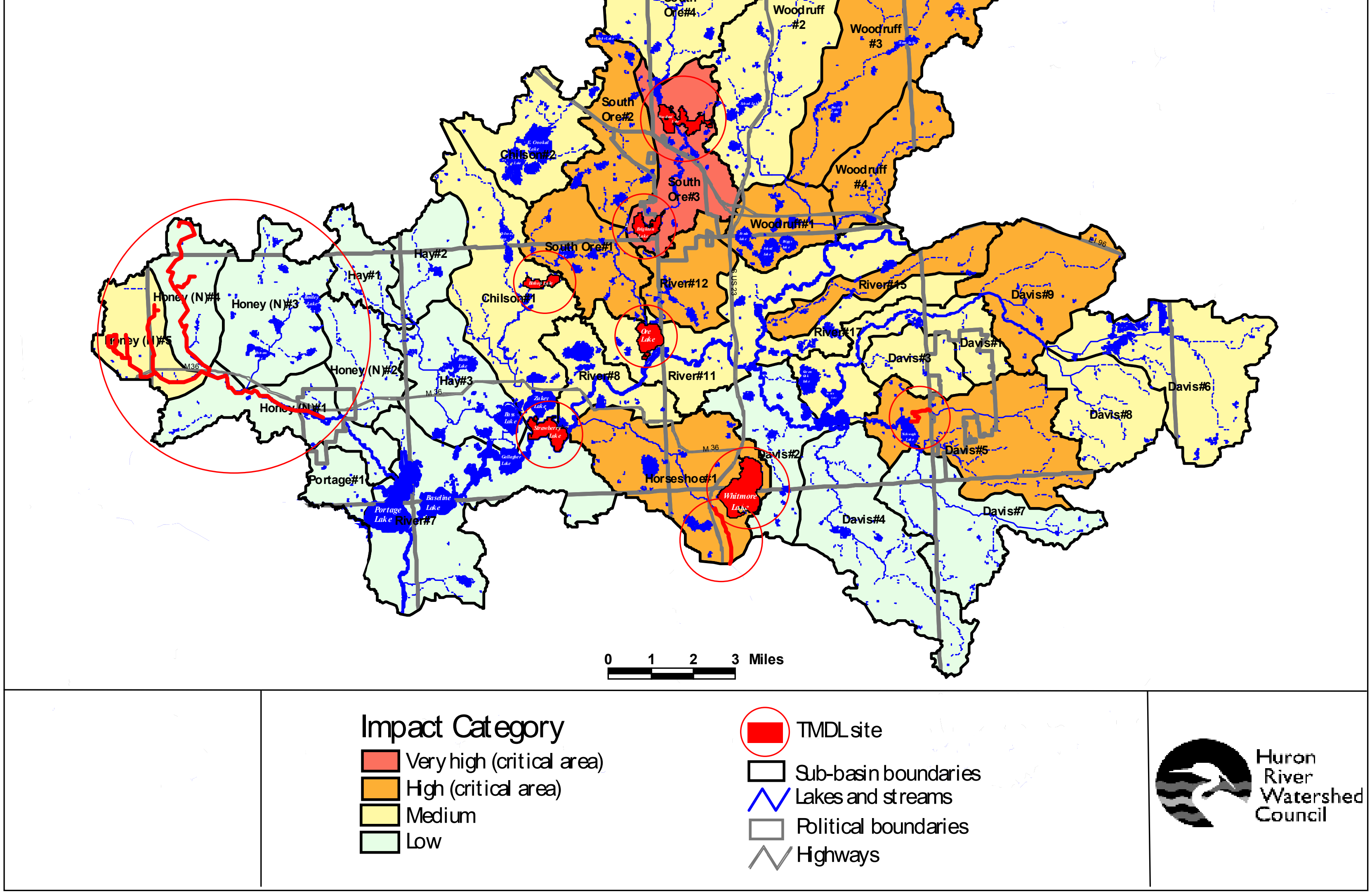
The critical areas of the Huron Chain of Lakes Watershed derived from this methodology are the sub-basins presented in Table 3.5 and Figure 3.8. The 11 highest-ranking sub-basins were identified as the critical areas, as they ranked "very high" or "high" in the methodology used to weight the impacts of all 35 sub-basins. Watershed restoration and protection efforts targeted to these sub-basins will produce the most cost-effective improvements toward meeting the goals of this plan. All sub-basins are presented below with their impact categories. Additional information about the methodology used for this procedure is provided in Appendix F.

Table 3.5. Critical Sub-basins (High Impact Category) of the Huron Chain of Lakes Watershed

Impact Category	Sub-basin
Very High	South Ore #3
High	Horseshoe #1
	River #12
	Davis #9
	Woodruff #4
	South Ore #2
	Woodruff #3
	Woodruff #1
	South Ore #1
	River #15
	Davis #5
Medium	Woodruff #2
	River #11
	South Ore #4
	Davis #1
	River #8
	Davis #6
	Davis #3
	Chilson #2
	River #17
	Davis #8
	Chilson #1
	Honey (N) #5
Low	Honey (N) #4
	Honey (N) #1
	Davis #2
	Davis #7
	Hay #3
	Davis #4
	Honey (N) #2
	River #7
	Portage #1
	Hay #1
	Honey (N) #3
	Hay #2

Figure 3.9

Huron Chain of Lakes Watershed Critical Areas and TMDLs



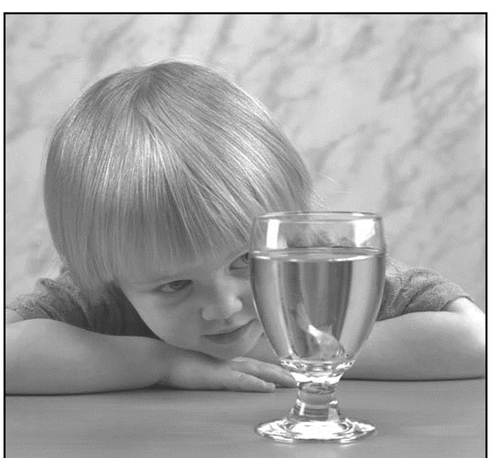
CHAPTER 4: ACTION PLAN FOR THE HURON CHAIN OF LAKES WATERSHED

Filling sandbags during the May 2004 flooding of the Huron River and Ore Lake
Photo: LCDC

Watershed management planning provides the opportunity for communities and other stakeholders to assess the current condition of their watershed and peer into the future to see what the watershed will look like if the status quo is maintained. The quality of life desired by the community for future residents often is not in step with the realities of where the community is headed.

This chapter outlines designated and desired uses of surface waters in the Watershed, the threats (impairments) posed to them, and the sources and causes of those threats. A set of goals and objectives has been developed by the Steering Committee to ensure that the designated and desired uses in the watershed will be met. Because surface water quality is ultimately a function of what water carries off of the land, much of the discussion will focus on how human activities impact the land and actions that can be taken to improve human land use from a water quality/quantity perspective. These recommended actions are described and summarized in the Action Plan (Table 4.6) at the end of this chapter.

4.1 DESIGNATED AND DESIRED USES



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

All surface waters of the state of Michigan are designated for and shall be protected for all of the following uses. [162] The designated uses that apply to the Huron Chain of Lakes Watershed are in boldface:

- **Agriculture**
- **Industrial water supply**
- **Public water supply at the point of intake**
- Navigation
- **Warmwater fishery**
- **Other indigenous aquatic life and wildlife**
- **Partial body contact recreation**
- **Total body contact recreation between May 1 and October 31**
- Coldwater fishery

Due to human impacts throughout the Huron Chain of Lakes Watershed, not all of the designated uses are fulfilled. Warmwater fishery is impaired due to elevated levels of PCBs in Whitmore Lake and Woodland Lake and high mercury levels in fish tissue samples from Bishop Lake. Other indigenous aquatic life and wildlife is also impaired due to poor macroinvertebrate communities in portions of Honey Creek and Horseshoe Lake Drain, and low levels of dissolved oxygen in a small segment of Yerkes Drain between the South Lyon Wastewater Treatment Plant and Nichwagh Lake. Aquatic life and warmwater fisheries may be threatened throughout the watershed as high nutrient loads that can lead to low dissolved oxygen levels and cause nuisance algal blooms in lake environments – most notably in Brighton, Ore, and Strawberry Lakes, for which phosphorus TMDLs have been established.

In addition to state-designated uses are uses of the watershed that are desired by its residents but not yet achieved. The Steering Committee identified the following desired uses:

- **Coordinated development**
  Promote a balance of environmental and economic considerations through intentional community planning and coordinated development within and among the Huron Chain of Lakes communities

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

- **Open space and greenways**
  Protect priority natural habitat, recreational areas and trails, and agricultural lands from development in order to maintain their natural functions, preserve rural character, and enhance recreational opportunities for present and future generations

4.2 Impairments and Their Sources and Causes

Various pollutants, or impairments, to the water quality of the Huron River and its tributaries are found throughout the Huron Chain of Lakes Watershed, which present challenges to meeting the designated and desired uses. Analysis of existing data indicates that the Huron Chain of Lakes Watershed has areas of medium-quality and low-quality waters that require mitigation of existing impairments. This section summarizes current impairments in the watershed and identifies the sources and causes of those impairments. The Steering Committee spent one year gathering the information necessary to identify and understand these impairments and their sources and causes, as well as to prioritize them from greatest to least threat. This prioritization of impairments is based upon the results of analysis of existing data, Steering Committee member observations, and citizen input. Although the partners in this Plan intend to address all of these challenges in the long term with targeted programs, it has been important to rank the most pressing concerns in the watershed so that resources can be spent cost-effectively in a phased approach. Table 4.1 presents this prioritized listing of impairments, sources, and causes in the Huron Chain of Lakes Watershed.

The sources and causes of each impairment in Table 4.1 are presented in priority order, based on the availability of data indicating direct linkages and assessments of the degree of contribution to the chain from cause to impairment. Known causes (k) are generally listed before suspected causes (s). Known impairments, sources or causes are defined as those where there exists direct data (i.e. a study or observation) or information establishing a connection. Elements listed as suspected are those for which a connection is implied by land use analysis or common sense. In cases where impairments, sources, or causes were suspected since not enough information was known about them, effort was made to gather additional information. Methods ranged from field work to desktop analyses using a geographic information system, to review of available literature and water quality studies. While much data was compiled to eliminate most suspected items in the table below, some items require further investigation to confirm their presence in the watershed and/or determine the extent to which they are hindering the designated uses in the watershed. As additional information is obtained that indicates that a lower ranked impairment, source or cause should be elevated in priority, the priority ranking should be adjusted to reflect the new information.

4.2.1 Excess Nutrients

A certain amount of nutrients are found in water resources naturally. In excess, nutrients can cause aquatic systems, both flowing and impounded, to become out of balance favoring certain organisms over others and changing the function, use and look of creeks, ponds and the river. Phosphorus is the primary nutrient of concern in the Huron Chain of Lakes Watershed because phosphorus is usually the limiting growth factor for algae and other nuisance plants in

Excess phosphorus from nonpoint sources encourages algae blooms. Photo: HRWC

Michigan aquatic ecosystems. When excess phosphorus enters waterways from excess fertilizer or other sources, it encourages the accelerated growth of plants and algae, reducing the dissolved oxygen and light entering the water and creating an environment where it is difficult for most fish and aquatic insects to live. High nutrient concentrations interfere with recreation and aesthetic enjoyment of waterbodies by causing reduced water clarity, unpleasant swimming conditions, foul odors, blooms of toxic and nontoxic organisms, and interference with boating.

Due to the persistent and systemic presence of high concentrations of phosphorus throughout many of the lakes and impoundments in the watershed, high nutrient loading is the top challenge identified in this Plan. TMDLs for excessive phosphorus loading from nonpoint sources exist in Brighton, Strawberry, and Ore Lakes. While the Huron River and its tributaries do not generally show signs of excessive phosphorus concentrations, many lakes and impoundments along these waterways tend to act as sinks for phosphorus loading, which can lead to eutrophic conditions. Sources of phosphorus in the watershed include fertilizers from lawns, golf courses, and croplands; failing septic systems; sediment and eroded soils; pet/wildlife wastes; illicit connections between sanitary sewers and storm drains; wastewater treatment plants; and contributions from upstream of the Kent Lake Dam. Most of these sources are associated with existing or newly developed areas, which continue to increase and therefore are a source of additional nutrient loads on water bodies in the watershed. Eroded soils can serve as a significant source of phosphorus to streams since the nutrient bonds with particles in the soil.

4.2.2 Altered Hydrology

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

Undercut banks are a sign of flashy flows
Photo: HRWC

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

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

The Huron River and its tributaries in the Huron Chain of Lakes Watershed have been altered substantially by wetlands drainage, stream channelization, dam construction, deforestation, and urbanization. These activities have affected the hydrology of the Huron River and its tributaries, including flow volume and flow stability, and channel morphology, including channel gradient and shape. The extensive network of dams and lake control structures, developed areas, engineered drains, and construction sites all play a role in producing flashy, sediment-laden flows. The large mass of curly-leaf pondweed growing in the Huron River downstream of Hamburg Road has also altered the hydrology of the river by slowing down the flow, which is particularly noticeable and problematic during periods of heavy precipitation, leading to disproportionately large floods.

4.2.3 Sediment

While some sedimentation in a river system is natural, as the streambanks in one area erodes and the soil is deposited downstream, the Huron Chain of Lakes experiences heavy sedimentation on the Huron main-stem, its tributaries, and lakes and impoundments. Impacts of soil erosion and sedimentation on downstream water resources include decrease of aesthetic quality with an increase of turbidity, decreased light penetration and decreased plant growth, and decrease in aquatic habitat with increased sediment islands blocking fish migration and sediment covering and clogging gills of fish and aquatic insects. In addition, nutrients and other pollutants often bond with soil particles, increasing the detrimental impacts of sedimentation on water resources.

HRWC volunteer Eric Piehl measures erosion on South Ore Creek Photo: HRWC

Many streambeds in the Huron River system are naturally composed of sand, gravel, and cobble, but a problem arises when a dramatic shift from these coarse materials to more fine sediments occurs. Silt, which is fine-grained sediment, is an important factor when considering a creek's quality. Silt is smaller than sand and larger than clay. Dramatic fine sediment increases suggest unnaturally high erosion rates. Excessive deposits of fine sediment appear to contribute to the impairment of macroinvertebrate communities in a number of locations, including Honey Creek, Davis Creek near Rushton Road, Yerkes Drain, and Horseshoe Lake Drain. Residents have also expressed concern for sedimentation in Brighton Lake, South Ore Creek from the Mill Pond downstream to Brighton Lake, and Lake Moraine on Mann Creek. Sediment also appears to be accumulating in the Huron River between Hamburg Road and Highway M-36, which is where the large mass of curly-leaf pondweed has become established that has exacerbated flooding around the Ore Lake area. Numerous other sites with sediment problems likely exist, but have not been reported or documented.

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

4.2.4 Pathogens

Impacts of pathogens in water resources include loss of recreational opportunities such as wading and canoeing due to public health concerns. Major sources of pathogens, specifically *E. coli,* in the Huron Chain of Lakes include failing on-site sewage disposal systems (OSDS, or septic systems), land application of untreated waste from these septic systems, and illicit discharges of sanitary waste into storm sewers that are mainly located in more urbanized areas. Little water quality data were found on pathogens in the watershed, and data provided by the Livingston County Health Department on *E. coli* monitoring at public beaches showed no instances of pathogen levels exceeding state water quality standards for designated uses in the watershed. Nevertheless, acceptable levels of pathogens are critical to overall water quality and BMPs must be implemented to ensure that pathogen levels are maintained or reduced throughout the watershed.

Approximately 42,000 households in Livingston County use septic tanks, generating 12 million gallons of untreated septage annually that is currently disposed of via land application at 13 permitted sites, which poses a risk to groundwater contamination. An estimated 1,000 new septic tanks are installed each year, which is predicted to increase septage volumes to 16 million gallons by 2020.[163] In an effort to reduce disposal of untreated septic waste via land application, Livingston County is in the process of designing a septage receiving station in Hartland Township that will allow trucks to unload their septage waste into a pipe that will transport the waste to a treatment plant in Genesee County.

Septic systems can fail for a number of reasons including inadequate soil conditions, long term use, and lack of proper maintenance or use. Failing septic systems may allow untreated human waste to eventually be discharged to nearby surface waters, where it can affect drinking water supplies, cause unacceptable water quality, and present a public health risk. Little information exists for septic system failure rates in the Huron Chain of Lakes Watershed, but studies in surrounding counties provide some insight. In Washtenaw County, 19% of all inspected septic systems have been found to be non-conforming as part of its ordinance requiring inspection of all septic systems at time of property transfer.[164] Wayne County also has a time-of-sale septic system inspection ordinance, which has demonstrated a failure rate of 26% of all inspected septic systems between 2000 and 2003. An inspection program in the City of Southfield in Oakland County has shown a failure rate of 20%.

Illicit discharges may be broadly defined as the introduction of untreated pollutants into surface waters through improperly connected pipes or improper disposal (illegal dumping). Illicit connections, which can originate in residential or commercial areas, can include floor drains, toilets, or washing machines that are improperly connected to storm drains instead of sanitary sewers. Septic systems that connect to storm drains are also illicit connections. Other examples of illicit discharges include pouring used motor oil or holding tank waste from a boat, RV, or mobile home into a storm drain or roadside swale. The frequency of illicit connections is difficult to estimate accurately. In Oakland County, the Rouge River Watershed has implemented a successful program to detect and eliminate illicit connections, and their findings indicate that the pollutants carried by these discharges can result in overabundance of *e. coli*, high ammonia levels, fecal coliform, phosphorus, and excessive algal growth in surface water. In 2004, with 353 facilities dye-tested, 97 illicit connections (24%) were identified. 82 of these were discharges related to floor drains.

Pet, livestock and wildlife wastes are also sources of pathogens, but it is even more difficult to quantify the extent and impacts of these sources than of the aforementioned sources.

At this time, the extent of pathogen contributions from a lack of adequate septage facilities is unclear. Little water quality data was found on pathogens, and data provided by the Livingston County Health Department on *E. coli* monitoring at public beaches showed no instances of pathogen (specifically *E. coli*) levels regularly exceeding state water quality standards for designated uses in the watershed. Nevertheless, acceptable levels of pathogens are critical to overall water quality and BMPs must be implemented to ensure that pathogen levels are maintained or reduced throughout the watershed.

4.2.5 Salts, Organic Compounds and Heavy Metals

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

Salt entering local waterways from road de-icing efforts was cited as a common concern among watershed residents. However, little data was found regarding salt concentrations in local waterways or impacts of salts on water quality. Conductivity data collected through HRWC's Adopt-A-Stream program at several sites on Mann Creek, Davis Creek, Horseshoe Lake Drain, and one site on the Huron River at Whitmore Lake Road all show consistently excessive conductivity readings. These high conductivity readings may suggest the presence of high concentrations of dissolved salt ions, although the extent to which other non-salt ions are influencing the readings is unknown.

A study by the USGS in Oakland County on the effects of urban land use change on streamflow and water quality showed a strong positive correlation between salt ions (sodium, potassium, and chloride) and residential and commercial landcovers, as well as overall percentage of the watershed built, and population density. These ions were negatively correlated with agriculture, open space, forest, and wetland land covers.[165] While it may reasonably stated that the rapid urbanization in the Huron Chain of Lakes Watershed has lead to increased salt concentrations in the water, the extent to which this is occurring and the impacts of these salt concentrations requires additional monitoring data and studies.

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

In the watershed, potential sources of organic compounds and heavy metals include urban areas, roads, permitted industries, existing in-stream contamination from historic activities, chemicals from lawns, and runoff from agricultural operations. Little data exists for organic compounds and heavy metals in the Huron Chain of Lakes. As discussed in Chapter 2, Huron River water chemistry data collected in 2002 by MDEQ at Whitmore Lake Road in Green Oak Township showed that all contaminants covered under Michigan Rule 57 (which includes a variety of organic compounds, trace and heavy metals, and PCBs) were in compliance with water quality values, with the exception of PCBs, which were also exceeded at all 35 monitoring stations throughout the state. TMDLs for PCBs in fish tissue are scheduled to be established for Whitmore Lake and Woodland Lake. A TMDL for mercury in fish tissue is scheduled to be established for Bishop Lake in the Chilson Creekshed.

4.2.6 Elevated Water Temperature

Water temperature directly affects many physical, biological, and chemical characteristics of a waterbody. Temperature affects the amount of oxygen that can be dissolved in the water; the rate of photosynthesis by algae and larger aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases. These factors limit the type of macroinvertebrate and fish communities that can live in a stream. Thermal pollution, the discharge of heated water from industrial operations, dams, or stormwater runoff from hot pavement and other impervious surfaces often cause an increase in stream temperature. Suspended sediment loads can also contribute to elevated water temperatures.

All waters in the Huron Chain of Lakes are warmwater fish streams. However, some coldwater fish species are found in portions of watershed, and the presence of EPT and sensitive aquatic insect families at many monitoring sites is an indication of adequately cool stream temperatures. Davis Creek at Rushton Road had the warmest average stream temperature from available data at 77º F, which is warm enough to restrict or exclude many species of fish and macroinvertebrates. Monthly temperature fluctuations were greatest on sites at Hay and Honey creek, which varied by 20º F and 24º F respectively. Such high temperature fluctuations can impact biodiversity. Low flows below impoundments, removal of streambank vegetation, and inputs of stormwater runoff (which are typically substantially warmer than base stream flows) are all potential contributing factors to elevated water temperatures.

4.2.7 Litter/Debris

Observations from the stream crossing inventory, as well as observations from Steering Committee members and watershed residents, indicate that debris and litter is a problem throughout the Huron Chain of Lakes Watershed. Debris refers to broken down pieces of materials such as those used in construction while litter refers to strewn trash and wastepaper. The presence of debris and litter reduces the aesthetic value of water resources as well as poses potential hazards to humans and wildlife. Field observations indicate that the sources of debris and litter include roadways, residential areas, parks, urban areas.

Table 4.1. Prioritized Impairments, Sources and Causes in the Huron Chain of Lakes Watershed

Impairment 1: High Nutrient Loading (k)	
Sources	**Causes**
1. Excessive runoff from developed areas (k)	Lack of BMPs at existing development areas (k) Impervious surfaces (k) Poor storm drain maintenance (s)
2. Failing septic tanks (k)	Old units are too small or don't meet codes (k) Lack of a required maintenance program (k) Poor maintenance/lack of education (s)
3. Fertilizers from residential, commercial, and golf courses (k)	Lack of buffers (k) No ordinance in place (k) Overuse/improper application of fertilizers (s)
4. Illicit discharges (k)	Aging sanitary sewer infrastructure (s) Inadequate inspection/detection and repair due to cost (s) Illegal septic application and trailer waste disposal (s)
5. NPDES permitted facilities (k)	Nutrients in effluent (k)
6. Agricultural runoff from fertilizers/ livestock waste (s)	Lack of BMPs (upland and riparian buffers) (s) Exposed soils (s)
7. Pet and wildlife waste (s)	Improper disposal of pet waste (s) Ponds increase habitat for waterfowl, wildlife (s)

Table 4.1. (continued) Prioritized Impairments, Sources and Causes in the Huron Chain of Lakes Watershed

Impairment 2: Altered Hydrology (k)	
Sources	**Causes**
1. Runoff from developed areas (k)	Lack of BMPs at existing development areas (k) Impervious surfaces (k) Removal of woodland/forest, wetlands, and other pervious areas (k)
2. Runoff from construction sites, new development (k)	Removal of woodland/forest, wetlands, and other pervious areas (k) Rerouting channel for development (k) Lack of resources for enforcement/inspection (s) Site exemptions (s) Lack of education on alternatives (s)
3. Engineered drains and streams (k)	Loss of connection between stream and floodplain from channelization (k) Removal of riparian buffer (k)

Impairment 3: Sedimentation, Soil Erosion (k)	
Sources	**Causes**
1. Eroding stream banks and channels (k)	Flashy flows (k) Channelization (k) Drain maintenance (k) Eroding crossing embankments (k) Clear cutting/lack of riparian buffers (k)
2. Construction sites (k)	Clear cutting/lack of riparian buffers (k) Lack of resources for enforcement/inspection (s) Lack of soil erosion BMPs and BMP education (s) Exposed soils (s) Site exemptions (s)
3. Developed areas (k)	Lack of BMPs at existing development areas (k) Impervious surfaces (k) Clearcutting/lack of riparian buffers (k)
4. Dirt, gravel roads (k)	Poorly designed/maintained road stream crossings (k) Poor road maintenance (s)
5. Agricultural field runoff (s)	Lack of BMPs (upland and riparian buffers) (s) Exposed soils (s)

Impairment 4: Pathogens (k)	
Sources	**Causes**
1. Failing septic tanks (human waste) (k)	Old units are too small or don't meet codes (k) Lack of a required maintenance program (k) Inadequate enforcement by Health Departments (s) Poor maintenance/lack of homeowner education (s)

Impairment 4: Pathogens (k)	
Sources	**Causes**
2. Illicit Discharges (k)	Aging development sanitary sewer infrastructure (k) Illegal septic application and trailer waste disposal (s) Inadequate inspection/detection and repair due to cost (s) Lack of education (s)
3. Pet and waterfowl waste (s)	Improper disposal of pet waste (runoff from paved areas) (s) Ponds increase habitat for waterfowl, wildlife (s)
4. Illegal/improper septage application (s)	Lack of adequate septage disposal facilities (s)
5. Livestock waste from agricultural operations (s)	Lack of BMPs (s)

Impairment 5: Salts, Organic Compounds and Heavy Metals (k)	
Sources	**Causes**
1. Developed areas (k)	Lack of stormwater BMPs (k) Illegal dumping (s) Illicit connections (s)
2. Roads (k)	Auto emissions (k) Lack of BMPs during road de-icing (s) Poor road maintenance (s)
3. Existing in-stream pollution (k)	Illegal dumping (s) Oil spill in Yerkes Drain in 1970s (k) PCBs in Whitmore Lake and Woodland Lake (k) Excessive mercury in Bishop Lake (k)
4. NPDES permitted facilities (s)	Inadequate inspection (s) Lack of BMPs (upland and riparian buffers) (s)
5. Turfgrass chemicals from residential, commercial lawns (s)	Improper lawn care (s) Illegal disposal (s)
6. Agricultural runoff (s)	Lack of BMPS (upland, riparian buffers) (s)

Impairment 6: High Water Temperature (k)	
Sources	**Causes**
1. Directly connected impervious areas (k)	Heated stormwater from urban areas (k)
2. Eroded soil areas (s)	Soil erosion from channel and upland (k)
3. Solar heating (s)	Lack of vegetated canopy in riparian zone (k)

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

Several overarching challenges play a role in generating the impairments discussed above. Addressing these challenges is a prerequisite to mitigating the sources and causes of the impairments in order to reach the designated and desired uses in the Huron Chain of Lakes Watershed.

Land Use Changes

New development along surface waters often increases the amount of nonpoint sources of pollution in the waterbody. Photo: HRWC

Perhaps the greatest concern and threat to water quality degradation in the watershed is land use change. Between 1982 and 1992, Michigan lost approximately 854,000 acres of farmland to suburban development, which is comparable to losing the area of 3.75 Michigan townships per year.[166] Moreover, the conversion of farmland to other uses accelerated from 1992 to 1997 by 67% over the previous 5-year period.[167] The economic impact of such changes in land use is potentially significant. In fact, the Michigan Economic and Environmental Roundtable (2001) estimates that the state loses $66 billion of economic output annually from decreased tourism and recreation, farming, forestry, and mining due to poorly planned suburbanization. The U.S. Department of Agriculture considers much of southeast Michigan to be high-quality farmland facing high development pressure.[168]

When land is converted from natural areas and low-density use, as in a rural area, to a more intensive use such as medium density residential or commercial land use, water quality and quantity can be negatively impacted. Increased flow rates and velocities, increased stormwater pollutants, as well as a decrease of natural areas can lead to sedimentation, stream bank erosion, loss of wildlife habitat, water temperature increase, algal blooms, decreased dissolved oxygen and other impacts.

Loss of Natural Features

The loss of natural features often comes hand in hand with new development. Natural features - including groundwater recharge areas, woodlands, wetlands, watercourses, permeable soils, vegetative buffers, and steep slopes – provide many natural functions in the landscape with regard to protecting water quality, regulating water quantity and providing wildlife habitat to receiving watercourses. In natural areas, most of the stormwater is infiltrated and utilized where it falls, allowing most pollutants to be filtered through soils. When these areas are lost, and their functions are not replaced (with infiltration, detention or restoration measures), nearby water resources are impacted negatively with increased flow and increased pollutant loads.

Areas where riparian vegetation is still fairly intact should be prioritized for preservation and restoration based on the critical importance of this natural feature to the whole Huron River watershed. Riparian vegetation has many benefits to water resources, including stream bank stabilization, terrestrial and aquatic wildlife habitat structure, and shading and cooling of water. The impacts of losing riparian vegetation include the increase of stream bank erosion, loss of habitat and warmer water, which could threaten the survival of fish and aquatic insects.

Studies indicate that half of the state's inland wetlands and 70% of the coastal wetlands no longer exist.[169] Permitted fills for commercial and industrial development, housing, roads, agriculture, and logging claim an estimated 500 acres of wetlands statewide each year. The Huron River Watershed has lost approximately 66% of its wetlands to human activities. This great change in the landscape has the potential to contribute to increased flooding, loss of property values, water pollution, and diminished and fragmented wildlife habitat. Wetlands smaller than 5 acres or not within 500 feet of another waterbody are not regulated by the state. Such wetlands often serve as many or more important functions than do the larger wetlands.[170] Therefore, local protection of these systems is needed.

Need for Public Awareness and Action

A general lack of awareness exists regarding the wide range of behaviors and policies that affect water quality, and a misperception exists about who contributes to the pollution in the watershed. For example, the basic concept of a watershed is not grasped by a majority of the public. Likewise, many people are unaware that storm drains lead directly to surface waters without treatment of stormwater. Another common misperception is that point sources such as wastewater treatment plants and industrial facilities, rather than nonpoint sources, are responsible for a majority of the pollutants in our waterways. Such misperceptions leads to complacent attitudes and a lack of personal responsibility, which in turn translate into a lack of community-based action to protect and restore local water resources. The impact of this lack of awareness and action has direct and indirect consequences. Directly, it encourages the further degradation of the resource by continuing to allow stormwater runoff and pollutants into our waterways. Indirectly, lack of public awareness and action can lead to a lack of interest by local decision-makers and thus lack of initiatives, programs, policies, and funding to either protect or restore water resources.

Need for Administrative Support and Institutional and Financial Arrangements

The members of the Huron Chain of Lakes Steering Committee have made commitments to protect and restore water resources with a broad spectrum of projects and programs. There is a corresponding need for additional support within these communities in order to implement, document and report on the various aspects of these increased responsibilities. Some communities have responded to this need to integrate stormwater projects and education into their regular activities by contracting with a consultant or hiring new personnel. With this need for additional support comes a need for additional funding. Creative partnerships, new fees, and grant funds need to be explored. The potential impact of inadequate program support, financial resources and institutional arrangements is the failure to create and implement programs, policies and projects that ensure the designated and desired uses.

Monitoring Programs and Data

Integrated and coordinated water quality monitoring needs to be more firmly established within the watershed. Review of readily available and relevant data reveals a number of concerns. In some cases, studies and data significant to water quality decisions are only minimally distributed within the area of interest. In other cases, existing datasets are not complete enough to be used as a basis for watershed decisions. Other datasets are nearly non-existent, especially those dealing with emerging issues such as the presence or absence of endocrine disrupting compounds (EDCs) in the water, sediments, and biota. The wide range of EDCs includes birth control pills, steroids, pesticides, inorganics, and industrial chemicals. In addition, the quality of some of the existing data causes concerns, given that the quality assurance/quality control (QA/QC) protocols of sampling parties is unknown. The type of data that has been historically collected is often not useful for answering the key questions about the watershed. Moreover, the lack of time-series data prohibits the detection of trends.

4.3 Goals and Objectives for the Huron Chain of Lakes Watershed

The designated and desired uses for the Huron Chain of Lakes Watershed provide a basis from which to build long-term goals and objectives. Long-term goals describe the future condition of the watershed toward which the Steering Committee will work. Long-term goals are not expected to be met within the first five years of plan implementation, but are to be met at some time beyond the first five years of implementation. The long-term goals have been developed on a watershed-wide basis and are also based on creating the most effective solutions to address the highest priority impairments, sources and causes in the watershed. No single community or agency is responsible for achieving all of the goals or any one of the goals on its own. The goals represent the desired end product of many individual actions, which will collectively protect and improve the water quality, water quantity and biology of the watershed. The communities of the Huron Chain of Lakes Watershed will strive together to meet these long term goals to the maximum extent practicable by implementing a variety of BMPs over time, as applicable to the individual communities and agencies, relative to their specific priorities, individual jurisdictions, authority, and resources.

Due to the complex ecological nature of the response of watersheds to stormwater management, it is difficult to predict when these goals will be met. Some of the administrative long-term goals might realistically be met in the next few years, whereas some of the ecological goals will require more study and improvements, and may take multiple permit cycles to achieve. Rather than attempting to predict when these goals will be achieved, the partners will continuously strive to meet these goals by implementing various best management practices (BMPs) that are recommended for addressing the various goals. The partners will understand what progress is being made to achieve these goals by using an iterative process of implementing BMPs and evaluating the effects of these BMPs by regularly monitoring the river for change and degree of improvement.

The long-term goals and objectives as agreed upon by the Steering Committe are presented in Table 4.2. Short-term objectives are presented for each goal, and will be partially or wholly fulfilled within the first five years of plan implementation. Long-term objectives are developed for some of the goals, and may be partially fulfilled during the first five years of plan implementation but realistically will be fulfilled in subsequent implementation phases.

The goals and objectives are listed in priority order. These priorities were determined in discussion with the Steering Committee after reviewing the list of priority impairments, sources and causes in conjunction with the relevant data and analyses presented in previous sections of this plan. The Committee determined that the combined actions implied by these goals and objectives would be the most effective way to address high-priority watershed impairments.

Table 4.2. Goals and Objectives for the Huron Chain of Lakes Watershed, and the Designated and Desired Uses They Address

Long-Term Goal	Short-Term Objective	Uses(s) Addressed
1. Increase public awareness of their role in protecting water resources	a. Increase opportunities for public involvement in protection of watershed resources b. Promote education, incentive, and stewardship programs that encourage individual source control of pollutants c. Promote coordination among local units of government in educational program development and implementation. d. Encourage partnerships between public and private entities in funding and promoting educational messages and activities **Long-Term Objective** e. Reduce pollution impacts to the Watershed by providing practical knowledge to key audiences	Designated Uses: all Desired Uses: all
2. Reduce nonpoint source nutrient loading	**Short-Term Objective** a. Support establishment of water quality monitoring programs to measure progress toward phosphorus TMDL goals. b. Develop ordinances, strategies, and/or programs for reducing nutrient loading. c. Promote implementation of structural and vegetative BMPs at new and existing developed areas. **Long-Term Objective** d. Meet established TMDL goals for Brighton, Ore, and Strawberry lakes.	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Partial and total body contact recreation Desired Uses: Hydrologic functions of natural features
3. Reduce flow variability	**Short-Term Objective** a. Establish current stream flow dynamics through established monitoring strategy b. Increase the use of Low Impact Development (LID) design principles c. Develop ordinances, strategies, and/or programs to manage peak flow rates **Long-Term Objective** d. Protect and increase storage in wetlands, floodplains, groundwater, and other pervious areas with infiltration capacity	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Desired Uses: Hydrologic functions of natural features
4. Reduce soil erosion and sedimentation	**Short-Term Objective** a. Establish baseline data for sediment fines in monitored streams through established monitoring program b. Improve application and enforcement of soil erosion and sedimentation controls (SESC) c. Increase education of BMPs among property owners and the building community **Long-Term Objective** d. Increase clarity in surface waters	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Industrial water supply; Public water supply Desired Uses: Hydrologic functions of natural features
5. Protect and mitigate loss of natural features for indigenous riparian and	**Short-Term Objective** a. Integrate natural features mapping data into land use planning decisions b. Develop policies that protect natural areas c. Monitor water quality and biota to measure progress	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Industrial water supply; Public water supply

aquatic animals and plants	d. Educate local decision makers and the public about the benefits of critical habitat protection e. Consider groundwater recharge data when identifying priority natural features protection areas **Long-Term Objective** f. Maintain or improve the aquatic community, including meeting TMDL goals for poor macroinvertebrate communities in Horseshoe Lake Drain and Honey Creek. g. Increase areas of natural features, including wetlands, woodlands, riparian buffers, and floodplains	Desired Uses: Hydrologic functions of natural features; Open space and greenways
6. Protect existing open space and agricultural land	**Short-Term Objective** a. Identify and prioritize key opportunities for protection of undeveloped lands b. Develop policy and planning tools that address urban sprawl c. Facilitate regional coordination in preserving open space corridors, especially riparian corridors d. Work with land conservancies and other land preservation groups to facilitate use of land protection/conservation tools	Designated Uses: Warmwater fishery; Aquatic life and wildlife; Desired Uses: Hydrologic functions of natural features; Open space/greenways
7. Protect and enhance recreational opportunities	**Short-Term Objective** a. Identify and reduce sources of pollution that inhibit recreational activities b. Increase regional coordination of recreational planning efforts c. Research and pursue grant opportunities for recreational planning efforts	Designated Uses: Partial and total body contact recreation; Warmwater fishery; Desired Uses: Open space/greenways; hydrologic functions of natural features
8. Increase monitoring of water quality, water quantity, and biological indicators	**Short-Term Objective** a. Develop a monitoring strategy b. Secure funding and develop partnerships to conduct short-term and long-term monitoring of key indicators c. Implement and maintain Illicit Discharge Elimination Program (IDEP) investigations	Designated Uses: all Desired Uses: all
9. Balance environmental and economic benefits in the subwatershed	**Short-Term Objective** a. Integrate stormwater management in planning and site plan review process b. Educate land use decision makers and developers on long-term economic benefits of stormwater BMPs, impacts of development on the watershed, and tools for low impact development c. Increase coordinated planning efforts and implementation among local units of government	Designated Uses: all Desired Uses: all
10. Attain full plan implementation	**Short-Term Objective** a. Establish financial and institutional arrangements for WMP fulfillment b. Ensure the long-term viability of the Huron Chain of Lakes Steering Committee to guide watershed-wide planning decisions. c. Increase public awareness of progress in WMP implementation	Designated Uses: all Desired Uses: all

4.4 WATERSHED MANAGEMENT ALTERNATIVES

Once the Steering Committee members identified the current conditions – specifically, the priority list of impairments, sources and causes -- of the watershed and the direction in which they want the watershed to go (the designated and desired uses), they reviewed their existing management approaches. Communities identified existing ordinances, policies, and practices that contribute to the group's vision of a healthy watershed, as well as gaps and inconsistencies that present opportunities for improvement. Understanding current management provides a starting point for identifying alternatives to improve protection of critical sensitive areas and mitigation of critical degraded areas. The Steering Committee utilized two tools to inventory their current management strategies, the Codes and Ordinances Worksheet and the Best Management Practices Menu. Both of these tools are described in this chapter.

4.4.1 Assessment of Community Development Codes and Ordinances

If the watershed communities would like to protect the quality of the water resources and the character of the landscape under a continued growth scenario, local governments, developers, and site designers alike must fundamentally change the way land is developed. Deciding where to allow or encourage development, promote redevelopment, or protect natural resources are difficult issues jurisdictions have to balance. While effective zoning and comprehensive planning are critical, communities should also be exploring ways to minimize the impact of impervious cover, maintain natural hydrology, and preserve contiguous open space on development sites.

An in-depth review of local development standards, ordinances and building codes that shape how development occurs in a community was completed by the following ten communities in the Huron Chain of Lakes: Brighton Township, City of Brighton, Genoa Township, Green Oak Township, Hartland Township, Highland Township, Lyon Township, Milford Township, Village of Pinckney, and Putnam Township. The review utilized a Codes & Ordinances Worksheet (COW) adapted by the Huron River Watershed Council for Huron River Watershed communities from the original COW developed by the Center for Watershed Protection. The COW evaluates the level of protection afforded by a community's building codes and ordinances. It is a useful guide to review development rules, and serves as a basis for determining where future improvements can be made.

The responses to the COW were compared to a set of Model Development Principles which are set forth in the publication *Better Site Design: a Handbook for Changing Development Rules in Your Community*[171]. Taken together, these Development Principles reduce impervious cover, conserve natural areas, and prevent stormwater pollution from new development while maintaining quality of life within a community. Participating communities in the Huron Chain of Lakes Watershed received individual results, prioritized suggestions for improving codes and ordinances to address stormwater, and supporting materials for how to begin implementing the recommendations. In addition, HRWC presented the general results and facilitated a discussion

that focused on the benefits and challenges of implementing a subset of common recommendations that applied to all or most of the participating communities.
The model development principles upon which *Better Site Design* is based are merely benchmarks; each community should adapt relevant principles and refine recommendations appropriate to local circumstances. Every community has opportunities to alter some part of its subdivision and development codes to foster development that better protects environmental resources and is economically advantageous for the development community.

BENEFITS OF APPLYING THE MODEL DEVELOPMENT PRINCIPLES[172]

The model land development principles have documented benefits for both the natural environment and the community. Communities implementing the model principles have realized the following benefits:

- Protected the quality of local streams, lakes, and estuaries
- Resulted in a more attractive landscape
- Reduced car speed on residential streets
- Generated smaller loads of stormwater pollutants
- Allowed for more sensible locations for stormwater facilities
- Helped to reduce soil erosion during construction
- Reduced development costs
- Increased local property tax revenues
- Increased property values
- Facilitated compliance with wetlands and other regulations
- Created more pedestrian friendly neighborhoods
- Provided open space for recreation
- Promoted neighborhood designs that provide a sense of community
- Protected sensitive forests, wetlands, and habitats from clearing
- Preserved urban wildlife habitat

Common gaps in local policies that were identified through this process yielded opportunities that are presented in Table 4.3.

Table 4.3: Policy Opportunities Identified in Communities of the Huron Chain of Lakes Watershed

Recommendation	Benefits
Adopt and implement ordinances for stream buffers, wetlands with natural features setback, and floodplains. Incorporate plans for buffer maintenance and management in the ordinances.	• Reduces amounts of nonpoint source pollutants (nutrients, sediment, oil, salt, metals, pesticides, etc…) • Reduce hydrologic impacts from loss of floodplains and wetlands, and increased imperviousness • Reduce stream temperature
Establish a land runoff program for water quality improvement; i.e. adopt a phosphorus reduction ordinance to reduce non-point sources of phosphorus to local waterways; provide incentives for reduction of fertilizer & herbicide use.	• Reduces amounts of nonpoint source pollution from nutrients, sediment, and pesticides • Reduces amounts of nonpoint source pollutants (nutrients, sediment, oil, salt, metals, pesticides, etc…)
Incorporate requirements for managing the quality and quantity of stormwater runoff from new development sites, including residential, commercial and institutional.	• Reduce hydrologic impacts from loss of floodplains and wetlands, and increased imperviousness • Reduces amounts of nonpoint source pollutants (nutrients, sediment, oil, salt, metals, pesticides, etc…)
Provide preservation and conservation options in development codes: - Develop land conservation incentives - Adopt and implement a farmland preservation ordinance - Preserve specimen trees - Establish open space management requirements	• Reduce hydrologic impacts from loss of floodplains and wetlands, and increased imperviousness
Allow for and promote more on-site retention of stormwater, i.e. allow for bioretention islands in landscaped areas of parking lots; allow for rooftop runoff to be discharged over pervious areas on residential sites.	• Reduce hydrologic impacts from loss of floodplains and wetlands, and increased imperviousness • Reduces amounts of nonpoint source pollutants (nutrients, sediment, oil, salt, metals, pesticides, etc…)
Establish a minimum percentage of parking lot area that is required to be landscaped	• Reduce hydrologic impacts from loss of floodplains and wetlands, and increased imperviousness • Reduce stream temperature
Incorporate options in development code to reduce impervious surface cover, i.e. street widths, right of ways, minimum cul-de-sac radius, driveway widths and parking ratios. Allow for pervious materials to be used in spillover parking areas.	• Reduce hydrologic impacts from loss of floodplains and wetlands, and increased imperviousness • Reduce stream temperature

Recommended alternative policies and programs deemed to yield the most benefit for the cost are included in the Action Plan. Appendix D contains a copy of the COW questions and corresponding desired responses, as well as the summarized results and recommendations for each community that completed the COW exercise. Based on the responses, there are many opportunities for enhancing current local standards within the Huron Chain of Lakes Watershed. The following areas seem particularly promising:

- Stream, wetland, steep slope, and floodplain buffer requirements, education and maintenance activities;
- Stormwater management in the site plan review process;
- Floodplain and wetland (<5 acres in size) protection criteria & standards;
- Impervious surface reduction through promoting incentives for clustering, reducing residential street widths and lengths, and reducing cul-de-sac radii;
- Open space requirements/encouragement (consolidation, use/alteration restrictions);
- Native landscaping techniques, soil testing, and integrated pest management;
- Enhanced soil erosion control standards and enforcement (e.g., based on site specific particle size analysis); and
- Rewarding the use of ecological landscaping design (e.g., capture of smaller and more frequent storms, disconnection of downspouts, utilization of bioretention, recycling of captured stormwater for on-site irrigation, reduced grading and alteration of natural slope, etc.)

Although not all communities in the watershed participated in this exercise, it is reasonable to assume that most of the recommendations presented to the participating communities could be extended to the non-participating communities, given the similarities in administrative resources and socio-economic conditions, among other factors.

4.4.2 Selection of Management Alternatives (Menu of Best Management Practices)

In the field of watershed management, management alternatives to address the sources and causes of the challenges are called Best Management Practices, or BMPs. BMPs cover a broad range of activities that vary in cost, effectiveness, and feasibility, depending on a complex set of factors. A stormwater best management practice is a technique, measure, or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost effective manner. BMPs fall into one of three categories:

Structural BMPs are engineered and constructed systems that improve the quality and/or control the quantity of runoff such as detention ponds and constructed wetlands. Structural BMPS are inherently site-specific and are designed to treat or manage stormwater at a specific location.

Vegetative BMPs are natural processes that preserve existing vegetation or establishes ground cover to minimize soil erosion. Vegetative BMPs are sometimes considered as a sub-set of structural BMPs.

Non-structural BMPs, also known as *Managerial BMPs*, consist of institutional, educational or regulatory pollution prevention practices designed to limit the generation of stormwater runoff or reduce the amounts of pollutants contained in the runoff.

No single BMP can address all stormwater problems. Each practice has certain limitations based on drainage area served, available land space, cost, pollutant removal efficiency, as well as a variety of site specific factors such as soil types, slopes, depth of groundwater table, etc. Careful consideration of these factors is necessary in order to select the appropriate group of BMPs for a particular location or situation.

Structural Practices

Structural stormwater BMPs are physical systems that are constructed for a development – new or existing – that reduce the stormwater impact of development. Such systems can range from underground, in-line storage vaults to manage peak flows, to slightly graded swales vegetated with wildflowers to slow flows as well as treat pollutants. Structural BMPs can be designed to meet a variety of goals, depending on the needs of the practitioner. In existing urbanized areas and for new developments, structural BMPs can be implemented to address a range of water quantity and quality considerations. Because the effect of these physical systems can often be quantitatively measured by monitoring inflow and outflow parameters, recent studies have suggested certain pollutant removal efficiencies of various BMPs. These data are summarized in table 4.4.

Residential stormwater BMPs, most of which are designed to reduce stormwater runoff via capture and later use by homeowners or via enhanced onsite infiltration, have several advantages. For instance, these practices can be readily applied in older development areas where space for drainage area BMPs is often limited, often low in cost, easily installed and maintained, and act as an educational vehicle for pollution reduction. Some examples of such practices include rain barrels (cisterns), rainwater gardens, concrete grid (porous pavers) walkways, and vegetated roofs. The application of individual homeowner BMPs can sometimes be variable and with uncertain pollutant removal rates. However, the importance of individual homeowner BMPs and managerial BMPs should not be discounted, and recommendations for implementation are provided below.

No single BMP type is ideally suited for every situation and each brings with it various performance, maintenance and environmental advantages and disadvantages. BMPs which consistently achieve moderate to high levels of removal for particulate and soluble pollutants include: wet ponds, sand filters, and infiltration trenches. Wet ponds have demonstrated a general ability to continue to function as designed for relatively long periods of time without routine maintenance. BMPs which are generally not capable of predictable pollution reduction rates until their fundamental design is improved or modified include: infiltration basins, grass filters and swales, and oil/grit separators.[173]

Table 4.4. Pollutant Removal Efficiencies for Stormwater Best Management Practices

Management Practice	Pollutant Removal Efficiencies: Total Phosphorus	Total Nitrogen	TSS	Metals	Bacteria	Oil and Grease
High-powered street sweeping	30-90%		45-90%			
Riparian buffers	forested: 23-42%; grass: 39-78%	forested: 85%; grass: 17-99%	grass: 63-89%			
Vegetated roofs	Note: 70-100% runoff reduction, 40-50% of winter rainfall. 60% temperature reduction. Structural addition of plants over a traditional roof system.					
Vegetated filter strips (150ft strip)	40-80%	20-80%	40-90%			
Bioretention	65-98%	49%	81%	51-71%		
Wet extended detention pond	48 - 90%	31-90%	50-99%	29-73%	38-100%	66%
Constructed wetland	39-83%	56%	69%	(-80)-63%	76%	
Infiltration trench	50-100%	42-100%	50-100%			
Infiltration basin	60-100%	50-100%	50-100%	85-90%	90%	
Grassed swales	15-77%	15 - 45%	65-95%	14-71%	(-50) - (-25)%	
Catch basin inlet devices		30-40% sand filter	30-90%			
Sand and organic filter	41-84%	22-54%	63-109%	26-100%	(-23) - 98%	
Stabilize soils on construction sites			80-90%			
Sediment basins or traps at construction sites			65%			

Sources: Claytor, R. and T. R. Schueler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection, Ellicott City, MD.
Ferguson, T., R. Gignac, M. Stoffan, A. Ibrahim and J. Aldrich. 1997. Cost Estimating Guidelines, Best Management Practices and Engineered Controls. Rouge River National Wet Weather Demonstration Project.
Brown, W. and T. Schueler. 1997. National Pollutant Removal Performance Database for Stormwater BMPs. Center for Watershed Protection, Ellicott City, MD.
Schueler, T. R. and H. K. Holland. 2000. The Practice of watershed Protection. Center for Watershed Protection, Ellicott City, MD.
Tetra Tech MPS. 2002. Stormwater BMP Prioritization Analysis for the Kent and Brighton Lake Sub-Basins, Oakland and Livingston Counties, Michigan.
Tilton and Associates, Inc. 2002. Stormwater Management Structural Best Management Practices – Potential Systems for Millers Creek Restoration. Ann Arbor, MI.
U.S. EPA. 2002. National Menu for Best Management Practices for Storm water Phase II.

Information regarding the pollutant removal efficiency, costs, and designs of structural stormwater management alternatives is evolving and improving constantly. As a result, information contained in Table 4.4 is dynamic and subject to change. While potential locations are recommended for some management alternatives in the Action Plan, general guidelines can be consulted for their common sense placement. The location guidelines shown in Table 4.5 are adapted from the Rapid Watershed Assessment Protocol of the Center for Watershed Protection.

Table 4.5. General Guidelines for Locating BMPs

Amount of Development	*Undeveloped*	*Developing*	*Developed*
Philosophy	Preserve	Protect	Retrofit
Amount of Impervious Surface	< 10 %	11 - 26 %	> 26 %
Water quality	Good	Fair	Fair-Poor
Stream biodiversity	Good-Excellent	Fair-Good	Poor
Channel stability	Stable	Unstable	Highly unstable
Stream Protection Objectives	Preserve biodiversity; channel stability	Maintain key elements of stream quality	Minimize pollutant loads delivered to downstream waters
Water quality objectives	Sediment and temperature	Nutrients and metals	Bacteria
BMP selection and design criteria	Maintain pre-development hydrology	Maintain pre-development hydrology	Maximize pollutant removal and quantity control
	Minimize stream warming and sediment	Maximize pollutant removal, remove nutrients	Remove nutrients, metals and toxics
	Emphasize filtering systems	Emphasize filtering systems	
Example locations	Rural headwater areas	Suburban and developing areas like Genoa, Brighton, Hamburg, Green Oak Twps	Heavily urbanized areas like South Lyon and Brighton City

Non-Structural Practices

Non-structural stormwater BMPs include managerial, educational, and regulatory practices designed to prevent pollutants from entering stormwater runoff or reduce the volume of stormwater requiring management. These BMPs focus on modifying behaviors and practices through education programs, public involvement programs, land use planning, natural resource protection, regulations, operation and maintenance, or any other initiative that does not involve designing and building a physical stormwater management mechanism. Although most of these non-structural BMPs are difficult to measure quantitatively in terms of overall pollutant reduction and other stormwater parameters, research demonstrates that these BMPs have a large impact on changing policy, enforcing protection standards, improving operating procedures and changing public awareness and behaviors to improve water quality and quantity in a watershed over the long term. Moreover, they target source control which has been shown to be more cost effective than “end-of-the-pipe” structural solutions. Therefore, these BMPs should not be overlooked, and in some cases, should be the emphasis of a stormwater management program.

Considerations in Selection of BMPs

The Steering Committee took steps to determine which BMPs are more environmentally effective and more cost effective toward meeting the goals for the Huron Chain of Lakes Watershed and addressing the priority impairments, sources and causes. An extensive, but not exhaustive, list of possible BMPs and their potential effectiveness at addressing specific impairments, cost, and feasibility was discussed and additions were included based on ideas generated at meetings. The Steering Committee considered which BMPs would (1) best address the priority impairments for the watershed in their locality, (2) be among the more environmentally effective at addressing priority sources and causes, and (3) be more likely to be implemented. This list of BMPs was shared among the Steering Committee members in order to coordinate ideas and resources, as well as to solicit suggestions from participants, identify gaps and ensure that watershed goals were being addressed adequately. These steps have resulted in the development of the Action Plan (Table 4.6).

The watershed is comprised of diverse communities, from rural townships to urban centers. Consequently, a variety of structural and non-structural management alternatives, or practices could be considered across the watershed. The alternatives described in this chapter may apply to one community but not to another, and so it is important to note that each of the alternatives is a unique solution to a specific pollution source that is a priority in the specific geography. This diversity of applications is described both in the Action Plan and in each individual SWPPI to be submitted after this plan is complete. Although each of these alternatives is applicable to at least one of the communities or agencies in the watershed, not all of them are appropriate for every community. Each community undertook their own assessment of impairment, source and cause priorities for their area and compared that with the description of the characteristics of each BMP to develop their own part of the action plan. Although it is not an exhaustive list of all of the possible management alternatives that could be considered, the recommended management alternatives for the watershed are summarized below in Section 4.5.

4.5 HURON CHAIN OF LAKES ACTION PLAN

To prepare the Action Plan Table, Steering Committee members assessed the information available about types of management alternatives and their appropriateness and efficiencies, the recommendations from the Codes & Ordinances Worksheet, the goals and objectives developed for the Huron Chain of Lakes, and their existing policies and programs. The management alternatives that are listed in the Action Plan include activities that the communities have selected as priorities to implement, as well as other BMPs that may contribute to achieving the plan’s goals and objectives but are not feasible to implement at this time.

While the individual communities and entities are responsible for meeting the goals and objectives of the Plan by implementing the recommended actions, the Action Plan is intended as a resource for *all* stakeholders in the Watershed. Local planners and governmental officials can draw upon these tools in their everyday decisions in their jobs. Local citizens can become involved at the grass roots level to implement some of these ideas, and also press their elected and local officials to carry out the management alternatives. Watershed-wide awareness of, and active support for, the management alternatives in the Action Plan is ultimately needed to ensure that the goals and objectives of the Plan are realized.

The management alternatives presented in the Action Plan are described briefly below in the order in which they appear on the Action Plan.

4.5.1 Recommended Actions to Achieve Watershed Goals and Objectives

Managerial Actions: Ordinances and Policies

Sample ordinances and supplemental resources for several of the policies and ordinances described in this section are available in the Appendices. McComb County's Department of Environmental Planning and Economic Development also maintains a list of model ordinances at: http://macombcountymi.gov/planning/Model_Envir_Ordinances.asp.

BMP #1: Adopt Phosphorus Fertilizer Reduction Ordinance
Nitrogen, phosphorus, potassium and other nutrients are necessary to maintain optimum growth of lawns and most gardens. While phosphorus is a naturally occurring nutrient in Michigan waters, human activities such as turfgrass fertilizing contribute excess amounts of phosphorus to lakes and rivers. Over-nutrification of freshwater systems can create nuisance algal blooms that deplete oxygen needed by aquatic organisms, which can lead to fish kills, and prevent water-based recreation. A local phosphorus fertilizer reduction ordinance can address the proper selection, use, application, storage and disposal of fertilizers, and incentives to reduce residential and commercial herbicide/fertilizer use. The ordinance should be combined with a coordinated information and education campaign to communicate the need for the ordinance. Research has shown that phosphorus is not needed as a soil additive in most areas within southeast Michigan. Hamburg Township, West Bloomfield Township and Commerce Township have successfully implemented such ordinances, and the City of Ann Arbor will be implementing its own in the near future.

BMP #2: Implement Native Landscaping Ordinance
Many of the native plants and shrub landcover of the watershed have been replaced with non-native plants and shrubs and turfgrass, both of which require intensive cultivation and application of chemicals. Native plant and shrub species are adapted to this area and require less water and less maintenance because of their deep root system and resistance to disease. Natives improve stormwater infiltration and stabilize soils by replacing turf grass or other introduced cover with native grasses, flowers, shrubs and trees. In addition, native species provide habitat and food to insects and wildlife. Native landscaping resources are available in southeast Michigan from plant growers to landscaping consultants. A native landscaping ordinance would promote planting of native species and remove any existing obstacles to growing these plants on residential and commercial lands.

BMP #3: Adopt No Dumping Ordinance
Several communities in the Huron Chain of Lakes Watershed already have ordinances in place that address dumping of substances in surface waters and wetlands. The ordinance can address a variety of substances from toxics to organic waste such as leaves. Residents of the watershed have commented on the presence of litter in the Huron River, so this ordinance may go a long way toward reducing it if enforcement and education mechanisms are included.

BMP #4: Adopt Pet Waste Ordinance
Pet waste can be washed into nearby surface waters and wetlands via direct runoff or storm water systems, thereby adding *E. coli* and nutrients to these freshwater systems. An ordinance that states proper pet waste management practices and provides for education, enforcement and necessary infrastructure (e.g., bag dispensers) can reduce the incidences of pet waste entering the watershed.

BMP #5: Adopt Private Roads Ordinance
A private roads ordinance complements efforts to reduce directly connected impervious surfaces by permitting roads to be built that are narrower than county road standards. Narrower roads produce a smaller area of impervious surface. The ordinance can promote rural character by allowing narrow roads in certain developments in order to preserve open space. Census data shows that most communities in the Huron Chain of Lakes Watershed will experience an increase in population and development, so this ordinance can be a preemptive means of protecting water resources. Sample ordinance language is available through County Planning Departments and the Huron River Watershed Council.

BMP #6: Adopt Purchase of Development Rights Ordinance
The purchase of development rights, known as PDR, is an effective tool for local government or non-governmental organizations such as land conservancies or land trusts, to purchase the development rights of a property to limit development and protect natural features, open space or agricultural land in perpetuity. The ordinance is a tool for guiding growth away from sensitive resources and toward delineated development centers. A PDR ordinance identifies areas that may be protected through conservation easements or purchased for public ownership either outright or through PDR. Communities in southeast Michigan have adopted PDR ordinances and garnered the resources to purchase important parcels of land for preservation in perpetuity.

BMP #7: Adopt Stormwater Management Ordinance
Regulations that can guide land development with regard to protecting the water quality, water quantity and biological integrity of the receiving surface water are important in undeveloped and soon-to-be-developed areas. This regulation can use existing data to determine the development impact that can be tolerated by the surface waters before that system will become degraded. Future development or redevelopment can be guided to control runoff so that local streams and water resources are not negatively affected by the development to the greatest extent practicable. The ordinance can incorporate requirements for managing the quality and quantity of stormwater runoff from new development sites, including residential, commercial and institutional sites. Adopting the Rules of the County Drain Commissioner's Office can be an element of the ordinance in order to be protective of local water resources. Modifications to existing engineering and design standards for stormwater management BMPs is a necessary element of this activity.

BMP #8: Adopt Local Wetlands Ordinances with Natural Features Setback
Wetlands serve as giant sponges, which soak up storm water during wet weather events allowing the water to infiltrate into the soil instead of running off directly to surface waters. As the stormwater infiltrates into the soil, pollutants are filtered out before it reaches groundwater. Wetlands serve to reduce storm water velocities, reduce peak flows and to filter out storm water pollutants, they also provide habitat for numerous wildlife species. A subset of all wetlands are regulated by state and federal authorities, i.e. in counties with 100,000 people or more, wetlands 5 acres or larger and wetlands within 500 feet of a waterbody are regulated. A wetlands ordinance that is more protective than required by the state or federal government is necessary to protect those smaller, isolated wetlands deemed important to a community. A model wetlands

ordinance is available to local communities from the Huron River Watershed Council and the Michigan Coastal Zone Program of the MDEQ.

BMP #9: Support County-wide Septic System Time-of-Sale and/or Maintenance Ordinance
An ordinance requiring specified time and standards for septic tank maintenance measures can be used to prevent, detect and control leaks, overflows and seepage from occurring. Septic systems should be designed, sited, operated and maintained properly to prevent nutrient/pathogen loadings to surface waters and to reduce loadings to groundwater. Septic tanks should be pumped at least every three years depending on the size of the family or group using the tank. Educational materials should be distributed to new and current homeowners that use septic tanks so that pollution prevention is emphasized.

A county-wide "Time of Sale" program requires the inspection and evaluation of septic systems and/or wells before residential property changes ownership. Such programs, which have successfully been implemented in Washtenaw and Wayne counties, protect public health and safety by ensuring safe and adequate water supplies and proper disposal of human sewage. In Washtenaw County, a seller may not transfer ownership of their property unless they have a letter from the Washtenaw County Health Department stating that their well and septic systems are in substantial compliance with the rules of Washtenaw County. In order to obtain this certificate, the Seller must have their systems inspected by a certified inspector. This procedure takes a minimum of three weeks to accomplish (assuming the inspections are satisfactory). The inspector completes a series of tests and fills out a written report of the test results which he submits to the Health Department. Within 5 days the Health Department either: (l) issues a letter stating that the systems are in substantial compliance; or (2) issues a letter stating that the system is not in substantial compliance. If this happens, the seller must obtain and submit to the Health Department a written bid which outlines the correction of the problem. If it is approved, the seller may proceed to have the problem corrected. Once the correction is completed, the Health Department will issue the letter of compliance. If the Seller needs to close on the sale before the remediation work can be completed, the Seller must escrow 1 1/2 times the amount of the bid with the title company at closing. Once the work is completed and approved, any remaining escrow funds will be returned to the Seller.

BMP #10: Adopt Overlay Zoning for Riparian Corridor (as part of Natural Features Ordinance)
In order to direct land development while protecting key local natural resources, local ordinances that clarify why the protection of certain features is important and how they will be protected under the law are necessary. These local ordinances can be more protective than state or federal law and can better reflect the priorities of a local community. The Code and Ordinance Worksheet process identified the following components that local communities could consider in a Natural Features Ordinance: woodlands, preserve specimen trees, natural features setback, floodplains, provide preservation and conservation options in development code such as develop land conservation incentives; adopt and implement a farmland preservation ordinance, and establish open space management requirements. Plans for natural features buffer maintenance and management should be included in the ordinances. Sample language is available from resource agencies and organizations such as the Huron River Watershed Council and Wayne County Planning.

BMP #11: Enhance Site Plan Review Requirements
Community site plan review standards can be revised to include, if applicable, the 100-year floodplain, location of waterbodies and their associated watersheds, location of slopes over 12

percent, site soil types, location of landmark trees, groundwater recharge areas, vegetation types within 25 feet of waterbodies, woodlands and other vegetation on site, and site topography.

BMP #12: Incorporate Low Impact Development Principles

Land use planning and management involves a comprehensive planning process to promote Low Impact Development (LID) and control or prevent runoff from developed land uses. LID is a low cost alternative to traditional structural stormwater BMPs. It combines resource conservation and a hydrologically functional site design with pollution prevention measures to reduce development impacts to better replicate natural watershed hydrology and water quality. Through a variety of small-scale site design techniques, LID reduces the creation of runoff, volume, and frequency. Essentially, LID strives to mimic pre-development runoff conditions. This micro-management source control concept is quite different from conventional end-of-pipe treatment or conservation techniques. The LID planning process involves the following steps: 1) determine water quality and quantity goals with respect of human health, aquatic life and recreation; 2) identify planning area and gather pertinent hydrological, chemical and biological data; 3) determine and prioritize the water quality needs as they relate to land use and the proposed development; 4) develop recommendations for low impact development to address the problems and needs that have been previously determined; 5) present recommendations to a political body for acceptance and 6) implement adopted recommendations.

BMP #13: Improve Enforcement of Litter Laws and Nuisance Properties

According to surveys by Keep America Beautiful, litter is caused by any of the following: pedestrians, motorists, uncovered trucks, loading docks, construction sites, improper residential refuse set-out, and improper commercial refuse set-out. Of all litter, 40 percent is accidental, such as something blowing out of a dump truck, while much of the 60 percent that's intentional occurs in places where litter has already accumulated.

BMP #14, 15, and 16: Improve Enforcement of Soil Erosion and Sediment Control Policies/ Improve Enforcement of Construction Site Inspections

Regular inspection of control measures is essential to maintain the effectiveness of during construction and post-construction stormwater best management practices. Generally, inspection and maintenance of practices can be categorized into two groups—expected routine maintenance and non-routine (repair) maintenance. Routine maintenance refers to checks performed on a regular basis to keep the practice in good working order. In addition, routine inspection and maintenance is an efficient way to prevent potential nuisance situations (odors, mosquitoes, weeds, etc.), reduce the need for repair maintenance, and reduce the chance of polluting stormwater runoff by finding and correcting problems before the next rain. In addition to maintaining the effectiveness of stormwater BMPs and reducing the incidence of pests, proper inspection and maintenance is essential to avoid the health and safety threats inherent in BMP neglect. The failure of structural storm water BMPs can lead to downstream flooding, causing property damage, injury, and even death.[174]

BMP #17: Minimize Total Impervious Cover in Zoning Ordinance

Utilizing a Low Impact Development (LID) Plan for new developments can reduce directly connected impervious surfaces. LID plans combine a hydrologically functional site design with pollution prevention measures to compensate for land development impacts on hydrology and water quality. The result will be a reduction in storm water peak discharge, a reduction in runoff volume and the removal of storm water pollutants. LID principles can apply to new residential, commercial and industrial developments. Under the umbrella of LID are specific options such as reducing street widths, right of ways, minimum cul-de-sac radius, driveway widths and parking ratios, allowing for pervious materials to be used in spillover parking areas, and establishing a minimum percentage of parking lot area that is required to be landscaped (preferably with native plants). Communities are encouraged to minimize the total impervious cover in Zoning Ordinances to protect water resources in the buildout scenario.

BMP #18: Promote Open Space Preservation in Zoning Ordinance and Master Plan
Zoning maps may be amended to increase protection for water resources. Inclusion of natural features and open space zoning are two of the most common and useful ways. Allowing for compact development design increases the ability to preserve a significant amount of open, undeveloped land by grouping buildings and paved surfaces to provide more compact developments while maintaining open spaces.

BMP #19: Review and Revise Grading and Land Clearing Practices
It is desirable for the protection of the Huron River that as much of a site be conserved in a natural state as possible. Areas of a site that are preserved in their natural state retain their natural hydrology and do not erode during construction. In general, grading and clearing ought to be restricted to the minimum area required for building footprints, construction access, and fire safety setbacks. Several tools may be adapted to limit clearing, including the soil erosion and sediment control ordinance, grading ordinances, tree or forest protection ordinances, and open space development.

BMP #20: Revise Parking Standards for New Developments and Redevelopments
The required parking ratio governing a particular land use or activity would be enforced as both a maximum and minimum in order to curb excess parking space construction. Parking codes would be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made. Reduce overall imperviousness of parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes and using pervious materials in spillover parking areas.

BMP #21: Revise Stormwater Management Standards for Pond Landscaping
This practice is meant to reduce nuisance geese habitat at storm water ponds through installation of shoreline buffer planting or other means. The practice is utilized each time the storm water system is reviewed or equivalent, with no end date. Parks departments may become involved to employ the same strategy near public water features.

Managerial Actions: Practices

BMP #22: Incorporate Results of Conservation Planning Analysis into Local Ordinances and Policies
In order to help state and local planning agencies, land conservancies, and local communities make better decisions about where to encourage growth and where to target preservation and restoration efforts, remaining natural areas in the Huron Chain of Lakes Watershed have been mapped and prioritized. In 2002, the Huron River Watershed Council mapped and ranked natural areas in the Huron River Watershed through the Conservation Planning in the Huron Watershed project. Mapped sites were ranked based on ecological and hydrological factors including size, presence of water, presence of wetlands, groundwater recharge, potential for rare plant communities, topographical diversity, and glacial diversity. Similar projects to map and prioritize natural areas are also found in Livingston County's High Quality Natural Areas Report (2003) and Oakland County's 2005 Potential Conservation/Natural Areas report. The results of these analyses need to be reviewed and then incorporated into each community's maps and land use decision making processes in order to protect the ranked priority areas.

BMP #23: Reduce Directly Connected Impervious Surfaces

After strategies have been employed to reduce overall site imperviousness in new developments and redevelopment, additional environmental benefits can be achieved and hydrologic impacts reduced by disconnecting impervious areas. Strategies include:

- Disconnecting roof drains and directing flows to vegetated areas or to dry wells
- Directing flows from paved areas such as driveways to stabilized vegetated areas
- Breaking up flow directions from large paved surfaces
- Encouraging sheet flow through vegetated areas
- Carefully locating impervious areas so that they drain to natural systems, vegetated buffers, natural resource areas, or permeable zones/soils. Ensure that flow velocities are maintained so as to not degrade the natural, vegetated filtering system.

In some cases, disconnecting impervious areas can reduce the effective impervious cover in a watershed by 20-50%.[175] In urban communities, especially older areas, there may be opportunities to disconnect impervious areas through downspout disconnection and the discharge of footing drains/sump pumps to green space rather than to stormwater conveyance systems.

BMP #24: Practice High-Powered Street and Paved Area Sweeping
High-powered street sweeping is a management measure that involves pavement cleaning practices on a regular basis to minimize pollutant export to receiving waters. These cleaning practices are designed to remove sediment debris and other pollutants from road and parking lot surfaces that are a potential source of pollution impacting urban streams. Recent improvements in street sweeper technology (e.g., regenerative air or vacuum assisted systems) have enhanced the ability of the current generation of street sweeper machines to pick up the fine grained sediment particles that carry a substantial portion of the stormwater pollutant load. Many of today's sweepers can now dramatically reduce the amount of street dirt entering streams and rivers. Street sweeping is recommended in cold climate areas during, or prior, to spring snowmelt as a pollution prevention measure.

BMP #25: Provide Pet Waste Bags in Parks and Public Areas
This program provides bags for pet waste clean up in order to reduce pet waste in parks, subsequently reducing the amount of *E. coli* entering surface waters from pet waste.

BMP #26: Increase Amount of Refuse Containers and Review Distribution
Some littering and dumping occurs for the simple reason that a refuse container are not in close proximity. Increasing public access to refuse containers reduces the motivation for intentional dumping or littering.

BMP #27: Alternative Drain Practices that Rehabilitate Stream and Riparian Habitats
The channelization of the Huron Chain of Lakes system to drain the land is the root of many problems in the watershed today. While the responsibilities of County Drain Offices continues to include maintenance of drains to prevent flooding by removing obstructive vegetation and sediment, opportunities to return stretches of drains to their more natural condition should be identified. Locations where agricultural uses have given way to development are candidates for alternative drain practices and rehabilitation. Breaking of drainage tiles in developing areas can be pursued in conjunction with rehabilitation of drains in order to increase the opportunity to restore hydrologic function to the river system. This practice should be done in conjunction with development, rather than after the fact. Often the tiles are not part of the drain, but are torn up as a result of development.

BMP #28: Practice Storm Drain/Catch Basin Marking

The purpose of storm water drain marking is to eliminate waste entering the Huron River through storm drains by creating public awareness of the danger of dumping into these drains. Storm drains are marked with a warning stating that any waste entering the drain goes straight to the Huron River. Along with the marking, the project places educational fliers on the doors of residences in the vicinity of newly marked drains. Markers are continuously placed on drains and replaced every few years when old markers begin to fade or fall off.

Managerial Actions: Studies and Inventories

BMP #29: Reduce the Use of Conventional Road De-icers
Managers are encouraged to consider the use of alternatives to conventional road salt (sodium chloride) such as a calcium chloride, or to ensure proper calibration of salt spreaders to reduce the amount of salt needed to the maximum extent practicable.

BMP #30: Develop and Implement Coordinated Monitoring Strategy to Measure Water Quality, Water Quantity, and Biota
A consistent dataset of water quality parameters, biotic indicators and stream flow is needed for a better understanding of conditions in the Huron Chain of Lakes Watershed and to use as baseline when measuring conditions following implementation of recommended management alternatives. Furthermore, pollutant removal efficiencies should be measured as part of any implementation project since the literature remains incomplete. Monitoring needs to include dry and wet weather events and seasonal variation over multiple years. Some of the monitoring could be conducted by trained volunteers affiliated with the Huron River Watershed Council's Adopt-A-Stream program or the Stream Team.

BMP #31: Initiate Hydrologic and Hydraulic Studies
A comprehensive study of the hydrology of the Huron Chain of Lakes system would provide an understanding of the interaction of precipitation, infiltration, surface runoff, stream flow rates, water storage, and water use and diversions. A hydraulics study would yield information about the river's velocity, flow depth, flood elevations, channel erosion, storm drains, culverts, bridges and dams. Information resulting from these studies would provide greater detail on the sources and causes of problems related to hydrology-induced erosion and flooding. The studies are prerequisite to identify the most appropriate management alternatives and best locations for practices that can restore the hydrology of the river and its tributaries.

BMP #32: Inventory and Stabilize Eroding Streambanks
Streambank stabilization measures are treatments used to stabilize and protect banks of streams or constructed channels, and lake shorelines. Understanding the cause of the erosion problem is paramount to implementing any streambank stabilization measure. If the cause is extreme peak storm water flows, then peak flow problems must first be addressed before stabilization measures can be expected to succeed. Streambank stabilization measures work by either reducing the force of flowing water and/or by increasing the resistance of the bank to erosion. Vegetating streambanks also provides important ecological benefits such as shading water and providing crucial habitat for both terrestrial and aquatic wildlife species. Three types of streambank stabilization methods exist: engineered, bioengineered and biotechnical. Engineered structures include riprap, A-Jacks, gabions, deflectors and revetments. Bioengineering refers to the use of live plants that are embedded and arranged in the ground where they serve as soil reinforcement, hydraulic drains, and barriers to the earth movement and/or hydraulic pumps. Examples of bioengineering techniques include: live stakes, live fascines, brush mattresses, live cribwall and branch packing. Biotechnical measures include the integrated use of plants and inert structural components to stabilize channel slopes, prevent

erosion and provide a natural appearance. Examples of biotechnical techniques include: joint plantings, vegetated gabion mattresses, vegetated cellular grids and reinforced grass systems. Bioengineered or biotechnical methods are preferred over engineered methods, so as to increase habitat and aesthetics.

BMP #33: Inventory Areas Lacking Stormwater Management for Retrofit Opportunities
Urban areas and older subdivisions in the watershed were developed in an era where the dominant philosophy was to move all water off-site. With the current understanding of the need to manage stormwater on-site, older developments should be inventoried for the most cost-effective and environmentally beneficial locations for management alternatives.

BMP #34: Investigate Opportunities for Recreation Areas
In order to encourage public awareness and concern for rivers, streams and wetlands, it is important to increase opportunities for people to access these water resources. If provided with aesthetic and accessible, well-advertised recreational areas - be it a canoe livery, a fishing pier, or a trail system - the public will be able to experience the human benefits that the water offers and in turn, may want to work to protect the resource. First, the designated and desired uses must be restored so that it is safe for the public to use the resource in the manner it is intended; i.e., reduce sediment in order to construct a canoe livery. Then, the recreational amenity can be planned, built and promoted.

BMP #35: Conduct Municipal Mapping of Wetlands
A current wetlands map is a required component of a local wetlands ordinance. Ground-truthing wetlands that appear on maps, that is assessing them in the field, improves municipal information about the size, type, performance, and delineation of wetlands. This information then can be incorporated into maps that the municipality can use to improve protection and preservation of the wetlands, as well as to assess the future impacts to a wetland from a proposed development.

BMP #36: Conduct Natural Features Inventories
The composition and condition of natural features throughout most the watershed is virtually unknown. Conducting natural features inventories is the typical approach to gathering natural features information. Several dozen state-listed and federally-listed plant and animal species have been sighted in the watershed. The distribution and status of those species should be surveyed and management plans for their survival and sustainability developed. These species and the habitats that they need for survival can serve as bellwethers for how management of the Huron Chain of Lakes Watershed is proceeding. The Livingston Natural Features Coalition, which is a partnership of public and private interests working to inventory the natural features of Livingston County, is a potential resource and partner in conducting community-driven natural features inventories.

Managerial Actions: Public Information & Education

The number one goal for the Huron Chain of Lakes Watershed is to increase public awareness of their role in protecting water resources. A key action to fulfilling that goal is the implementation of a coordinated information and education campaign throughout the watershed. An estimated 75% of the nonpoint source pollutants in the Huron River Watershed are the result of individual practices. Audiences need to include homeowners, local governments, riparian landowners, lake and home associations, commercial lawn care businesses, businesses, and institutions. It is critical that these target audiences understand and respond to their impacts on the River system. Preventing pollutants from reaching the River is far more cost effective than waiting until restoration is required.

This project should target nonpoint source pollution prevention through traditional marketing outlets including print advertising, direct mail and retail promotions. Behaviors addressed by the campaign should include: proper lawn care practices; home toxics disposal; septic system maintenance; water conservation; storm drain awareness; and pet waste. Market research would be used to determine core behavioral motivations and how to use these motivations to inspire behavior change. Messages would focus on items of interest to the homeowner, such as savings in time and money, with water quality protection positioned as an “added benefit.” Individual impacts should be stressed to empower homeowners with the message that “their actions do make a difference.” Consistency of messages across the watershed and repetition will be crucial to success of the campaign.

Specific actions that can help fulfill the objectives for this goal are:

- **BMP #37: Conduct Homeowner Education about Septic System Maintenance**
- **BMP #38: Provide Watershed Education Materials to Residents**
- **BMP #39: Provide Trash Management Information and Education to Public**
- **BMP #40: Provide Information and Education Program to Homeowners on Yard and Lawn Care, and Native Landscapes**
- **BMP#41: Promote County Extension Service soil testing programs**
- **BMP #42: Provide Information and Education Program to Homeowners on Proper Pet Waste Management**
- **BMP #43: Provide Information and Education Program to Farmers**
- **BMP #44: Conduct Recreational Vehicle (RV) Waste Disposal Education**
  This program seeks to prevent the illicit discharge of black water from RVs. The plan can educate RV owners about proper waste disposal to prevent illicit discharges through signs and fliers. The plan may prohibit RVs from parking overnight in parking lots, except in parking lots posted for RV parking.
- **BMP #45: Submit Stormwater-Related Information to Cable TV**
- **BMP #46: Submit Watershed-related Articles to Community Newspapers**
- **BMP #47: Watershed-related News and Materials on Entity Website**
- **BMP #48: Develop and Distribute Materials on LID Tools for Land Use Decision Makers**
- **BMP #49: Promote Reporting System for Illicit Discharges**
- **BMP #50: Household Hazardous Waste Collection Site/Day**

- **BMP #51: Yard Waste Collection and/or Recycling**

- **BMP #52 Watershed and River Crossing Signage**

Increased watershed education and watershed ethic among watershed residents is needed along with a coordinated information and education campaign. Public participation and involvement programs are meant to be activities where people learn about the watershed and/or work together to control stormwater pollution. These programs would be based on the following four objectives: 1) promote a clear identification and understanding of the problem and solutions; 2) identify responsible parties/target audiences; 3) promote community ownership of the problems and solutions; and 4) integrate public feedback into program implementation. To achieve these objectives the audience needs to be identified, the program carefully designed and the program effectiveness periodically reviewed.

Public participation and involvement programs can include the following activities:

- Adopt-A-Stream programs – trained citizen volunteers conduct benthic macroinvertebrate and habitat monitoring on a regular basis
- Program identity – program message, logo and tag line
- Collateral material – newsletters, fact sheets, brochures, posters
- Coordinating committees – focus groups, stewardship/protection groups that meet regularly
- Residential programs – storm drain stenciling, demonstration lawns and gardens, rain barrels
- Presentations – environmental booths, speakers' bureau and special events
- School education – facility tours, contests and curriculum, outdoor education, schoolyard habitats
- Southeast Michigan Stewardship Network –brings together volunteer stewards to share their experiences and learn from each other about how to protect and restore natural areas in and around their neighborhoods. Volunteers study creeks, remove invasive species, collect seed from native plants, map the land around waterways, burn prairies, and participate in many other activities

Public information and education activities implemented by the communities in the Huron Chain of Lakes Watershed will dovetail with each community's MDEQ-approved Public Education Plan (PEP). Each community's PEP presents a community-specific strategy for addressing the education goals and objectives included in this plan. Additionally, the commitments of each of the communities are included in the Action Plan in Table 4.6. The Livingston County PEP is included in Appendix W as an example. Updated PEPs and annual progress reports for the county and all other entities covered under this WMP can be obtained directly from the community.

Managerial Actions: Illicit Discharge Elimination

Illicit discharge detection and elimination requires: 1) the prevention, detection and removal of all physical connections to the storm water drainage system that conveys any material other than storm water; 2) the implementation of measures to detect, correct and enforce against illegal dumping of materials into to streets, storm drains and streams; and 3) implementation of spill prevention, containment, cleanup and disposal techniques of spilled materials to prevent or reduce the discharge of pollutants into storm water. Crews must be trained on how to identify illicit discharges and locate illicit connections. Although this effort can be labor intensive, the pay off is a reduction in the amount sanitary sewage and chemicals that enters surface waters.

Specific activities within an Illicit Discharge Identification and Elimination program include:

- **BMP #53: Conduct Outfall Screening Program**
- **BMP #54: Perform Smoke/Dye Testing**
- **BMP #55: Develop Reporting System/ Follow-up Plan for Illicit Connections**
- **BMP #56: Trace Illicit Connections**
- **BMP #57: Enforcement for Non-correction of Illicit Discharges**
- **BMP #58: Train Staff to Identify Illicit Discharges**
- **BMP #59: Minimize Seepage from Sanitary Sewers**
- **BMP #60: Minimize Seepage from On-site Sewage Disposal Systems**
- **BMP #61: Update Outfall and/or Drainage Map**
- **BMP #62: Develop and Implement Method to Identify and Record Outfalls from New Construction**

Illicit discharge identification and elimination activities implemented by the Huron Chain of Lakes communities will dovetail with each community's MDEQ-approved Illicit Discharge Elimination Plan.

Managerial Actions: Coordination and Funding

BMP #63: Establish and Maintain Long-term Committee of Community/Entity Representatives to Promote Implementation of the Watershed Management Plan
Watersheds are formed by hydrologic boundaries, not political boundaries. Therefore, some level of institutional arrangements must be established so that the various local, county, state and federal jurisdictions of the watershed are coordinated. Local examples of watershed groups working on implementation of watershed management plans include the Rouge Assembly, the Middle Huron Watershed Partnership, and the Malletts Creek Coordinating Committee (a Huron River tributary in Washtenaw County). Program maturity and funding sources will help to determine which institutional arrangements will work best to continue restoration and protection efforts. Among the main functions of the committee will be to **Conduct Work Sessions to Prioritize Specific Projects for Funding, Establish Estimated Costs, and Identify Funding Mechanisms (BMP #64).**.

An activity of the Committee should be to **Promote Consistency of Ordinances Among the Huron Chain of Lakes Watershed Communities (BMP #65)**. The Steering Committee expressed interest during the review of community development codes and ordinances in working toward consistent codes and ordinances to the maximum extent feasible that reduce stormwater runoff and thereby protect the watershed.

BMP #66: Improve Drain Maintenance Coordination with County Drain Offices and Road Commissions and/or MDOT

This activity will be necessary in order to make progress on BMP #27: Practice Alternative Drain Practices that Rehabilitate Stream and Riparian Habitats.

BMP #67: Create and Maintain Partnerships with Institutions, Schools, and Private Sector to Promote a Collaborative Effort in Watershed Management

BMP #68: Seek Alternative Funding Sources
Integrating stormwater management programs into the daily procedures of a community will generate new costs. In many cases, communities and agencies will need to explore creative solutions to finance new staff, new programs, or new commitments. Specifically, **Secure Funding and Develop Partnerships to Conduct Monitoring (BMP #69)**. Grants may be available, often with a local match involved, but these grants usually are short term solutions for one-time projects. Solutions that have been tested in other areas include the following: implementing a stormwater utility fee incurred by users of the stormwater system; using impervious cover as basis for user fees; giving credits to fees if private detention/retention practices exist; assessing a one-time septic system installation fee; establishing forest and wetland mitigation banking system; creating a Buffer Restoration Incentive Program that provides $500/acre payment to landowners; purchasing environmental easements by the private sector; and participating in a statewide Purchase/Transferable Development Right Bank (PDR/TDR). Other activities that could help generate funds for program implementation include **Create a Funding Source for Land Acquisition and Protection (BMP #70)** or **Creating a Law to Allow Illicit Discharge Enforcement as a Source of Revenue (BMP #71).**

Vegetative Management Alternatives

BMP #72: Construct Stormwater Wetlands
Stormwater wetlands, or constructed wetlands, are structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Wetlands are among the most effective stormwater practices in terms of pollutant removal and they also offer aesthetic value. Although natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the stormwater wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.[176]

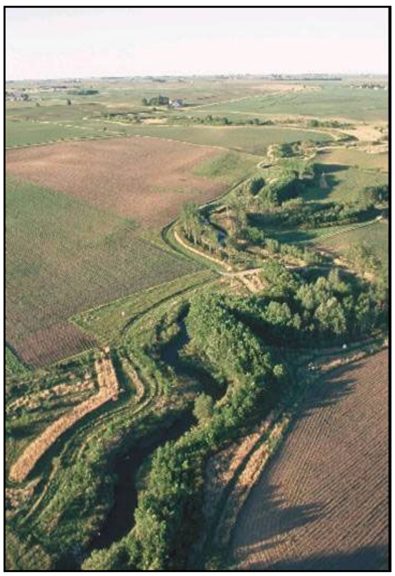

Grassed waterway. Photo: Washtenaw Co. Conservation District

BMP #73: Create and Maintain Grassed Waterways
A grassed waterway is a natural or constructed channel that is shaped or graded to required dimensions and established with suitable vegetation. This practice is used primarily on agricultural lands. On agricultural lands, land owners can be eligible for USDA programs such as Environmental Quality Incentives Program (EQIP) and Conservation Reserve Program (CRP) to help pay for the practice. Local NRCS (Natural Resource Conservation

Service) Conservation Districts can provide expertise for this practice.

BMP #74: Install and Maintain Vegetated Filter Strips
This BMP is a strip of grass or other permanent vegetation designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. A Cross Wind Trap Strip – Field, a type of filter strip, is an herbaceous cover resistant to wind erosion, established in one or more strips across the prevailing wind erosion direction. A Cross Wind Trap Strip – Filter, another type, is an herbaceous cover resistant to wind erosion, established adjacent to surface drainage ditches across the prevailing wind erosion direction. As with grass waterways (BMP #74), this practice is used primarily on agricultural lands and may be supported by financial and technical assistance from the USDA and local NRCS programs.

BMP #75: Install and Maintain Riparian Buffers



Riparian buffer. Photo: USDA NRCS

The effects of urbanization on low order streams (1^{st}-3^{rd} order) are well documented, and include alterations that results in degraded stream habitat and aquatic communities. Riparian buffer systems are streamside ecosystems managed for the enhancement of water quality through control of nonpoint source pollution and protection of the stream environment. These systems may be placed along a shoreline, stream or wetland. The primary function of the practice is to physically protect and separate the natural feature from future disturbance or encroachment by development. Buffers remove stormwater pollutants such as sediment, nutrients and bacteria, and slow runoff velocities. The degree to which buffer systems remove pollutants is dependent on loading rates from upland land uses, stream order and size, and the successful establishment and sustainability of the practice.[177] Design and size of the buffer also plays a large role in effectiveness. The three-tiered system recommended by the Center for Watershed Protection is detailed in the publication Better Site Design. On agricultural lands, land owners can be eligible for USDA programs that help pay for the practices. Local NRCS Conservation Districts can provide expertise for this practice.

BMP #76: Install and Maintain Bioretention Systems in Developed/ Redeveloping Areas
Bioretention areas are landscaping features commonly located in parking lot islands or within small pockets of residential land uses that are adapted to provide on-site treatment of stormwater runoff. Surface runoff is directed into shallow landscaped depressions where it pools above the mulch and soil in the system, then filters through the mulch to underdrain systems and a prepared soil bed. Typically, filtered runoff is collected in a perforated underdrain and returned to the storm drain system. Emergency overflow outlets are provided to direct flows in excess of the system's capacity to the stormwater conveyance system during large storm events.

Bioretention System. Photo: Center for Watershed Protection

BMP #77: Install Grassed Swales

Grassed swales are open channel management practices designed to treat and attenuate stormwater runoff. As stormwater runoff flows through these channels, it is filtered first by the vegetation in the channel, then through a subsoil matrix, and finally infiltrates into the underlying soils. Grassed swales are improvements on the traditional drainage ditch and are well suited for treating highway or residential road runoff. Grassed channels are the most similar to a conventional drainage ditch, with the major differences being flatter side and longitudinal slopes and a slower design velocity for water quality treatment of small storm events. The type and coverage of vegetation grown in the swales will influence pollutant treatment. Pollutant reduction values in this analysis assume the use of well-established turf grasses consistent with traditional residential settings. Other plantings may provide greater pollutant reduction, but may also alter conveyance hydraulics.

BMP #78: Install Pond Buffer Native Plantings
This activity diminishes turfgrass cover at pond's edge and replaces it with native tall grasses and flowering plants that are suited to wet conditions. Native plantings discourage and displace foraging geese, subsequently reducing bacteria contributions to surface waters from bird droppings. Native plantings also slow stormwater runoff and filter out pollutants in the runoff prior to the water entering the pond.

BMP #79: Practice Conservation Cover
This BMP involves establishing and maintaining permanent vegetative cover to protect soil and water resources. This practice is used primarily on agricultural lands. Local NRCS Conservation Districts can provide expertise for this practice.

BMP #80:Practice Conservation Crop Rotation with Cover Crop and Mulch/No-till
This BMP involves a system of three individual practices. Conservation crop rotation describes the practice of growing crops in a recurring sequence on the same field. The crops may be grasses, legumes, forbs or other herbaceous plants established for seasonal cover and conservation purposes. Residue management as mulch till is the practice of managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round, while growing crops where the entire field is tilled prior to planting. Residue Management as no-till and/or strip till is the practice of managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-around, while growing crops in previously untilled soil and residue. Local NRCS Conservation Districts can provide expertise for this practice.

No-till crop. Photo: Washtenaw Co. Conservation District

BMP #81: Restore Wetlands
A restored wetland is the rehabilitation of a drained or degraded wetland where the soils, hydrology, vegetative community, and biological habitat are returned to the natural conditions to the greatest extent possible. A constructed wetland is a human-made wetland with more than 50% of its surface area covered by wetland vegetation. It is ideal for large, regional tributary areas (10 to 300 acres) where there is a need to achieve high levels of particulate and nutrient removal. Wetland size and configuration, hydrologic sources, and vegetation selection must be considered during the design phase. Constructed wetlands provide a suspended solid removal of approximately 70%, while nutrient removal ranges widely due to a lack of standard design

criteria, but is in the range of 40-80%. These wetlands also benefit the area by providing fish and wildlife habitat and aesthetic benefits.

BMP #82: Install Rain Gardens

The term "rain garden" refers to a constructed depressional area that is used as a landscape tool to improve water quality. Rain gardens should be placed strategically to intercept water runoff, and typically are placed beside impervious surfaces such as driveways, sidewalks, or below downspouts. Rain gardens are designed to allow for ponding and infiltration of first flush stormwater. Nutrient removal occurs as the water comes in contact with the soil and the roots of the trees, shrubs or other vegetation. As such, plant selection should focus on native wildflowers and grasses that are adapted to local conditions. A rain garden can be as simple to establish and maintain as a traditional garden.

BMP #83: Reduce Turf with Shrubs and Trees

Unlike conventional turfgrass, native trees, shrubs and grasses have extensive, deep root systems that can improve stormwater infiltration. Research of stormwater runoff from various land surfaces indicates that runoff coefficients from turfgrass can more closely resemble runoff coefficients for paved areas due to the shallow root structure of turfgrass and more compacted soils on which it grows. A popular technique for reducing turf is to use native landscaping for attractive borders. Because native plants have adapted to local soils and pests, they require less watering and need no chemicals or fertilizers to protect them. So less turfgrass can mean cost savings.

Replacing turfgrass with native plants increases infiltration
Photo: Center for Watershed Protection

BMP #84: Evaluate Areas for Instream Habitat Restoration Techniques

Habitat restoration techniques include instream structures that may be used to correct and/or improve fish and wildlife habitat deficiencies over a broad range of conditions. Examples of these techniques include: channel blocks, boulder clusters, covered logs, tree cover, bank cribs, log and bank shelters, channel constrictors, cross logs and revetment and wedge and “K” dams.[178] The majority of these structures require trained installation with hand labor and tools. After construction, a maintenance program must be implemented to ensure long-term success of the habitat structures. In areas that experience high stormwater peak flows, instream habitat restoration should be installed after desired flow target is reached, to ensure the success of the habitat improvement project.

BMP #85: Stabilize Soils at Crossing Embankments

Soil erosion control is the process of stabilizing soils and slopes in an effort to prevent or reduce erosion due to storm water runoff. Source areas are construction sites where soil has been disturbed and exposed, streambanks that are eroding due to lack of vegetation and an excess of peak flows during storm events, and road crossing over streams where the integrity of the structure is compromised or where the road itself contributes gravel or dirt. Soils can be stabilized by various physical or vegetative methods, while slopes are stabilized by reshaping the ground to grades, which will improve surface drainage and reduce the amount of soil eroding from a site. In areas where development activity is underway, it is important to emphasize the Soil Erosion and Sediment Control ordinance inspection and enforcement, which often entails hiring an adequate number of field staff.

Structural Management Alternatives

BMP #86: Construct Stormwater Retention or Detention Basins or Other Structures that Promote Runoff Infiltration and Detention
Stormwater infiltration basins are any stormwater device or system, which causes the majority of runoff from small storms to infiltrate into the ground rather than be discharged to a stream. Most infiltration devices also remove waterborne pollutants by filtering water through the soil. Stormwater infiltration can provide a means of maintaining the hydrologic balance by reducing the impacts of impervious areas. Infiltration devices can include any of the following: basins, trenches, permeable pavement, modular pavement or other systems that collect runoff and discharge it into the ground. Infiltration devices should only be used on locations with gentle slopes, permeable soils and relatively deep water tables and bedrock levels. In new developments, permeable soil areas should be preserved and utilized as stormwater infiltration areas.

Extended wet detention ponds, or wet ponds, are constructed basins designed to contain a permanent pool of water in order to detain and settle stormwater runoff. The primary pollutant removal mechanism is settling as stormwater resides in the pool and pollutant uptake occurs through biological activity in the pond. Wet ponds are among the most cost-effective and widely used stormwater practices. A sediment forebay should be incorporated into the pond design, which promotes increased settling of sediments and helps prevent outlet clogging. Landscaping design requirements should include a natural vegetated buffer around the pond to increase aesthetics, reduce pollutants entering the area, and discourage goose habitation. Studies indicate that wet ponds may outperform dry detention basins for nutrient and sediment removal, and dry detention basins do not treat first flush stormwater.

BMP #87: Install and Maintain Infiltration Trenches
An infiltration trench is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff must pass through a pre-treatment measure, such as a swale or detention basin, to remove or reduce the amount of suspended solids prior to reaching the infiltration trench. Within the trench, runoff is stored in the voids of the stones and infiltrates through the bottom where it is again filtered by the underlying soils. Trenches are appropriate in most residential areas where curb and gutter would be considered.


Infiltration trench. Photo: Center for Watershed Protection

BMP #88: Install and Maintain Vegetated ("Green") Roofs
The green roof concept is akin to the popular, but traditionally heavy and difficult to maintain, garden roofs found atop buildings worldwide. Essentially, a green roof is the structural addition

of plants over a traditional roof system. Green roofs reduce stormwater runoff and increase energy efficiency. In the past there were many concerns regarding the safety and durability of these structures; however, recent advances have dramatically and successfully addressed these concerns. A recent, highly visible green roof was installed on the roof of a large building at the Ford Motor Company's Rouge Plant in Dearborn, Michigan. Examples of smaller residential and municipal green roofs are present in Washtenaw County.

BMP #89: Install BAT to Reduce Nutrients at Permitted Point Sources
Best Available Technology (BAT) to reduce nutrients, pathogens and other pollutants in permitted point source effluent should be used to minimize contributions to surface waters. Communities can work with MDEQ and NPDES point source dischargers in their jurisdiction to determine whether the facilities' effluent would benefit from increased pollutant removal technology. Due to the decreasing rate of return for ever increasing technological standards, the more cost effective approach to improving water quality will be to prevent pollution in stormwater runoff in the first place.

BMP #90: Install and Maintain Catch Basin Inserts
A catch basin is an inlet to the storm drain system that typically includes a grate or curb inlet and a sump to capture sediment, debris, and associated pollutants. Catch basins require regular cleaning and maintenance for proper functioning. A number of proprietary technologies are now available to augment the pollutant capture rates of these systems. These technologies generally employ additional sump chambers to enhance the capture of solids, and many employ filtering media to capture additional pollutants or fractions of the pollutant inflows. The generic term "catch-basin inserts" is used here to describe a variety of in-sump or in-line designs.

BMP #91: Install Grade Stabilization Structures
A grade stabilization structure is used to control the grade and head cutting in natural or artificial channels (like a grassed waterway). This practice is used primarily on agricultural lands. On agricultural lands, land owners can be eligible for USDA programs such as Environmental Quality Incentives Program (EQIP) and Conservation Reserve Program (CRP) to help pay for the practice. Local NRCS Conservation Districts can provide expertise for this practice.

BMP #92: Install Porous Pavement
Porous pavement can be made of concrete, stone or plastic and promote the absorption of rain and snowmelt. The most common type of porous pavement is paving blocks and grids which are modular systems that contain openings filled with sand and/or soil. Some pavers can support grass or other suitable vegetation providing a green appearance. Porous pavement can be effective in reducing the quantity of surface runoff for small to moderate-sized storms, and may also reduce the amount of pollutants associated with these events. Typically, these systems will work better when overlaid on sandy, permeable soils (as opposed to less permeable clay soils). Effectiveness of these pavements can be improved by maximizing the opening in the paving material and providing a sub-layer of at least 12 inches. This type of pavement is particularly applicable for overflow and special event parking, driveways, utility and access roads, emergency access lanes, fire lanes and alleys.

BMP #93: Install and Maintain Media/Sand and Organic Filters
Filters are usually two-chambered storm water practices; the first is a settling chamber, and the second is a filter bed filled with sand, a sand/peat mixture, or another filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as storm water flows through the filtering medium. Modifications

include surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and multi-chamber treatment train.

BMP #94: Install and Maintain Sediment Trapping Devices at Construction Sites
Sediment trapping devices such as a barrier, basin or other devices are designed to remove sediment from runoff. Sediment basins should be located at the downstream end of drainage areas larger than 5 acres, and before a treatment train of other BMPs such as a wet detention pond or constructed wetland that is built to treat excess sediments and other pollutants. Dikes, temporary channels and pipes should be used to divert runoff from disturbed areas into the basin and runoff from undisturbed areas around the basin. Simpler devices for areas less than 5 acres include a sediment trap and sand bag barrier, silt fences and straw bales. Silt fences and straw bales can be placed along level contours downstream of exposed areas where only sheet flow is anticipated. Sediment trapping devices can also be used on storm drain inlets and can include filter fabric, excavated drop traps, gravel filters and sandbags. Maintenance is a key requirement of any of these soil erosion control BMPs. Sediment traps, barriers, basins and filters should be inspected frequently for repairs and sediment removal.

BMP #95: Repair Undersized Culverts/Repair Misaligned or Obstructed Culverts
During the Stream Crossing inventory, some sites were found to have erosion problems in the stream due to undersized culverts or because of culverts that are poorly aligned with the current channel shape or that are obstructed by an instream object. Where undersized culverts are the cause of the problem, the proper size culvert will need to be determined by the County Road Commissions in order to accommodate existing and anticipated future flows. Where misalignment or obstruction are the problems, the remedy may not be as straightforward as replacing the culvert. Changes in hydrology from upstream development or from an instream obstruction will need to be determined in order to find the appropriate solution. Local units of government, specifically the townships, will need to work through the county governments to implement this practice.

BMP #96: Stabilize Eroding Road and Bridge Surfaces
Many county roads in the watershed are unpaved. The gravel and sand/gravel composite used for road surface can be the source of sediment pollution to surface waters when precipitation washes it into the stream or when road grading builds piles of the surface along the sides of the road. Stabilization of the eroding road and bridge surfaces may involve structural techniques such as retrofitting the bridge to prevent runoff from entering the stream or managerial techniques such as altering grading practices and selecting a different road and bridge surface. Local units of government, specifically the townships, will need to work through the county governments to implement this practice.

Additional Resources for Stormwater Management Alternatives

Additional information on stormwater management alternatives can be found at the following web-based resources:

International Stormwater BMP Database:
http://www.bmpdatabase.org/

Low Impact Development Center:
http://www.lowimpactdevelopment.org/

MDEQ's Guidebook of Best Management Practices for Michigan Watersheds:
http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3716-103496--,00.html

MDEQ's Index of Individual BMPs:
http://www.michigan.gov/deq/0,1607,%207-135-3313_3682_3714-13186--,00.html

MDOT Approved BMPs:
http://www.michigan.gov/documents/SWMP_05_MDOT_v_4_120609_7.0_Appendix_D.pdf

The Stormwater Manager's Resource Center:
http://www.stormwatercenter.net/

US EPA's National Menu of BMPs for Stormwater Phase II:
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/menu.cfm

4.5.2 Understanding the Action Plan Table

The Steering Committee recognizes that the activities of entities holding jurisdictional stormwater permits within the Huron Chain of Lakes Watershed affect the integrity of the watershed and, therefore, influences the degree of success in meeting the goals and objectives. Entities with jurisdictional stormwater permits in the watershed are Hamburg Township, Dexter Township, Webster Township, Northfield Township, Salem Township, the Washtenaw County Drain Commissioner, and the City of South Lyon. These entities are required to develop their own action plans to meet the minimum requirements of the NPDES Phase II Stormwater program but those actions need not be reflected in this watershed management plan.

As previously mentioned, the Action Plan Table is intended to provide a broad, though not complete, list of management alternatives to address the Plan's goals and objectives. Not all management alternatives apply to all permitted entities; neither must they all be implemented in order to achieve the Plan's goals and objectives, and address the priority impairments, sources and causes. The responses by each permitee for each management alternative, or BMP, indicate how that community intends to use that particular BMP to meet their Phase II stormwater permit obligations and the goals and objectives of the watershed. The seven possible responses are:

C (currently doing): The BMP is already established or is practiced by the entity or community and therefore is already contributing towards meeting the goals and objectives of the Plan and will continue to do so in the future. How the BMP is being practiced will be explained in that community's Storm Water Pollution Prevention Initiative (SWPPI).

S (planned for short term): The community intends to implement some form of the BMP within the next five years. Such BMPs will be incorporated in that community's SWPPI, which will outline in greater detail the schedule, scope, and methods of implementation.

L (planned for long term): The community intends to implement some form of the BMP, but not within the next five years. Implementation is expected to occur in future permit cycles and will be detailed in future versions of a community's SWPPI.

W (wish list item): According to the MDEQ's June 2005 draft Guidance for Watershed Management Planning for the Purpose of Writing Storm Water Pollution Prevention Initiatives, a wish list item is an activity that “may be included in the WMP without associated commitments.” The guidance also states:

> Wish list items are activities for which the communities recognize a need, but can’t or won’t commit to them for reasons such as:
> - They go beyond the scope of the storm water controls
> - They are not yet technologically feasible
> - They can’t be implemented with the resources (not counting funds) currently available
>
> There is no limit to the number of activities that may be added to the WMP wish list, as long as the WMP also includes a reasonable number of activities with commitments to accomplish the goals and measurable objectives.

Wish list items are particularly valuable as potential collective projects to be addressed with state or other non-point source funding. Items that are included as wish list by most communities were assessed for their concurrence with: 1) WMP goals and objectives, and 2) prioritized impairments, sources and causes. A short list of BMPs are highlighted in Table 4.6 as short-term priority activities for non-point source funding. These are listed separately in Table 4.7 for convenience.

SE (covered through County Soil Erosion and Sedimentation Control Standards): All of the permitees listed in the Action Plan Table use their County’s standards for soil erosion and sediment control (SESC). Local community implementation of management alternatives that are governed by county SESC standards can only be carried out by local communities if allowed by county SESC standards. Therefore, for local communities that indicate “SE” for an action, the county’s response (C, S, L, X, or NA) shall also apply to those communities.

X (not planned currently): These are BMPs which are not planned by a particular permitee to be implemented because of a lack of interest.

NA (not applicable): Not all BMPs apply to all permittees. For example, street sweeping does not apply to townships that do not own any roads or areas with only unpaved roads.

Table 4.7 Priority Activities for Collective Short-Term Implementation in the Huron Chain of Lakes Watershed

Management Activity		Impairments Addressed	Sources Addressed
7	Adopt stormwater management ordinance	1,2,3,5,6	1.1, 2(all), 3.1, 3.2, 3.3, 5.1, 6.1, 6.2
30	Develop and implement a coordinated monitoring strategy to measure water quality, water quantity and biota	1,2,3,4,5,6	1(all), 2(all), 3(all), 4(all), 5(all), 6.1, 6.2
31	Initiate hydrologic and hydraulic studies	1,2,3,5,6	1(all), 2(all), 3(all), 5(all), 6.1
9	Support County-wide septic system time-of-sale or maintenance ordinance	1,4	1.2, 4.1
33	Inventory area lacking stormwater management for retrofit opportunities	1,2,3,5,6	1.1, 1.3, 2.1, 2.2, 3.1, 3.3, 5.1, 6.1, 6.2
12	Incorporate Low Impact Design principles	1,2,3,5,6	1.1, 2.1, 2.2, 3.1, 3.2, 3.3, 3.4, 5.1, 6.1, 6.2
1	Adopt phosphorus reduction ordinance	1,5	1.3, 5.5
75	Plant and maintain riparian buffers	1,2,3	1.1, 1.3, 1.5, 2(all), 3.1, 3.2, 3.3, 3.5
76	Install bioretention areas in developed/redeveloping areas	1,2,3,5,6	1.1, 1.3, 2(all), 3.3, 5.1, 6.1
83	Reduce turf and replace with shrubs and trees	1,2,3,5,6	1.1, 1.3, 2.1, 3.3, 5.5, 6.1, 6.3
85	Stabilize soils at crossing embankments	3	3.1, 3.4
82	Install rain gardens	1,2,3,5,6	1.1, 1.2, 2.1, 3.1, 3.3, 5.1, 5.4, 6.1, 6.2
86	Construct stormwater retention/detention basins or other structures that promote infiltration and detention of runoff	1,2,3,5,6	1.1, 1.3, 2(all), 3.3, 5.1, 6.1

CHAPTER 5: IMPLEMENTATION AND EVALUATION

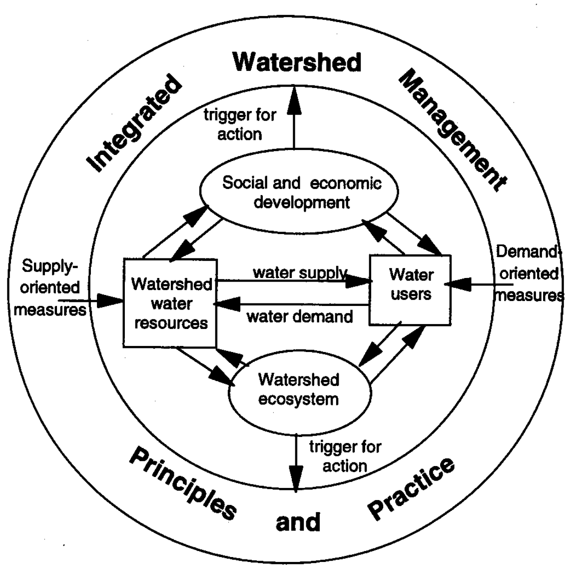
Taking a closer look at Chilson Creek Photo: HRWC

This chapter outlines considerations in the implementation and evaluation of the Huron Chain of Lakes Watershed Management Plan, as well as the interplay between evaluation and implementation, which shapes the revision process. A successful watershed plan is ultimately defined not by what is written on the pages of the plan, but by how the recommended plans and programs are put into action. A successful plan for implementation also recognizes that the state of the watershed changes over time. As such, evaluating the effectiveness and appropriateness of the actions taken to implement the plan, as well as the ability to adapt these actions to the changing conditions of the watershed, is critical.

5.1 INTEGRATED WATERSHED MANAGEMENT AND ADAPTIVE MANAGEMENT

A watershed is a complex integrated system with the whole being greater than the sum of its parts. This complexity stems for the ever-changing interaction of social, economic, and biophysical forces. The interplay of these forces, as shown in Figure 5.1, is the basis for the concept of integrated watershed management.

Figure 5.1. Forces Affecting Integrated Watershed Management[179]



Integrated watershed management is, by definition, dynamic in nature. Implementing the Huron Chain of Lakes Watershed Management Plan in a way that follows the principles of integrated watershed management therefore requires continuous evaluation of the effectiveness of the management alternatives in meeting the Plan's goals and objectives. The concept of "adaptive management" is central to successful implementation of the Plan. Adaptive management incorporates research into conservation action. Specifically, it is the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn.

The goals and recommendations of this Plan are based on the understanding of the conditions of the natural watershed ecosystem at the time this Plan was developed. However, both the conditions of the watershed and the goals and actions will change over time as new information is collected, available resources for implementation are assessed, and the values and needs of the watershed's residents evolve.

As stated by Veissman (1990) in Heathcote's Integrated Watershed Management: Principles and Practices:[180]

> *Watershed management institutions evolve from needs identified at some milestone in time. The problem is that times change, and so do needs. Unfortunately, institutions seem to march on with entrenched constituencies, and many in existence today are addressing yesterday's goals or addressing today's problems with yesterday's practices.*

Changes in social and economic forces can trigger changes in watershed management practices. Similarly, changes in a watershed's ecosystem can indicate a need for altered watershed management practices. Adaptive management recognizes the dynamic interplay of these forces, which implies a need to continually evaluate progress toward the meeting the Plan's goals and objectives.

5.2 Watershed Plan Implementation

Each Phase II community and agency must submit a SWPPI by May 1, 2006 that details the actions they will implement to meet the goals and objectives of the Huron Chain of Lakes Watershed Plan. The MDEQ will review these SWPPIs to ensure that actions meet Phase II requirements. The MDEQ will also review the annual reports that the communities will submit to report on progress toward meeting the goals and objectives of the Plan, as well as the activities related to their IDEP and PEP. These reports also help to ensure that compliance is being met for the objectives of the Phase II programs, while also keeping the Huron Chain of Lakes Steering Committee on track toward achieving the broad goals of water quality and natural resource protection and improvement.

To ensure successful implementation, nine key elements should be addressed, as summarized in Table 5.1 on the following page.

Table 5.1. Nine Key Elements of Successful Watershed Plan Implementation[181]

1. Appoint a single lead agency to act as an advocate and facilitator for the plan with the community and with political representatives.
2. Strong linkages to existing programs, including local and regional land use planning processes, water quality and flow monitoring programs, and similar programs, to optimize use of available information and minimize duplication of effort.
3. Clear designation of responsibilities, timetables, and anticipated costs for project actions.
4. Effective laws, regulations, and policies to provide a framework for the tasks identified in Element 3.
5. Ongoing tracking of the degree of implementation of management actions and of the success of those actions once implemented.
6. Ongoing monitoring and reporting of progress, both to assess the effectiveness of individual actions and to sustain public and political interest in and enthusiasm for the plan.
7. Ongoing public education and communication programs to consolidate and enhance the social consensus achieved in the planning process.
8. Periodic review and revision of the plan.
9. Adequate funding for these activities.

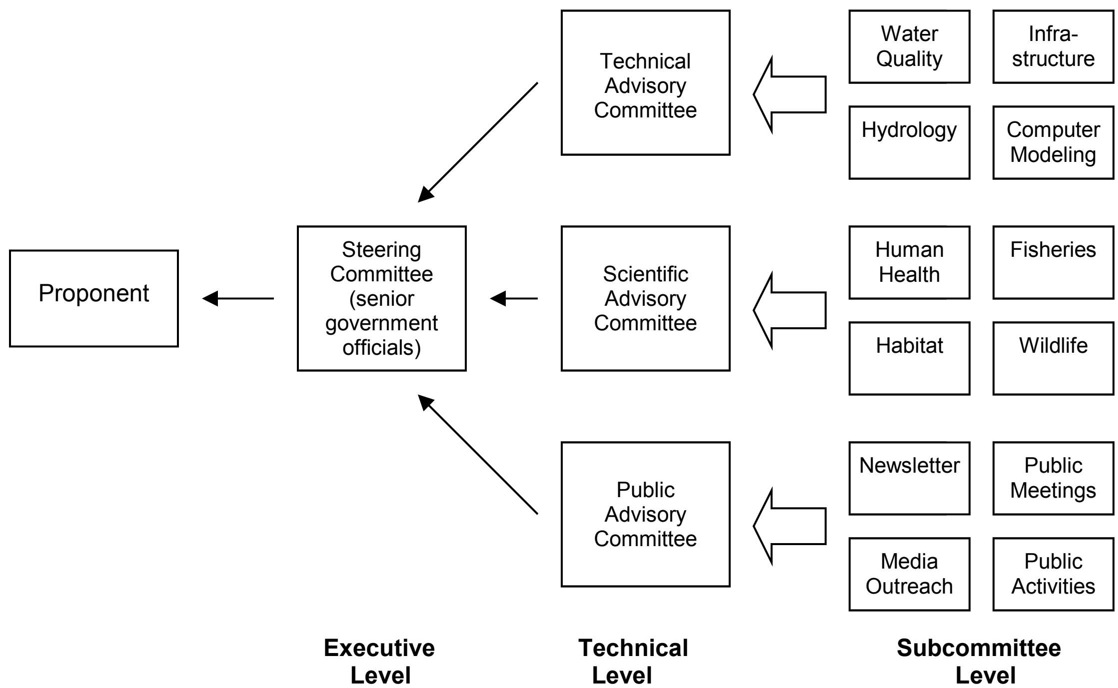
5.2.1 Advisory Committee Structure

To facilitate implementation of the Huron Chain of Lakes Watershed Management Plan over time, a framework for a series of working groups will help to provide a useful feedback loop for determining how, and the extent to which, the goals and objectives of the Plan are being successfully implemented. These working groups would ideally be comprised of the following groups of stakeholders:

- Managers, planners, coordinators, and their staff members
- Boards and steering committees
- Volunteers (citizens and watershed stewards)
- Environmental Interest Groups
- Funding Groups

These groups of stakeholders should ultimately allow for input and implementation assistance from a broad cross-section of all stakeholder and interest groups in the watershed, as outlined in the Huron Chain of Lakes Watershed Public Participation Plan (see Appendix H). Figure 5.2 provides a theoretical example of a two-tier advisory committee structure that could be employed to oversee the implementation and evaluation of the Huron Chain of Lakes Watershed Management Plan. A multi-tiered advisory structure is better suited for large watershed planning projects, as is the case in the Huron Chain of Lakes Watershed, as opposed to a single-tiered structure which is better suited for smaller, short-term projects.[182]

Figure 5.2. A Typical Two-tier Advisory Committee Structure



A committee structure based on the organization shown in Figure 5.2 could be used to implement, evaluate, and revise the watershed plan over time. The “proponent” (lead agency) in this schematic would be the Livingston County Drain Commissioner’s Office, which would ultimately provide support for, and oversight of, the activities of the Steering Committee and smaller committee/ subcommittee levels. The “Steering Committee” might be comprised of stormwater program managers and staff who recommend final decisions to be coordinated with support from the Livingston County Drain Commissioner. The “advisory committees” might be staffed by land use planners, commissions, boards, interested citizens, environmental group advocates, scientists, etc. that will pull together various aspects of the data and results during the implementation phases of the Plan (i.e. water quality data, public education initiatives, illicit discharge investigations, etc.).

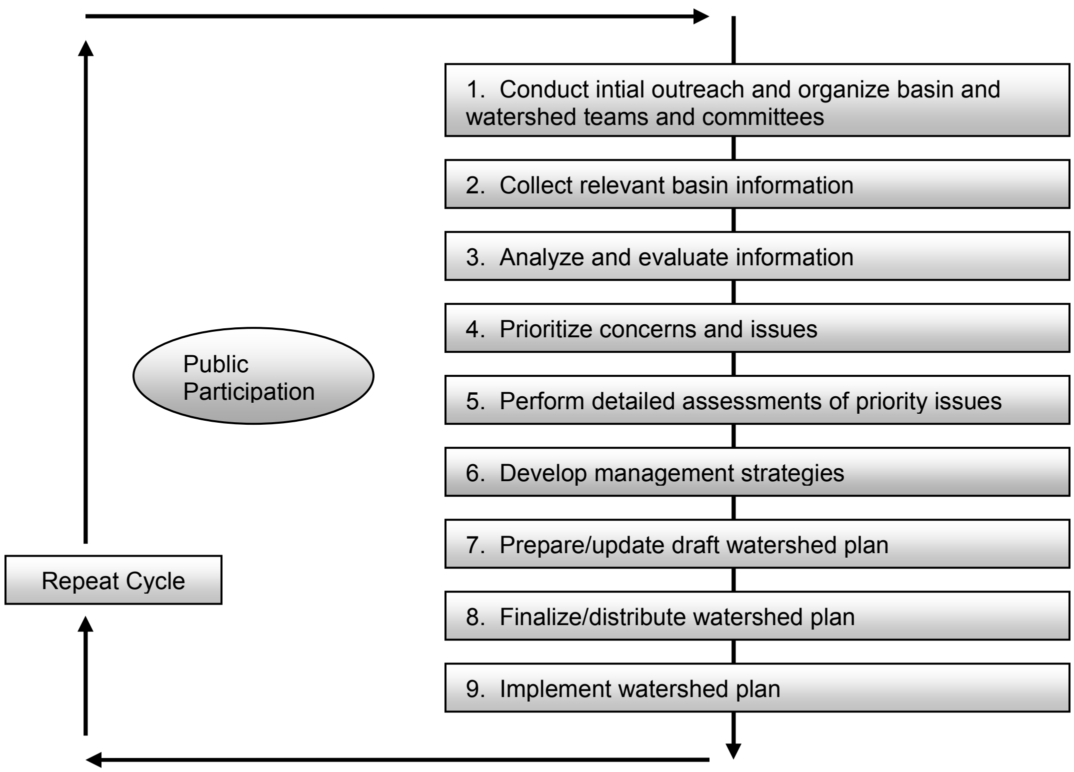
The importance of public representation and broad stakeholder involvement throughout any advisory committee structure must be stressed, as these individuals are in a position to explain and influence community opinion and help to build support for needed changes. One of the first tasks of the Livingston County Drain Commissioner’s office and current members of the Huron Chain of Lakes Steering Committee should be to begin developing an advisory committee structure that allows for involvement by a broad range of stakeholders as discussed above.

5.2.2 Watershed Plan Revisions

As noted in the Certificates of Coverage for each primary community/entity in the Huron Chain of Lakes Watershed, the MDEQ requires a revised version of the Huron Chain of Lakes Watershed Management Plan by be submitted by November 1, 2007, or a written determination not to revise the Plan. The Huron Chain of Lakes Steering Committee will continue to meet on a regular basis (at least quarterly), with oversight and support by the Livingston County Drain Commission's office to ensure that the Plan is being implemented on a watershed-wide basis. The LCDC's water resources coordinator will oversee the coordination effort. In addition, updates regarding watershed plan implementation and activities related to the Phase II stormwater efforts will be updated on the LCDC's stormwater 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 5.3.

Figure 5.3. Typical Steps in a Watershed Management Cycle[183]



5.3 Evaluation Methods for Measuring Success

How can we measure whether the management alternatives listed in the Action Plan have been successful at reducing pollutants? That is to say, have changes in behavior occurred among target audiences, how many management practices have been implemented, or have documented improvements in water quality occurred? There are a number of different ways to measure progress toward meeting the goals for the Huron Chain of Lakes Watershed. Objective markers or milestones will be used to track the progress and effectiveness of the management practices in reducing pollutants to the maximum extent possible (see Table 5.2). Evaluating the management practices that are implemented helps establish a baseline against which future progress at reducing pollutants can be measured. The U.S. EPA identifies the following general categories for measuring progress:

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

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

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

Table 5.2 presents environmental indicators that have been developed specifically for assessing stormwater programs.[184] Water quality indicators 1 through 16—physical, hydrological, and biological indicators—can be integrated into an overall assessment of the program and used as a basis for the long term evaluation of program success. Indicators 17 through 26 correspond more closely to the administrative and programmatic indicators and practice-specific indicators.

Table 5.2. Environmental Indicators for Assessing Stormwater Programs

Category	#	Indicator Name
Water Quality Indicators This group of indicators measures specific water quality or chemistry parameters.	1	Water quality pollutant constituent monitoring
	2	Toxicity testing
	3	Loadings
	4	Exceedence frequencies of water quality standards
	5	Sediment contamination
	6	Human health criteria
Physical and Hydrological Indicators This group of indicators measures changes to or impacts on the physical environment.	7	Stream widening/downcutting
	8	Physical habitat monitoring
	9	Impacted dry weather flows
	10	Increased flooding frequency
	11	Stream temperature monitoring
Biological Indicators This group of indicators uses biological communities to measure changes to or impacts on biological parameters.	12	Fish assemblage
	13	Macroinvertebrate assemblage
	14	Single species indicator
	15	Composite indicator
	16	Other biological indicators
Social Indicators This group of indicators uses responses to surveys, questionnaires, and the like to assess various parameters.	17	Public attitude surveys
	18	Industrial/commercial pollution prevention
	19	Public involvement and monitoring
	20	User perception
Programmatic Indicators This group of indicators quantifies various non-aquatic parameters for measuring program activities.	21	Number of illicit connections identified/corrected
	22	Number of BMPs installed, inspected and maintained
	23	Permitting and compliance
	24	Growth and development
Site Indicators This group of indicators assesses specific conditions at the site level.	25	BMP performance monitoring
	26	Industrial site compliance monitoring

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

Monitoring and measuring progress in the watershed will be two-tiered. First, individual agencies and communities will monitor certain projects and programs on the agency and community levels to establish effectiveness. For example, a community-based lawn fertilizer education workshop will be assessed and evaluated by that community. Also, with the implementation of a community project such as the retrofitting of detention ponds, the individual community responsible for the implementation of that task may monitor water quality/quantity parameters before and after the retrofit in order to measure the improvements. Secondly, there will be a need to monitor progress and effectiveness on a regional – subwatershed or watershed – level in order to assess the ecological affects of the collective community and agency actions on the health of the river and its tributaries.

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

5.3.1 Qualitative Evaluation Techniques

As seen in the Huron Chain of Lakes Action Plan, as well as the Storm Water Pollution Prevention Initiatives (SWPPIs) of each individual entity, there are and will be a range programs and projects implemented to improve water quality, water quantity and habitat in Huron Chain of Lakes Watershed– from constructing wet detention ponds to public education programs. Finding creative ways to measure the effectiveness of each of these individual programs will be recorded for each task under the individual SWPPIs.

A set of qualitative evaluation criteria can be used to determine whether pollutant loading reductions are being achieved over time and whether substantial progress is being made toward attaining water quality standards in the Watershed. Conversely, the criteria can be used for determining whether the Plan needs to be revised at a future time in order to meet standards. A summary (Table 5.3) of the methods provides an indication of how these programs might be measured and monitored to evaluate success in both the short and the long term. Some of these evaluations may be implemented on a watershed basis, such as a public awareness survey to evaluate public education efforts, but most of these activities will be measured at the local level. By evaluating the effectiveness of these programs, communities and agencies will be better informed about public response and success of the programs, how to improve the programs and which programs to continue. Although these methods of measuring progress are not tied directly to measurements in the river, it is fair to assume that the success of these actions and programs, collectively and over time, will impact positively on the instream conditions and measurements of the river system that are investigated concurrently as described below.

Table 5.3. Summary of qualitative evaluation techniques for the Huron Chain of Lakes Watershed

Evaluation Method	Program/Project	What is Measured	Pros and Cons	Implementation
Public Surveys	Public education or involvement program/project	Awareness; Knowledge; Behaviors; Attitudes; Concerns	Moderate cost. 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	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	Current and first-hand information. Time-consuming. Some cost involved.	Identify parameters to evaluate. Use form, such as Stream Crossing Inventory, to record observations. Summarize findings to identify sites needing observation.
Visual Documentation	Structural and vegetative BMP installations, retrofits	Aesthetics. Pre- and post- conditions.	Easy to implement. Low cost. 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.	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	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	Medium to high cost to do well. Instant identification of motivators and barriers to behavior change.	Select random sample of population as participants. 6-8 people per group. Plan questions, facilitate. Record and transcribe discussion.

Adapted from: Lower One SWAG, 2001

5.3.2 Quantitative Evaluation Techniques

In addition to measuring the effectiveness of certain specific programs and projects within communities or agencies, it is beneficial to monitor the long-term progress and effectiveness of the cumulative watershed efforts in terms of water quality, water quantity and biological monitoring. Watershed-wide long-term monitoring will address many objectives established for the Huron Chain of Lakes Watershed, and Goal 8 to increase monitoring of water quality, water quantity, and biological indicators. A monitoring program at the watershed level will require a regional perspective and county or state support. Communities and agencies in the watershed agree that there has not been adequate data collection (number of sites or frequency) to most effectively manage the watershed. Wet and dry weather water quality, stream flow, biological and other monitoring will afford communities and agencies better decision making abilities based on more data as implementation of this plan continues. Suggestions for the monitoring program are presented below. Details for the monitoring program will be decided and approved by the Steering Committee.

Parameters and Establishing Targets for River Monitoring
Upon reviewing the data collected for the Watershed Management Plan, the Steering Committee members recognize the need to augment the type of parameters monitored, the number of locations in the watershed, and the frequency of wet weather monitoring. A holistic monitoring program will help communities and agencies to identify more accurately water quality and water quantity impairments and their sources, as well as how these impairments are impacting the biological communities that serve as indicators of improvements.

Parameters
Establish a long-term monitoring program so that progress can be measured over time that includes the following components:

- Increase stream flow monitoring to determine baseflows and track preservation and restoration activities upstream. Include as physical and hydrological indicators: stream widening/downcutting; physical habitat monitoring; increased flooding frequency; and stream temperature monitoring.

- Collect wet and dry weather water quality data in the watershed to better identify specific pollution source areas within the watershed, and measure impacts of preservation and restoration activities upstream. Include as water quality indicators: water quality pollutant monitoring; loadings; exceedence frequencies of water quality standards; sediment contamination; and human health criteria.

- Increase biological data monitoring (fish, macroinvertebrates, and mussels) and use these as indicators of the potential quality and health of the stream ecosystem. Include as biological indicators: fish assemblage; macroinvertebrate assemblage; single species indicator; composite indicator; and other biological indicators.

- Identify major riparian corridors and other natural areas in order to plan for recreational opportunities, restoration and linkages.

- Review and revise currently established benchmarks and dates based on new data.

- Increase the use of volunteers where possible, for monitoring program (habitat, macroinvertebrates) to encourage involvement and stewardship.

Based on the goals of the watershed, the monitoring plan should measure Dissolved Oxygen (DO), Bacteria (*E. coli*), Phosphorus (P), total suspended solids (TSS), sediments, stream flow, conductivity, fisheries and aquatic macroinvertebrates, temperature, physical habitat, and wetlands.

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

Dissolved Oxygen: The Michigan Department of Environmental Quality (MDEQ) has established state standards for Dissolved Oxygen (DO). The requirement is no less than 5.0 mg/l as a daily average for all warm water fisheries. The Administrative Rules state:

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

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

Phosphorus: State water quality standards for phosphorus state that "phosphorus which is or may readily become available as a plant nutrient shall be controlled from point source discharges to achieve 1 mg/l of total phosphorus as a maximum monthly average effluent concentration unless other limits, either higher or lower, are deemed necessary and appropriate." The State also requires that "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the waters of the state." Monitoring frequency and number of sites for phosphorus and nitrogen needs to be increased to capture seasonal variation and dry and wet weather conditions.

Total Suspended Solids/Sediment: No numerical standard has been set by the state for Total Suspended Solids (TSS) for surface waters. However, the state requires that "the addition of any dissolved solids shall not exceed concentrations which are or may become injurious to any designated use." To protect the designated uses of fisheries and wildlife habitat, as well as the desired recreational and aesthetic uses of the surface waters in the watershed, there are recommended targets established on a scientific basis. From an aesthetics standpoint, it is recommended that TSS less than 25 mg/l is "good", TSS 25-80 mg/l is "fair" and TSS greater than 80 mg/l is "poor."[185] The TSS target, therefore, will be to maintain TSS below 80 mg/l in dry weather conditions. Another measurement that can be used to determine sediment load is to determine the extent of embeddedness of the substrate (how much of the stream bottom is covered with fine silts) and the bottom deposition (what percentage of the bottom is covered with soft muck, indicating deposition of fine silts). These are measurements taken by the Surface Water Assessment Section (SWAS) protocol habitat assessment conducted by MDEQ every five years, and by the Adopt-A-Stream program more frequently. Rating categories are from "poor" to "excellent." The target should be to maintain SWAS designations of "excellent" at sites where they are attained currently, "good" at sites where they are attained currently, improve "fair" sites to "good," and improve "poor" to "good."

Stream Discharge: Stream flow, or discharge, for surface waters do not have a numerical standard set by the state. Using the health of the fish and macroinvertebrate communities as the ultimate indicators of stream and river health is most useful in assessing appropriate flow. Recommended flow targets for the river and its tributaries will be established once the necessary research has been conducted that will determine the natural, pre-development hydrology and current hydrology. Peak flow data is needed to compare more accurately observed flow to the target flow. A USGS stream gage is located on the Huron River downstream of the bridge at Hamburg Road in Hamburg Township that provides continuous measurement of discharge. Data generated at the station can assist in establishing an appropriate flow target and assessing any progress made toward that goal.

Conductivity: Conductivity measures the amount of dissolved ions in the water column and is considered an indicator for the relative amount of suspended material in the stream. The scientifically-established standard for conductivity in a healthy Michigan stream is 800 microSiemens (μS), which should be the goal for the Huron River and its tributaries. Levels higher than the standard indicate the presence of stormwater runoff-generated suspended materials.

Fisheries: Numerical or fish community standards have not been set by the state. However, the Michigan Department of Environmental Quality has developed a system to estimate the health of the predicted fish communities through the SWAS 51 sampling protocol. This method collects fish at various sites and is based on whether or not certain expected fish species are present, as well as other habitat parameters; fish communities are assessed as poor, fair, good, or excellent. The state conducts this protocol every five years in the Huron River Watershed. The target should be to maintain SWAS 51 scores of "excellent" at sites where they are attained currently, "good" at sites where they are attained currently, improve "fair" sites to "good," and improve "poor" to "good" through the implementation of this plan. The SWAS 51 protocol also identifies whether or not there are sensitive species present in the Huron River and its tributaries, which would indicate a healthy ecosystem. Certain species are especially useful for demonstrating improving conditions. These species tend to be sensitive to turbidity, prefer cleaner, cooler water, and their distribution in the Huron Watershed is currently limited. The target is to continue to find species currently found, assuming that stable or increasing numbers mean that habitat and water quality is maintained or improved.

Benthic Macroinvertebrates: Similar to the assessment of fish communities, the state employs the GLEAS 51 protocol for assessing macroinvertebrate communities on a five-year cycle for the Huron River Watershed. The Adopt-A-Stream program of the Huron River Watershed Council currently monitors macroinvertebrate health and physical habitat on 19 sites in the Huron Chain of Lakes Watershed using an adaptation of the GLEAS 51 procedure. The sites are monitored for macroinvertebrates two or three times each year and periodically for physical habitat health. The monitoring target for macroinvertebrate communities will be to increase MDEQ and Adopt-A-Stream monitoring sites to improve the existing database and attain GLEAS 51 scores of at least “fair” at sites that currently are “poor,” and improve “fair” sites to “good,” and maintain the “good” and “excellent” conditions at the remaining sites.

Temperature: The state standard lists temperature standards only for point source discharges and mixing zones – not ambient water temperatures in surface water. However, recommendations for water temperature can be generated by assessing fish species’ tolerance to temperature change and these guidelines are found within the statute. Although some temperature data have been collected in the Huron Chain of Lakes system by the Adopt-A-Stream program of the Huron River Watershed Council, additional studies are needed to establish average monthly temperatures and whether increased temperatures are a problem for stream health.

Wetlands: An annual review should be done of MDEQ wetland permit information and local records in order to track wetland fills, mitigations, restoration and protection to establish net loss or gain in wetlands in the watershed. The target for this parameter is to track the net acres of wetland in the watershed to determine action for further protection or restoration activities.

Details regarding responsible parties, monitoring standards, sampling sites, and frequency of monitoring for qualitative and quantitative evaluation techniques will need to be defined and approved by the Steering Committee and integrated into individual SWPPIs as funding is secured.

Table 5.4 presents evaluation methods that will be used to track the progress and effectiveness of the management alternatives–presented in the Action Plan–in reducing pollutants and impairments to the maximum extent possible.

Table 5.4. Methods of Evaluating Progress for the Watershed Management Alternatives in the Huron Chain of Lakes Action Plan

	Management Alternative	Method of Evaluating Progress
	Managerial: Ordinances and Policies	
1	Adopt phosphorus reduction ordinance	Track # of fertilizer reduction ordinances/policies adopted
2	Adopt native landscaping ordinance	Track # of native landscaping ordinances/policies adopted
3	Adopt no dumping ordinance	Track # of no dumping ordinances/policies adopted

	Management Alternative	Method of Evaluating Progress
4	Adopt pet waste ordinance	Track # of pet waste ordinances/policies adopted
5	Adopt private roads ordinance	Track # of private roads ordinances/policies adopted
6	Adopt Purchase of Development Rights ordinance	Track # of PDR ordinances adopted
7	Adopt stormwater management ordinance (e.g., Livingston Co.)	Track # of stormwater management ordinances adopted
8	Adopt wetlands ordinance w/ natural features setback	Track # of wetlands ordinances adopted
9	Support County-wide septic system time-of-sale ordinance	Track # of ordinances adopted
10	Adopt overlay zoning for riparian corridor	Track # of ordinances adopted
11	Enhance site plan review requirements	Survey communities to compare pre- and post-site plan review enhancements
12	Incorporate Low Impact Design principles	Develop manual of coordinated standards for watershed
13	Improve enforcement of litter laws and nuisance properties	Track # of complaints and amount of litter collected
14	Improve enforcement of SESC policies	Track # of soil erosion and sedimentation violations and corrections
15	Review and revise SESC policies and practices	Track # of soil erosion and sedimentation violations and corrections
16	Improve enforcement of construction site inspections	Track installation and maintenance of construction site BMPs and # of violations and corrections
17	Minimize total impervious cover in zoning ordinance	Track # of zoning ordinances with measures to minimize impervious cover; Reduce build-out scenario impervious levels
18	Promote open space preservation in zoning ordinance and master plan	Track # of zoning ordinances and master plans that promote open space preservation
19	Review and revise grading and land clearing policies	Track # of BMPs employed and maintained
20	Revise parking standards for new development/redevelopment	Track # of zoning ordinances with measures to minimize impervious cover
21	Revise Stormwater Management Standards - pond landscaping	Track # of entities with enhanced pond landscaping requirements
Managerial: Practices		
22	Incorporate results of conservation planning analyses into local ordinances and policies	Track # of local ordinances and policies incorporating conservation planning
23	Disconnect directly-connected impervious surfaces (e.g. downspouts)	Track # of homes with disconnected downspouts
24	Practice high-powered street and parking lot sweeping	Track # of lineal feet swept and amount of debris removed
25	Provide pet waste bags in parks and public areas	Conduct public surveys; Track public participation

	Management Alternative	Method of Evaluating Progress
26	Increase amount of refuse containers and review their distribution	Conduct public surveys to measure pre- and post-measure public participation
27	Practice alternative drain practices that improve protection of stream and riparian habitats	Track BMPs established throughout riparian corridor
28	Storm drain/catch basin marking	Track # of storm drains marked; Track public participation
29	Reduce use of conventional road de-icers	Track reduction in amounts of road salt used
	Managerial: Studies and Inventories	
30	Develop and implement a coordinated monitoring strategy to measure water quality, water quantity and biota	Track development of monitoring strategy
31	Initiate hydrologic and hydraulic studies	Track data generated from studies; Rating curves developed
32	Inventory and stabilize eroding streambanks	To be established in upcoming permit cycle
33	Inventory areas lacking stormwater management for retrofit opportunities	To be established in upcoming permit cycle
34	Investigate opportunities for recreation areas	To be established in upcoming permit cycle
35	Municipal mapping of wetlands	Track # communities doing mapping; track # of acres or % of Watershed that is mapped
36	Conduct natural features inventories	Track # of inventories
	Managerial: Public Information and Education	
37	Homeowner education about septic system maintenance	Conduct public surveys; Track public participation; Stream surveys
38	Provide watershed education to residents	Conduct public surveys
39	Provide trash management information and education to public	Conduct public surveys; Track items and households from clean-up events; Stream surveys
40	Provide information and education program to homeowners on yard and lawn care, native landscapes	Conduct public surveys; Track public participation; stream surveys
41	Promote county soil testing program	Track # of soil tests submitted; Conduct public surveys
42	Provide information and education program to homeowners on proper pet waste management	Conduct public surveys; Track public participation; Stream surveys
43	Provide information and education to farmers	Conduct public surveys; Track participation; Stream surveys
44	Provide recreational vehicle (RV) Waste Disposal Education	Conduct public surveys; Track participation; Stream surveys
45	Regular storm water-related information on cable TV	Track # of televised spots; Track participation in events and practices; Conduct public surveys
46	Watershed-related articles in community newsletters	Conduct public surveys; Track public participation

	Management Alternative	Method of Evaluating Progress
47	Watershed-related news and I & E materials on entity website	Conduct public surveys; Track public participation
48	Develop and distribute education materials on Low Impact Design tools for land use decision makers	Conduct focus groups; Comparative analysis of developments pre- and post-implementation of LID campaign
49	Promote reporting system for illicit discharges	Track # of illicit connections identified and corrected; Track # of complaints
50	Household Hazardous Waste Collection Site/Day	Conduct public surveys; Track public participation
51	Yard Waste Collection and/or Recycling	Conduct public surveys; Track public participation
52	Watershed and River crossing signage	Conduct public surveys; Track # of signs erected
	Managerial: Illicit Discharge Elimination	
53	Conduct outfall screening program	Track # of illicit connections identified and corrected
54	Perform smoke/dye testing	Track # of illicit connections identified and corrected
55	Develop a reporting system/follow-up plan for illicit connections	Track # of illicit connections identified and corrected
56	Trace illicit connections	Track # of illicit connections identified and corrected
57	Enforcement for non-correction of illicit discharges	Track # of illicit connections identified and corrected; Track amount of fines collected
58	Train staff to identify illicit discharges	Track # of staff trained; Track # of illicit connections identified and corrected
59	Minimize seepage from sanitary sewers	Stream surveys
60	Minimize seepage from on-site sewage disposal systems	Stream surveys
61	Update outfall and/or drainage map	Track # of maps updated
62	Develop and implement method to identify and record outfalls from new construction	Track # of entities employing method in new construction; Track # of illicit connections identified and corrected
	Managerial: Coordination and Funding	
63	Establish long-term committee of community/entity representatives to promote implementation of the Watershed Management Plan	Track implementation of WMP; Track # of committee meetings; Track consistent participation of representatives
64	Conduct work sessions to prioritize specific projects for funding, establish estimated costs, and identify funding mechanisms	Track prioritization for project funding, project cost estimates, and funding mechanisms; Track implementation of WMP; Track # of work sessions
65	Ensure consistency of ordinances among the Huron Chain of Lakes communities	Track prioritization for project funding, project cost estimates, and funding mechanisms; Track implementation of WMP; Track # of work sessions
66	Improve drain maintenance coordination with County and/or MDOT	Track prioritization for project funding, project cost estimates, and funding mechanisms; Track implementation of WMP; Track # of work sessions

	Management Alternative	Method of Evaluating Progress
67	Create partnerships with institutions, schools, and private sector to promote a collaborative effort in watershed management	Number of partnerships established and maintained; Number of people reached through partnerships; Track BMPs established across partnerships
87	Seek alternative funding sources	Track number of proposals submitted; Track dollars and match raised
69	Secure funding and develop partnerships to conduct monitoring	Implementation of monitoring program
70	Create a funding source for land acquisition and protection	Track dollars raised for land acquisition and protection
71	Create law to allow illicit discharge enforcement as a source of revenue	Track progress of bill creation
Vegetative		
72	Construct stormwater wetlands	Stream surveys; Track acres of practice throughout watershed; Pollutant removal efficienty
73	Create and maintain grassed waterways	Stream surveys; Track area of practice throughout watershed
74	Create and maintain vegetated filter strips	Stream surveys; Track area of practice throughout watershed
75	Plant and maintain riparian buffer	Stream surveys; Track area of practice throughout watershed
76	Install bioretention areas in developed/redeveloping areas	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency
77	Install grassed swales, where feasible	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency
78	Install pond buffer native plantings	Stream surveys; Track area of practice throughout watershed
79	Practice agricultural conservation cover	Stream surveys; Track acres of practice throughout watershed; Pollutant removal efficiency
80	Practice conservation crop rotation with cover crop and mulch/no-till	Stream surveys; Track acres of practice throughout watershed; Pollutant removal efficiency
81	Restore wetlands	Stream surveys; Track acres of practice throughout watershed; Pollutant removal efficiency
82	Install rain gardens	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency
83	Reduce turf/ replace with shrubs and trees	Track area of practice throughout watershed
84	Evaluate areas for in-stream habitat restoration techniques	Records of all inventoried surface waters; Track area of practice throughout watershed; Stream surveys
85	Stabilize soils at crossing embankments	Baseline and ongoing embeddedness/stream habitat studies; Track completed road stream crossings; Track stabilized road stream crossings; Pollutant removal efficiency
Structural		
86	Construct stormwater retention/detention basins or other structures that promote infiltration and detention of runoff	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency

Management Alternative		Method of Evaluating Progress
87	Install infiltration trenches/basins	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency
88	Install vegetated roofs	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency
89	Install best available technology to reduce nutrients at permitted point sources	Stream surveys; Track # of eligible and participating point sources; Pollutant removal efficiency
90	Install catch basin inserts	Stream surveys; Track # of practice throughout watershed; Pollutant removal efficiency
91	Install grade stabilization structures	Stream surveys; Track # of practice throughout watershed; Pollutant removal efficiency
92	Install porous pavement	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency
93	Install sand and organic filters	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency
94	Construct sediment trapping devices at construction sites	Stream surveys; Track area of practice throughout watershed; Pollutant removal efficiency
95	Repair misaligned/obstructed culverts	Baseline and ongoing embeddedness/stream habitat studies; Track completed culverts; Pollutant removal efficiency
96	Stabilize road/bridge surfaces	Baseline and ongoing embeddedness/stream habitat studies; Track stabilized road/brige surfaces; Pollutant removal efficiency

5.4 PARTING WORDS

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

The task ahead of implementing this watershed management plan demands patience, persistence, determination, and cooperation of many partners and stakeholders at all levels. No matter how much effort and dedication was put into the Plan, it is of little value gathering dust on the shelves of the communities it is intended to serve. The concept of watershed management is new to many communities in the Huron Chain of Lakes Watershed and is only in the infant stages of being realized as a fundamental consideration in maintaining a high quality of life for its residents and protecting its natural resources for future generations. However, as these communities continue to face the challenges of balancing growth with natural resource protection, the costs of maintaining the status quo and the benefits of long-term planning on a watershed scale will become increasingly apparent.

Each community in the Watershed now has a choice. It can regard the Plan as merely another completed requirement of its Phase II stormwater permit and move on to the next requirement, or it can use the Plan as it is intended: to guide each community not only in fulfilling its own permit requirements, but also in partnering with other stakeholders throughout the watershed to protect the land and water that connects us all.

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