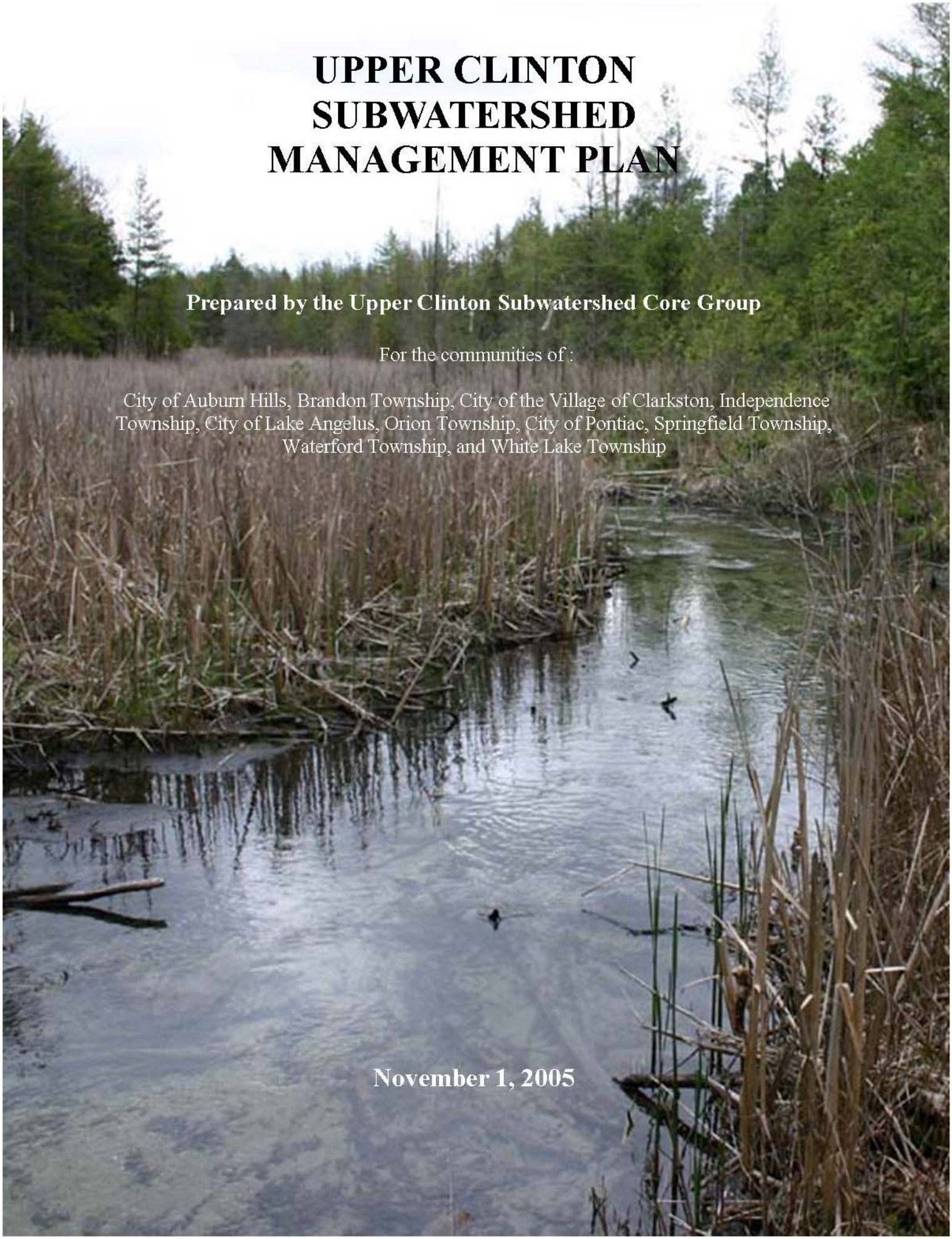

UPPER CLINTON SUBWATERSHED MANAGEMENT PLAN

Prepared by the Upper Clinton Subwatershed Core Group

For the communities of :

City of Auburn Hills, Brandon Township, City of the Village of Clarkston, Independence Township, City of Lake Angelus, Orion Township, City of Pontiac, Springfield Township, Waterford Township, and White Lake Township

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November 1, 2005

Upper Clinton Subwatershed Management Plan

Prepared by the Upper Clinton Subwatershed Core Group, Secondary Partners, and Steering Committee:

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City of Lake Angelus
George Frisch, Mayor
Bruce Kresge, Community Representative
Lee Embrey, Community Representative

Independence Township
Linda Richardson, Director, Department of Public Works

Orion Township
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Springfield Township
Nancy Strole, Clerk
Leon Genre, Planning and Building Director

Waterford Township
Rob Merinsky, Assistant Engineering Director
Stacy St. James, Environmental Coordinator

Secondary Partners:

City of Auburn Hills
Shawn Keenan, Water Resources Coordinator

Brandon Township
Ron Lapp, Supervisor
Lois Robbins, Community Representative

City of Pontiac
Tony Dombrowski, Nowak & Fraus, PLLC

White Lake Township
Steve Rumple, Planning Director
Mike McAdams

Steering Committee:

Scott Meyland, City of Village of Clarkston, Council & ZBA Member
Dan Travis, Independence Township Board Member
William Wilshire, Orion Township Board Member
Bill Ireland, Orion Township Department of Public Works
Tom Berger, Orion Township Building Department
Dennis Griffin, Waterford Township Planning Commissioner
Collin Walls, Springfield Township Supervisor
Wes Goodman, Clarkston Community Schools
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Karen Tauriainen, Oakland County Drain Commissioner's Office
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Eddie Delbridge, Waterford Chamber of Commerce
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Upper Clinton Subwatershed Management Plan
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CHAPTER 1
EXECUTIVE SUMMARY

The Upper Clinton Subwatershed Management Plan was developed to meet the Federal Phase II stormwater permit requirements. Since 1972, the Clean Water Act has been operating to reduce and control point-source water pollution. The next phase of this law (or "Phase II") is requiring communities that have "urbanized areas" within their boundaries to help control non-point source pollutants entering surface waters through stormwater. Urbanized areas are determined by criteria using data from the 2000 U.S. Census. This plan represents a "Watershed-based" approach to the Phase II permit process.

The Upper Clinton Subwatershed is part of the larger Clinton River watershed. It is called the "Upper Clinton" because it encompasses most of the headwaters, or sources, for the Clinton River system. The subwatershed is 86.24 square miles (55,194 acres), is located in the northwest portion of Oakland County, and covers ten communities: Springfield Township, White Lake Township, Brandon Township, Independence Township, City of the Village of Clarkston, Waterford Township, City of Lake Angelus, Orion Township, City of Auburn Hills, and the City of Pontiac.

This plan was developed using several levels of participation. A "Core Group" was established, which includes community representatives from each participating community. A "Steering Committee" was also organized, including a wider range of state, regional, and county agencies, and other organizations. Also, "Stakeholders" in the subwatershed were identified, representing specialized groups, public officials, and the public at large. The Core Group developed drafts of the Plan's chapters, and sought input from the Steering Committee and Stakeholders. Their comments and feedback where then analyzed by the Core Group and incorporated into the Plan.

To begin the planning process, a watershed analysis was conducted that looks at the current conditions within the subwatershed, and identifies trends and potential future water quality issues. As part of this analysis, regional growth trends and land use trends were assessed. On a regional basis, the subwatershed continues to develop, with fewer people living together per household, and with the average amount of land consumed by a typical home increasing. Southeast Michigan Council of Governments (SEMCOG) predicts that this trend will prevail over the next 30 years. The main land use trends within the subwatershed include single-family residential, recreation/conservation, and vacant. An analysis of the current sanitary treatment facilities show that slightly more than half of the subwatershed has a sanitary sewer system, where the remaining population is served by septic systems.

Existing water quality data from various federal, state, and local sources were also collected and analyzed. The analysis of available water quality and environmental data for the Upper Clinton subwatershed indicates that the Upper Clinton River, its tributaries and associated lakes, make up a generally high quality waterway that has begun to show some signs of impairment. The noted impairments have been prioritized based on how widespread and consistent they have been, the degree of impact they are currently having or may have in the future, and how they interrelate. These impairments (in priority order) include bacteria, changes in hydrology, nutrients, and sediments. Sources and causes for each of these impairments were determined and shown in

table 3.11. Critical areas in which to concentrate future actions were identified, including lakes with past beach-closure histories, stream sites with increased peak flows, and areas within 250 feet of lakes and streams. The existing land uses in these critical areas were also determined, and include single-family residential, recreation/conservation, and vacant land uses. These point to putting priorities on educating the public, working with land managers of large parklands, and implementing protective land planning tools (such as ordinance or engineering standards) to ensure the vacant lands are developed to protect water quality.

Through a series of public meetings, goals and objectives were worked out for the Plan. Each input group was provided with a summary of the existing conditions within the watershed, and was then asked to base their goals on this data, as well as their own knowledge of the watershed. These sessions also resulted in a list of "desired" uses that watershed residents envisioned for their communities. The resulting final goals deal with the main issues of water quality, water quantity (flow), preservation of natural features within the subwatershed, public understanding and education about water quality, aquatic and riparian habitats, and recreational uses.

Because so much of the subwatershed is yet to be developed, or developed in a way that could allow more intense re-development, an impervious surface analysis was conducted, along with an analysis of all the participating communities' planning documents. The impervious surface analysis was conducted by the Oakland County Planning and Economic Development Services. They used a model that predicts the quality and character of a stream based on the percentage of impervious cover in the watershed. Conclusions from this analysis indicate that the subwatershed is already 17% impervious, which significantly impacts streams so that they show signs of stream bed degradation, degraded physical habitat within the stream, and water quality problems. However, this level of impervious cover is not consistent throughout all areas of the subwatershed, but is an "average imperviousness." In addition, some areas can be improved through the use of better site design measures. Also, further research in this field has shown that in this subwatershed (given its level of imperviousness), that maintaining riparian cover along streams and lakes may be as, or more, important than minimizing impervious surfaces in future developments.

The analysis of each community's planning documents also provided some guidance regarding ways water can be better protected in the future. An extensive checklist was used to evaluate the Master Plans, Zoning Ordinances, Engineering Standards, and other planning documents of each community within the subwatershed. A narrative describing the checklist results was written for the Plan that describes where each community is strong in protecting water resources, and the challenges it faces in light of future development. The analysis uncovered several topics that were, in general, challenges for the subwatershed as a whole. These topics could be added to or expanded upon in planning documents, and include stormwater management, impervious surface mitigation, natural feature preservation, riparian buffers, native plants in landscaping, and in-fill or redevelopment.

Given the watershed analysis, impervious surface analysis, and planning analysis, the Core Group developed a set of 35 actions that could be used to meet the goals and objectives of the Watershed Plan. These actions, or Best Management Practices (BMPs), encompass both structural practices, and vegetative or managerial practices. These actions are described in Chapter 6 of the Plan, and then laid out in a matrix in Chapter 7, showing how these actions

relate to the pollutants, sources and causes, and other issues found throughout the planning process. Each community has carefully considered each action, and identified the ones that can be implemented within their boundaries based on the current conditions of their water resources, and political and economic parameters. Commitments within the Watershed Plan will be translated into an individual Stormwater Pollution Prevention Initiative, which is the next document to be forwarded to Michigan Department of Environmental Quality within the permit process. Once these documents have been approved, the Upper Clinton Subwatershed communities will begin implementing actions to improve and protect water resources for the future.

CHAPTER 2
INTRODUCTION

2.0 Purpose of the Plan

The Upper Clinton Subwatershed Management Plan was developed to meet the Federal Phase II stormwater permit requirements. Since 1972, the Clean Water Act has been operating to reduce and control point-source water pollution. The next phase of this law (or "Phase II") is requiring communities that have "urbanized areas" within their boundaries to help control non-point source pollutants entering surface waters through stormwater. Urbanized areas are determined by criteria using data from the 2000 U.S. Census.

Stormwater management is being accomplished through a permit process called the National Pollutant Discharge Elimination System (NPDES). In Michigan, two types of stormwater permits are available. The "Jurisdictional" permit follows the federal guidelines for NPDES permits and only covers the individual communities' political boundaries. The "Watershed-Based" permit includes rules that the State of Michigan developed to encourage communities to work together on a watershed basis.

Both permit types authorize the discharge of stormwater from drainage systems which are owned or controlled by governmental entities. The main differences are that the watershed permit considers an entire watershed rather than just the land within the community's boundaries. This makes more sense from an ecological standpoint because watersheds and subwatersheds usually cover large areas of land encompassing many communities. The watershed permit is also a locally-driven program, rather than a top-down mandate, creating more buy-in to the solutions outlined in the watershed plan.

2.1 The Upper Clinton Subwatershed

The Upper Clinton Subwatershed is part of the larger Clinton River watershed. It is called the "Upper Clinton" because it encompasses most of the headwaters, or sources, for the Clinton River system. The subwatershed is 86.24 square miles (55,194 acres), is located in the northwest portion of Oakland County, and covers ten communities:

- Springfield Township
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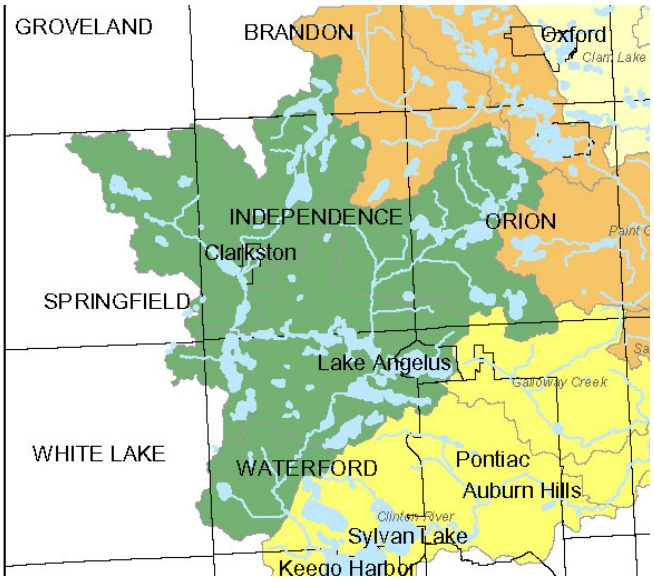


2.2 Watershed Plan Participants

When the Phase II regulations were released by the Michigan Department of Environmental Quality (MDEQ), the communities within the Upper Clinton Subwatershed met to discuss the permit options and decide upon which course to take. The watershed-based permit was decided on, and the communities created a "Core Group" of community representatives to begin developing the required documents under the permit rules.

The Core Group's main functions were to meet monthly, guide the process to satisfy the permit deadlines, develop draft documents, and to make final decisions on how each community will commit itself to actions included in the various permit documents. The Core Group also decided that there should be several other levels of involvement in developing the Watershed Management Plan:

- A "Steering Committee," was created which includes a wider range of regional and county agencies, state environmental agencies, nested jurisdictions, business organizations, and others who have information about the subwatershed and a unique perspective on water quality issues, and
- "Stakeholders," which includes an even broader range of people such as public officials and staff, civic groups and others within the general public who will assist in the planning and implementation of the Watershed Plan.

Both Steering Committee members and stakeholders have provided significant input throughout the planning process. At different points in the development of the plan, the Steering Committee was convened and asked to provide information about the subwatershed and to review and give feedback on document drafts. The stakeholders were also asked to give feedback on the plan drafts, as well as help to develop goals for the plan.

2.3 Watershed Plan Organization

The Watershed Plan was developed by following the guidelines in the book titled *Developing a Watershed Management Plan for Water Quality. An Introductory Guide.* This book was prepared by the Michigan State University (MSU) Institute of Water Research, MSU Extension and the Michigan Department of Environmental Quality (MDEQ) Nonpoint Source Program.

The first step in this process was identifying the other participants of the watershed management planning team. The Core Group determined who the Steering Committee members should be, and then the Steering Committee and the Core Group came up with a list of stakeholders. Next, the Core Group developed the watershed analysis, which identified the critical areas within the watershed, and prioritized pollutants, and the sources and causes of those pollutants. Another issue that was evaluated was how well the surface waters within the subwatershed met the designated uses identified by the State. All of this information was reviewed and commented upon by the Steering Committee.

The next step was to develop goals and objectives for the plan, which was achieved over a series of meetings with the Core Group, Steering Committee and stakeholders. The existing plans, policies, and projects for each permittee were evaluated for how well they protect water resources, and then Best Management Practices (BMPs) were developed to address the pollutants, sources and causes, and the goals of the plan. An action plan that outlines the BMPs and their proposed scheduled implementation was then developed, along with approximate costs. The last step in the planning process was to develop an evaluation process that can be used to assess the progress made by the participating communities. The action plan is summarized in Chapter 7 through an "Action Matrix," which shows how all of this information relates to each other.

CHAPTER 3
WATERSHED ANALYSIS

3.0 Introduction

This analysis looks at the current conditions within the Upper Clinton Subwatershed, and identifies trends and potential future water quality issues. The analysis was developed by the Core Group of communities within the subwatershed. A draft was then sent to the members of the broader Steering Committee for their comments and input. This input was collected at a Steering Committee meeting held on August 24, 2004. The document was then revised based on the comments collected.

3.1 Growth Trends, Land Use Analysis and Community Profiles

The Upper Clinton subwatershed is nearly 86.24 square miles in area and is located within the central portion of Oakland County. A total of eleven (11) communities make up the subwatershed, ten (10) of which have participated in the creation of this subwatershed plan. See the map on the following page that shows where this subwatershed (called the "Headwaters" subwatershed) is located within the Clinton River Watershed.

A summary of each of the communities is provided in the following table as well as in the descriptions that follow. With the exception of the City of the Village of Clarkston, no single community is contained entirely within the Upper Clinton subwatershed.

Table 3.1
Community Area in Subwatershed

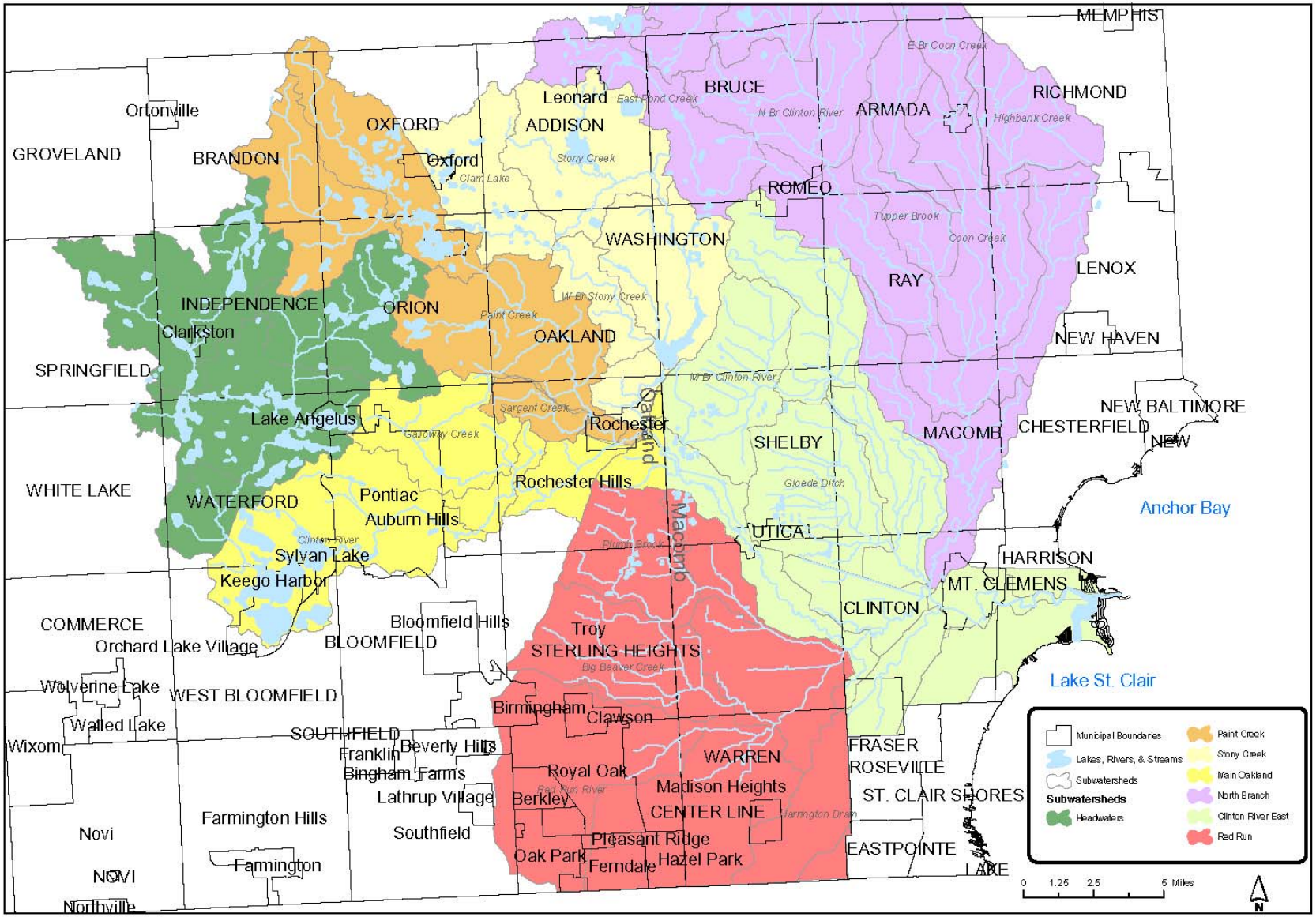
Community	Acres in Subwatershed	Percent of Community in Subwatershed
Charter Township of Springfield	6,265	27%
Charter Township of White Lake	827	3%
Charter Township of Brandon	1,127	5%
Charter Township of Independence	20,070	86%
City of the Village of Clarkston	328	100%
Charter Township of Waterford	14,620	65%
City of Lake Angelus	956	91%
Charter Township of Orion	9,887	45%
City of Auburn Hills	782	7%
City of Pontiac	332	3%
Total	**55,194 ***	

* 12 acres are contained within Groveland Township for a total of 55,206 acres in the subwatershed.

The Clinton River Watershed

This map is provided by the Environmental Stewardship Group
of Oakland County Planning & Economic Development Services

L. Brooks Patterson, County Executive



Growth Trends

In order to understand the land use changes within the Upper Clinton subwatershed, it is helpful to understand the growth trends observed within the Southeast Michigan Council of Government (SEMCOG) region. SEMCOG evaluated the changes that have occurred between the 1990 and 2000 census years. A summary of the findings is as follows:

- Developed land in the region has increased by 17% (159,300 acres). Thirty-seven percent (37%) of the region is now considered developed.
- The region's population grew by 5% (243,000 people).
- Between 1990 and 2000 the density of residential development decreased from 2.84 units per acre to 1.26 units per acre, or 55.6%.
- Average household size has decreased and the average home size has increased.
- The results of these changes are larger homes on larger pieces of land with fewer occupants.

The trends identified by SEMCOG are indicative of a growing region. The proximity of the subwatershed to the rapidly growing metropolitan Detroit region is reflective of these trends. SEMCOG projects that similar trends will prevail over the next thirty (30) years. Table 3.3 illustrates the population and housing profiles for each of the ten (10) communities. Note that this data is for the entire community, not just the area within the Upper Clinton subwatershed.

Table 3.2a
Population and Housing Profiles

	Springfield Township	White Lake Township	Brandon Township	Independence Township	Clarkston
Population					
1990 Population	9,927	22,677	10,799	23,717	1,005
2000 Population	13,338	28,219	13,230	32,581	962
2030 Population	20,326	34,313	18,509	38,103	957
Households					
1990 Households	3,276	7,805	3,535	7,977	431
2000 Households	4,619	10,092	4,475	11,765	406
2030 Households	7,854	13,580	6,738	15,381	411
2000 Housing Units	4,794	10,616	4,718	12,375	424
2000 Household Size	2.87	2.77	2.94	2.75	2.37
2030 Household Size	2.58	2.50	2.73	2.45	2.33
2000 Median Household Income	$71,977	$65,894	$66,895	$74,993	$62,667
2000 Median Housing Value	$209,100	$190,900	$195,000	$203,600	$231,300
Educational Attainment					
No High School	730	2,250	865	1,707	72
High School	2,345	5,917	2,607	4,775	106
Some College	2,334	4,767	2,439	5,494	167
Associates	752	1,439	803	1,576	46
Bachelor's	1,443	2,989	1,223	5,018	179
Graduate/Professional	956	1,295	434	2,670	125
Housing Types					
One-Family Detached	3,816	8,557	3,659	9,447	301
One-Family Attached	194	102	19	362	29
Two-Family / Duplex	21	15	0	59	25
Multi-Unit Apartments	224	354	23	1,899	85
Mobile Homes	538	1,590	1,011	584	2
Other	0	29	0	6	0
Total	4,794	10,616	4,718	21,375	424
2003 Residential Building Permits					
Single Family	93	175	82	166	0
Townhouse / Attached Condos	6	64	0	43	0
Two-Family / Duplex	0	0	0	0	0
Multi-Family	0	0	0	0	0
Total New Units	99	239	82	209	0

Table 3.2b
Population and Housing Profiles

	Waterford Township	Lake Angelus	Orion Township	Auburn Hills	Pontiac
Population					
1990 Population	66,692	328	21,019	17,076	71,136
2000 Population	71,981	326	30,748	19,837	67,506
2030 Population	72,863	264	40,948	21,013	75,544
Households					
1990 Households	25,476	122	7,331	6,453	24,763
2000 Households	29,387	132	11,048	8,064	24,234
2030 Households	33,287	139	16,030	9,753	30,204
2000 Housing Units	30,404	146	11,517	8,822	26,336
2000 Household Size	2.42	2.47	2.77	2.25	2.68
2030 Household Size	2.12	1.90	2.54	1.97	2.44
2000 Median Household Income	$55,008	$114,524	$73,755	$51,376	$31,207
2000 Median Housing Value	$144,400	$814,800	$199,100	$137,200	$74,300
Educational Attainment					
No High School	6,414	0	1,492	1,521	12,207
High School	15,155	28	4,280	3,263	12,775
Some College	12,718	55	4,767	2,696	8,442
Associates	3,909	8	1,797	990	1,819
Bachelor's	8,684	100	4,941	2,856	2,842
Graduate/Professional	3,330	56	2,292	1,278	1,212
Housing Types					
One-Family Detached	22,469	146	9,047	3,447	16,237
One-Family Attached	1,206	2	530	544	1,361
Two-Family / Duplex	222	0	38	64	1,210
Multi-Unit Apartments	2,689	0	1,448	3,912	6,996
Mobile Homes	191	0	456	888	517
Other	6	0	0	0	15
Total	30,404	148	11,517	8,822	26,336
2003 Residential Building Permits					
Single Family	132	1	164	64	272
Townhouse / Attached Condos	44	0	16	134	37
Two-Family / Duplex	0	0	4	0	0
Multi-Family	0	0	0	4	0
Total New Units	176	1	184	202	309

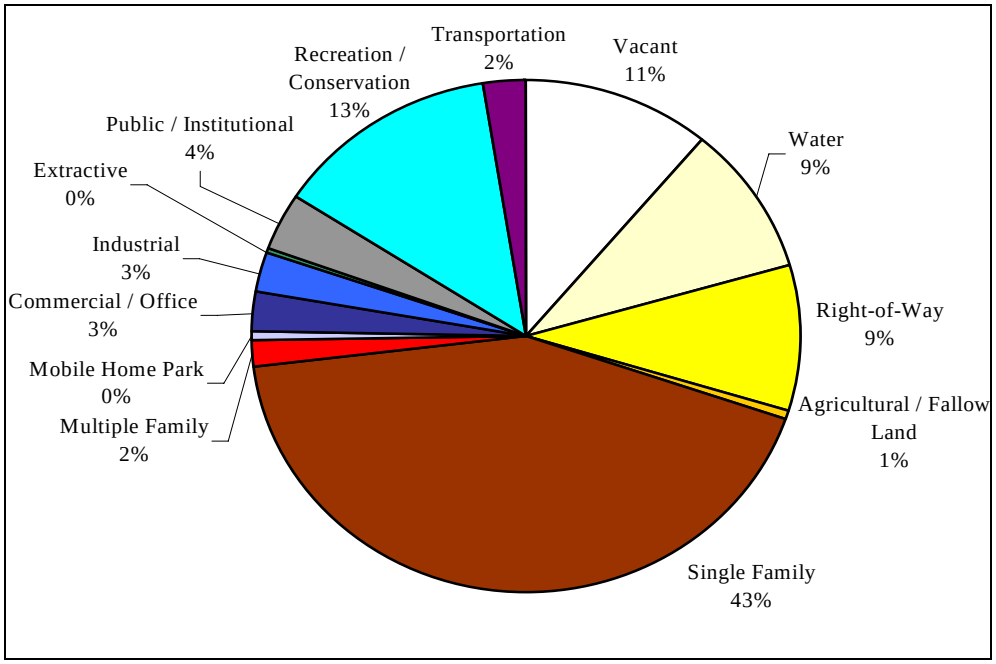
Land Use Analysis

The Upper Clinton subwatershed contains a wide range of existing land uses from single family to extractive. The twelve (12) land use categories used by Oakland County can be summarized in the following table and figure, and depicted in the map on the following page (see Map 1). A few of the categories have been combined for ease of use.

Table 3.3
2000 Existing Land Use Designations

Land Use Category	Total Acres	Percent Total
Single Family	23,514	42.6%
Recreation / Conservation	7,360	13.3%
Vacant	6,097	11.0%
Water	5,241	9.6%
Right-of-Way	5,110	9.3%
Public / Institutional	2,039	3.7%
Industrial	1,483	2.7%
Commercial / Office	1,404	2.5%
Transportation	1,338	2.4%
Multiple Family	948	1.7%
Agricultural/Fallow Land	332	0.6%
Mobile Home Park	245	0.4%
Extractive	95	0.2%
Total	**55,206**	**100%**

Figure 3.1
2000 Existing Land Use Designations



Map 2
Existing Land Use

The top three land uses in the Upper Clinton subwatershed are single family, vacant/water/right-of-way, and recreation/conservation, which combined represent nearly 86% of the total subwatershed land area. The high quantity of vacant/water/right-of-way land (29.9%) is reflective of the abundant lakes, ponds and streams within the subwatershed. The generally high water quality and stream corridor conditions within much of the area are also reflective of the low impact land uses. However, it appears that some lake and stream sections within the subwatershed are experiencing water quality problems as a result of the cumulative effects of the existing and expanding residential and other active land uses along their banks.

Over 13%, or 7,360 acres, of the subwatershed is contained within the recreation/conservation land use designation. The communities within the subwatershed have had the benefit of large tracks of land being maintained in public ownership through State and County park Master Plans. Many of these areas were previously identified as wetland and/or woodland ecosystems. The municipalities have also preserved other sensitive areas through the acquisition of local parkland.

Community Profiles

As the Upper Clinton communities continue to develop, the potential for negative environmental impacts increases; including water quality impacts resulting from erosion, sedimentation, and increased input of stormwater pollutants, as well as water quality impacts resulting from loss of wetlands, woodlands, and riparian vegetation, and increased impervious surfaces. The following are brief profiles of each of the ten (10) Upper Clinton subwatershed communities, highlighting their existing land uses and growth trends. The communities are generally listed from north to south and from west to east to reflect the changes in land use as one moves from the headwaters to the lower reaches of the creek.

In addition to each community's general land use features and trends, reference is also made to the results of the Michigan Natural Features Inventory (MNFI) study, which assesses the quality and extent of the natural areas in Oakland County (see Map 7).

Springfield Township – The majority of the northeast quadrant of the Township is located within the subwatershed. A total of 6,265 acres, or 27% of the Township, make up the western portion of the subwatershed. Approximately 75% of the area is occupied by single family residential developments. A few large parcels are contained within the private recreation and educational institutional land use designation. Other smaller parcels are being preserved as conservation areas. However, there is limited correlation between these areas and those identified by the Michigan Natural Features Inventory (MNFI). The MNFI has identified five (5) areas as Priority Three preservation areas, each located at the periphery of the subject area, three Priority Two areas have been identified within the central portions of the subject area. Two of the Priority Two areas consist of palustrine wetland ecosystems, but due to their desirable locations, have been developed for residential use. These wetlands were preserved as part of the residential developments by the use of clustering.

The greatest concentration of non-residential uses is along the Dixie Highway corridor where over the years several pockets of commercial/office uses have developed. A similar but more intensive pattern exists as Dixie Highway traverses the southwest corner of Independence

Township and extends into Waterford Township. The lack of sewer services places some limitations or additional requirements on non-residential developments in other portions of the Township. There are no plans to provide service to this portion of the Township. Capacity in the Clinton Oakland system is not available to Springfield.

The population within Springfield Township is projected to increase at a fairly steady pace over the next thirty (30) years with a slightly less dramatic increase in the number of households. The result of the different rate of growth between population and households is a projected decrease is household size. As of 2003 the number of residential building permits was still relatively low compared to that of the other communities within the subwatershed, but as compared to the base population figures, the percent increase is commensurate with that of the subwatershed as a whole.

White Lake Township – White Lake Township, along with the City of Pontiac, has the smallest quantity of their land area within the subwatershed. Only 3% (827 acres) of the Township is contained within the subwatershed. Nearly half of the area is occupied by a State recreation area which extends into Waterford Township. The majority of this area has been identified by the Michigan Natural Features inventory as a Priority One and Priority Two preservation area. Each of these areas also contains pockets of wetland ecosystems.

The population within White Lake Township is projected to increase at a slow but steady pace over the next thirty (30) years with a slightly less dramatic increase in the number of households. The result of the different rates of growth between population and households is a projected decrease in household size. Much like Springfield Township, the total number of residential building permits in 2003 was relatively low compared to that of the other communities within the subwatershed, but as compared to the base population figures, the percent increase is commensurate with that of the rest of the subwatershed. However, because these areas will never be sewered, the density levels will only be able to increase at a rate commensurate with the Oakland County Drain Commission standards.

Brandon Township – Brandon Township is located within the northern most reaches of the subwatershed. With only 5%, or 1,127 acres, of its land area within the subwatershed, it is the third smallest community within the subwatershed. Nearly all of the land area is occupied by single-family residential developments with a few pockets of commercial, agricultural and public/institutional land uses. Despite the limited land area, two (2) large areas have been identified by the Michigan Natural Features Inventory as Priority Two and Priority Three preservation areas. These designations are indicative of areas containing large Palustrine wetlands.

The population within Brandon Township is projected to increase at a slow but steady pace over the next thirty (30) years with a less dramatic increase in the number of households. The result of different rates of growth between population and households is a projected decrease in household size. The Township previously had the highest number of persons per household within the subwatershed. As of 2003 the number of residential building permits was relatively low compared to that of the other communities within the subwatershed, but as compared to the base population figures, the percent increase is commensurate with the rest of the subwatershed.

Independence Township – Independence Township has the third largest quantity of its land area contained within the subwatershed. A total of 20,398 acres (86%) of Independence Township is located within the subwatershed, of which the majority is occupied by single-family residential developments. Several large pockets of land are contained within County, educational institutions, municipal and private land holdings. The majority of the County parkland has been identified as a Priority One preservation area by the Michigan Natural Features Inventory. A large portion of the eastern perimeter of the Township, and extending into Orion Township, has also been designated as a Priority One preservation area. Pockets of Priority Two and Priority Three preservation areas are scattered throughout the Township. The highly sensitive environment within the Township is indicative of areas with extensive wetland ecosystems, abundant lakes and streams, and expansive floodplains. These sensitive areas are located primarily within the northern half of the Township. The lack of sewer connections within this area will ensure that the density is kept relatively low.

The greatest concentration of non-residential uses is along the Dixie Highway corridor where over the years several pockets of commercial/office uses have developed. A similar pattern exists as Dixie Highway extends to the south into Waterford Township. Other pockets of commercial and office uses are scattered along the principal arterials, primarily the Ortonville and Sashabaw Road corridors. The limitations associated with non-residential developments within the northern portions of the Township are associated with the lack of sewer service. Presently there are no plans to provide service to this portion of the Township.

The population within Independence Township is projected to increase at a steady pace over the next thirty (30) years with a commensurate increase in the number of households. However, the persons per household are projected to decrease over the same time frame. In 2003 the Township witnessed one of the highest growth rates for new residential construction. A total of 209 residential permits were issued that year. Based upon the population projections, and the availability of land within the Township, this number is expected to outpace the majority of the communities within the subwatershed.

City of the Village of Clarkston – The 328 acre City is located entirely within the subwatershed, and consists of predominantly single-family developments with a commercial core located in its center. Approximately 30% of the City consists of woodlands, wetlands and open water. A large municipal park exists within the southwest quadrant of the City and includes the stream between Mill Pond Lake and Deer Lake. According to the Michigan Natural Features Inventory, this land has been identified as a Priority Three preservation area because of the significance of its wetlands and proximity to the adjacent chain of lakes that extend into Independence and Waterford Townships.

The City has experienced a decline in population and households, a trend which is projected to continue over the next thirty (30) years. Based upon the correlation between these two indicators, the household size is projected to remain nearly the same.

Waterford Township – Waterford Township has nearly 65% of its land area within the subwatershed. A large quantity of the 14,620 acres is occupied by single family residential developments, but unlike the majority of the other communities within the subwatershed, a large quantity of non-residential uses are scattered throughout its confines. Dixie Road and Highland Road corridors contain the greatest quantity of commercial and office uses with a large pocket of industrial land located in and around the airport. Limited recreational land remains with the Township, the majority of which are contained within municipal park holdings and/or educational institutions. A small pocket of private recreation land exists to the southwest of Lake Angelus and a small pocket of State land exists within the northwest quadrant of the Township. There is also a large County park complex known as Waterford Oaks. The Michigan Natural Features Inventory has identified several pockets of priority preservation areas, the majority of which correlate closely with the previously noted parkland. With only a few exceptions in the southwest corner of the Township, each of these areas is being preserved through the parkland designation. Only one of these areas is designated as a Priority One preservation area and is contained at the extreme southern portion of the subwatershed. Three hundred and thirty (330) acres of the Priority One area has been preserved as the Elizabeth Lake Woods Conservation Area (Township Park). The density and intensity of development over the past several decades has had an impact on the environment within the Township, but the majority of the most sensitive lands have been preserved. The availability of sewer service has also perpetuated this land development pattern.

The population within Waterford Township is projected to be nearly constant between 2000 and 2030. The growth rate for the number of households is projected to increase slightly over the same time frame. Therefore, the persons per household should continue to decline. In 2003 the Township granted 176 residential building permits, a rate that is commensurate with several of the other communities within the subwatershed.

City of Lake Angelus – A total of 91% of the City is contained within the subwatershed. As the second smallest community within the subwatershed it also has the second largest quantity of its land area contained within the subwatershed. The predominant land use is the lake with a circle of single-family residential development around its confines. There are also two pockets of municipal recreational land at the northern and southern perimeters of the community and a pocket of commercial/office land to the northeast of the lake. The Michigan Natural Features Inventory designates each of the recreational areas as Priority Two and Priority Three preservation areas. Another Priority Three preservation area is located at the terminus of Rohr Road, but this area was previously developed for single-family residential use.

The City has experienced a slight decline in population with a slight increase in the number of households between 1990 and 2000. This pattern is projected to continue but at a slower pace over the next thirty (30) years. The household size is projected to decrease between 2000 and 2030 to the lowest rate within the subwatershed.

Orion Township – Just under half of Orion Township is located within the subwatershed. The majority of the 9,887 acres contained within the subwatershed have been developed for single-family residential use. The second largest land use category is recreation/conservation which is inclusive of several large County, municipal, private, State and educational institution land uses. A few of these areas have been identified as priority preservation areas by the Michigan Natural

Features Inventory. The eastern most preservation area has been designated as Priority One due to its abundant wetland ecosystems while a large quantity of the western preservation area has been lost to residential development. The Priority Two and Three preservation areas are located in close proximity to, or contain wetland ecosystems or open water. Large pockets of land within the Township will not have access to municipal sewer service to ensure that these highly sensitive areas are protected. However, the majority of the area within the subwatershed already has sewer service or it is planned for the near future.

The greatest concentration of non-residential uses is along the Baldwin Road corridor where over the years several pockets of commercial/office uses have developed. A large pocket of industrial and transportation uses are also located within the southeast quadrant of the subwatershed. Other small pockets of commercial uses are located at major intersections within the Township. There are few limitations associated with non-residential developments in this portion of the Township; therefore, this pattern of development is projected to expand into vacant or under-developed portions of the Township.

The population within Orion Township is projected to increase dramatically over the next thirty (30) years with a commensurate increase in the number of households. However, like the rest of the communities in the subwatershed, the persons per household are projected to decrease over the same time frame. In 2003 the Township witnessed one of the highest growth rates for new residential construction. A total of 184 residential permits were issued that year. Based upon the population projections, and the limited availability of land within the Township, this number is expected to be commensurate with the majority of the communities in the subwatershed.

City of Auburn Hills – Only 7% of the City, or 782 acres, is contained within the subwatershed. The predominant land use is industrial located contiguous to the industrial land in Orion Township. The rest of the City is occupied by a mix of residential and commercial/office uses. The land uses along Brown Road are nearly a mirror image of those in Orion Township. There is no recreational land and limited wetland ecosystems within this portion of Auburn Hills, but the Michigan Natural Features Inventory has identified one Priority Three preservation area just south of Lake Angelus.

The City has experienced a slight increase in population with a commensurate increase in the number of households between 1990 and 2000. This pattern is projected to continue at a similar pace over the next thirty (30) years. As exhibited in each of the communities within the subwatershed, the persons per household is projected to decrease between 2000 and 2030. The decrease is in part due to the high number of residential permits, in particular townhouse/ attached condominiums. In 2003 the City issued 202 residential building permits, one of the highest volumes within the subwatershed.

City of Pontiac – The City is tied with White Lake Township for the smallest quantity of land contained within the subwatershed. The 332 acres are located within the extreme northwest corner of the City and are occupied by single family residential, municipal recreation, and institutional uses along with a very small pocket of commercial uses along Walton Road. A portion of the southern most recreation area is contained within a Michigan Natural Features Inventory Priority Three preservation area and a portion of the northern conservation area is part of the southern preservation area in Lake Angelus.

The City has experienced a decline in population and the number of households between 1990 and 2000. This pattern is projected to change with an upswing projected over the next thirty (30) years. Therefore, the household size is projected to decrease but at a slower rate than that of the majority of the other communities within the subwatershed. In 2003 the City issued more residential building permits than any other community within the subwatershed, but it was not enough to maintain the growth levels exhibited during the 1980's and early 1990's.

3.2 Sanitary Sewer System and On-Site Sewage Disposal Systems

Wastewater is dealt with by either a system of sanitary sewers leading to a wastewater treatment plant or by on-site sewage disposal systems (OSDS). On-site sewage disposal systems typically include a septic tank and an absorption field. OSDS generally serve single family residences in less urbanized settings, although community septic systems are becoming more common in newer developments. The Sewer Service Areas Map (see Map 3) depicts the areas within the subwatershed that are currently serviced by sanitary sewers, are planned to be serviced by sewers, or are not planned to receive sewers. Table 3.4 depicts the present and planned status of wastewater disposal systems. Over half of the subwatershed is currently sewered; an additional small amount of unsewered area is also planned for conversion. The majority of the unsewered areas are found in the headwaters areas of the subwatershed, mainly in Springfield and Independence Townships and to a lesser degree in Orion and Waterford Townships.

If properly designed, constructed and maintained, both OSDS and sanitary sewers can provide for disposal of sewage in a safe and environmentally responsible manner. If either type of system fails, inadequately treated sewage can be a threat to aquatic ecosystems and human health due to harmful bacteria and excess nutrients.

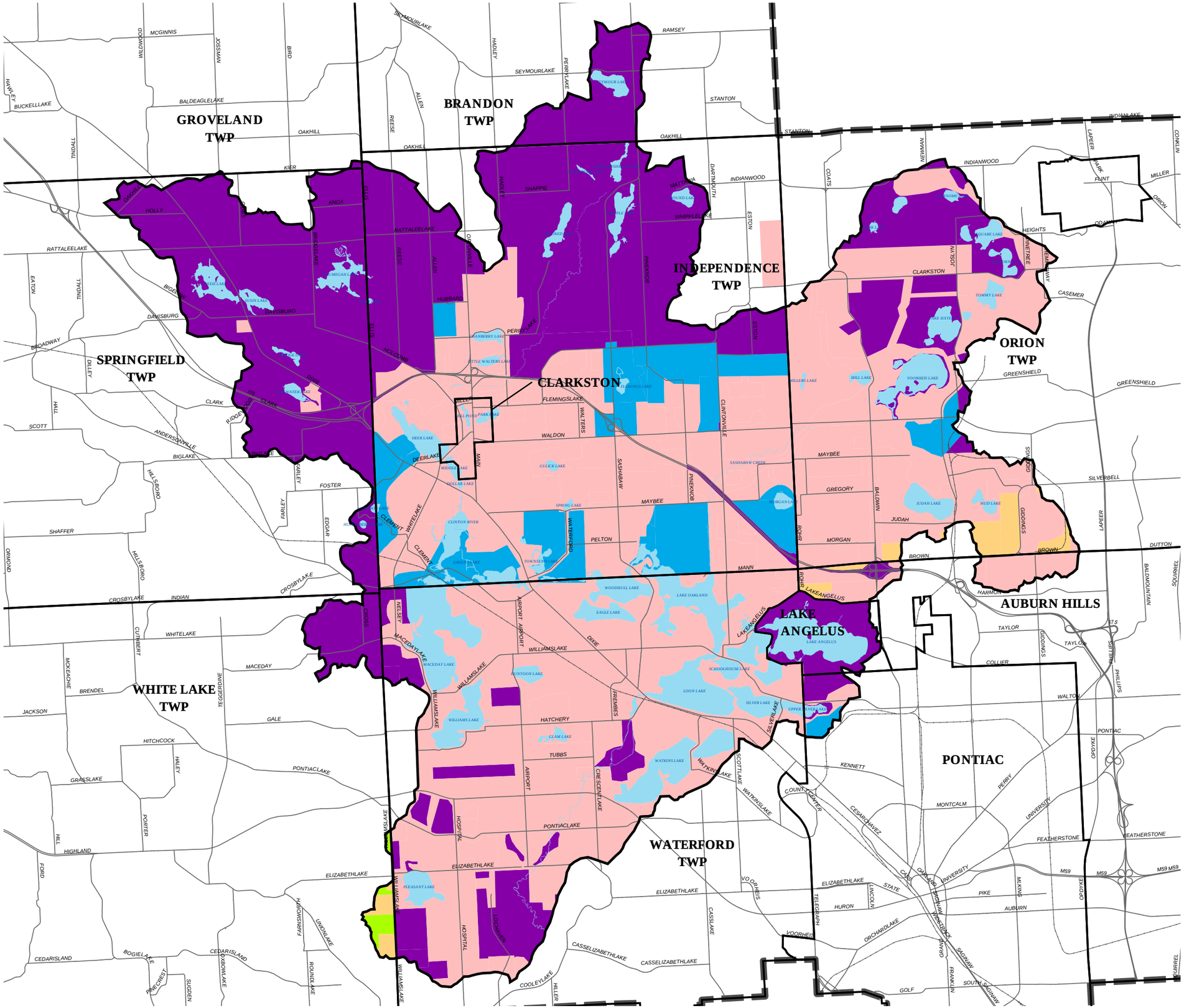
The installation and maintenance of septic systems within the watershed are regulated by the Oakland County Health Division. However, there is no system currently in place to monitor the functioning and maintenance of these systems following installation. While there have been no confirmed cases of septic systems contaminating surface waters in the Upper Clinton subwatershed, it remains a potential concern. Oakland County is currently considering enactment of regulations that would mandate professional inspection of OSDS at the time of the sale of a property or every five years, whichever comes first. Along with regulation, education is often considered central to addressing potential issues with OSDS. Owners, particularly those moving from areas with sanitary sewers to those with OSDS, often have limited understanding of the functioning and maintenance of OSDS. This lack of knowledge can lead to poor function and premature failure, leading to contamination of the ground and surface waters. The use of community septic systems can mitigate this situation by having written maintenance requirements in the condominium documents and making them the responsibility of the homeowners association.

Discharges from sanitary sewer systems have historically been a problem, but modern standards and regulations for these systems have reduced the most harmful discharges. Damaged sewer pipes may leak sewage into the ground or nearby storm drains and thereby contaminate ground or surface water. A sanitary sewer system may also be overloaded and overflow into local lakes or streams. Illicit connections are another potential source of water contamination. These connections are usually sanitary sewer pipes from a building that have been accidentally or purposefully connected to a storm drain. The locations of such discharges are usually identified by systematic water sampling and/or physical inspection of the banks of streams and lakes. The processes for the detection and correction for such discharges are required to be outlined in each community's Illicit Discharge Elimination Plan (IDEP). Communities are required to inspect their sanitary sewer systems and correct any sewage discharges into waterways under the NPDES Phase II stormwater regulations.

Table 3.4
Status of Sewer Systems within the Upper Clinton Subwatershed by Community

Sewer Status	Sub-watershed	Auburn Hills	Brandon Township	Clarkston	Independence Township	Waterford Township
Currently Sewered	55%	81%	0%	96%	55%	79.5%
Planned Sewer 2010	1%	9%	0%	0%	0%	0.4%
Planned or Forecasted Sewer 2030	1%	0%	0%	0%	3%	0%
Potential Sewer	1%	0%	0%	0%	2%	0.1%
No Sewer Planned	42%	10%	100%	4%	40%	20%

Sewer Status	Sub-watershed	Lake Angelus	Orion Township	Pontiac	Springfield Township	White Lake Township
Currently Sewered	55%	0%	70%	8%	1%	0%
Planned Sewer 2010	1%	0%	4%	0%	0%	14%
Planned or Forecasted Sewer 2030	1%	0%	0%	0%	0%	13%
Potential Sewer	1%	0%	2%	43%	0%	0%
No Sewer Planned	42%	100%	24%	49%	99%	73%



Legend

- Upper Clinton Subwatershed
- Rivers/Streams/Drains
- Lakes

Sewer Service Areas

- Existing Sewer
- Planned Sewer - 2010
- Planned or Forcasted Sewer - 2030
- Potential Sewer
- Not Currently Planned for Sewer

MAP 3

SEWER SERVICE AREAS

UPPER CLINTON SUBWATERSHED MANAGEMENT PLAN

Carlisle/Wortman Associates, Inc.
Community Planners & Landscape Architects

0 1 2 Miles

0

PLOT GENERATION: AUGUST 31, 2005
SOURCE: SEMCOG

3.3 Baseline Stream, Lake and Riparian Conditions

An assessment of the existing conditions of the streams, lakes and riparian corridors was completed to determine the nature and extent of any water quality issues present in the Upper Clinton subwatershed. The assessment incorporated a range of existing chemical, biological, and physical condition data gathered from a variety of sources. The Water Sampling Stations Map (see Map 4) depicts the locations of the sampling stations used for all the data sources consulted in the preparation of this report. The data sources and results are summarized in the following sections.

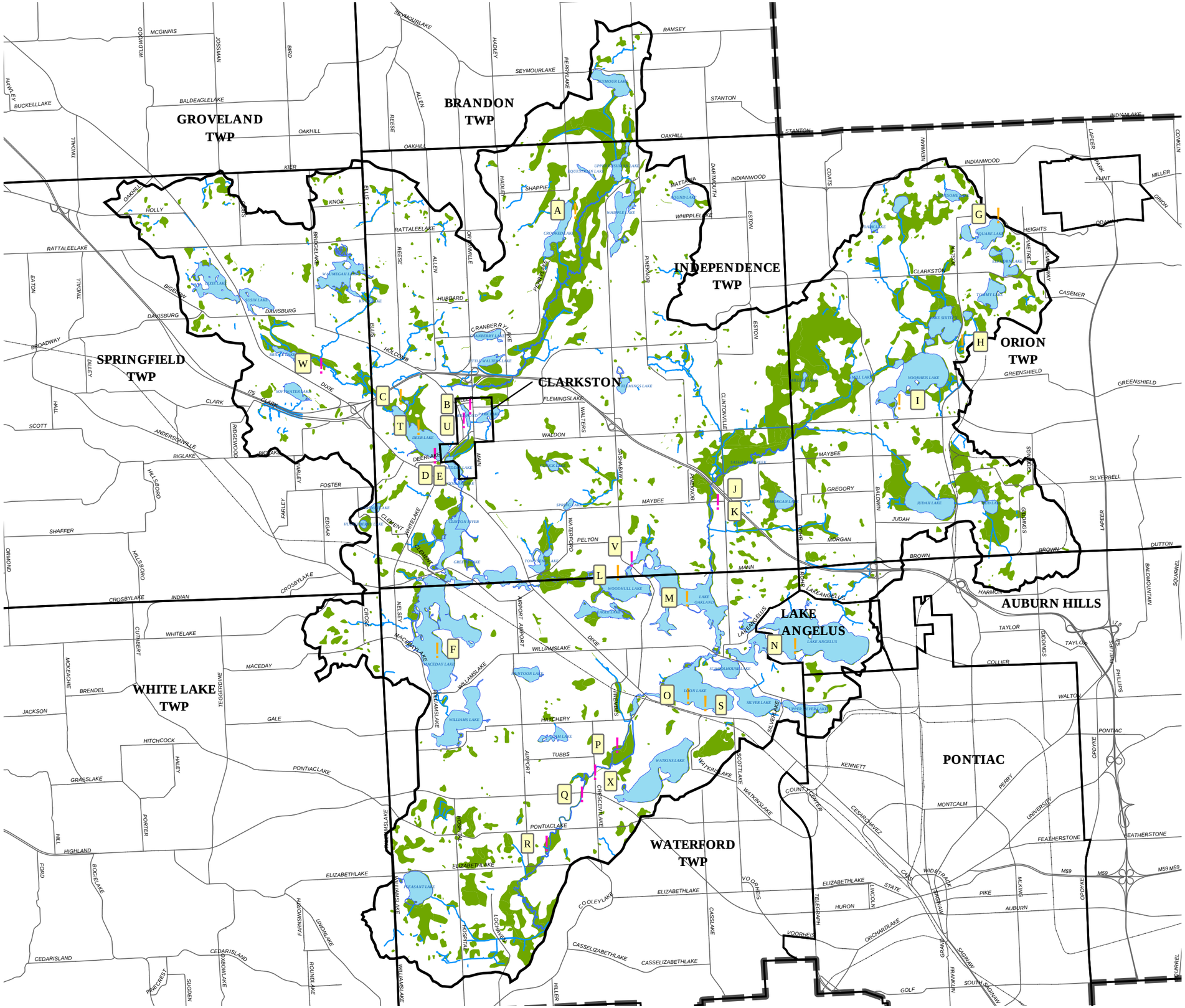
The following is a list of each of the consulted data sources:

USGS Stream Flow and Water Quality Data – The available USGS data contains water quality data for eleven sites within the Upper Clinton subwatershed and stream flow data for two (2) of those sites. The data collection time frames and water quality parameters vary from site to site, but in total extend between 1967 and 2003. Data for nine (9) of these sites are from the late 1960's and are mainly useful as a historic baseline for evaluating more current data on the subwatershed. Two (2) of the sites provide water quality and stream flow data over an extended period. The latter two (2) sites are located as follows: 1) in the Sashabaw Creek about one (1) mile north of its confluence with the Clinton River (Site J), and 2) in the Clinton River at the M-59 bridge near the outflow point of the subwatershed (Site Q).

MDEQ Water Quality Data on the EPA STORET Database – The EPA STORET Database contains water quality data for ten (10) sites within the Upper Clinton subwatershed. The data collection time frames and parameters vary from site to site, but in total cover the years 1974 to 1996. The data provides an historic baseline for evaluating more current data on the subwatershed.

CRWC Stream Leaders Stream Monitoring Data/Reports – The Clinton River Watershed Council coordinates a school-based volunteer water quality monitoring program called Stream Leaders. The Stream Leaders program has three (3) sampling locations within the Upper Clinton subwatershed. Beginning in 1995 the Clarkston High School students have been performing chemical water quality monitoring and macroinvertebrate inventories at a site near the intersection of Sashabaw and Fowler Roads (Site V). In 2003 the Cedar Crest Academy began performing macroinvertebrate surveys at a site on the main branch of the Clinton River northwest of Deer Lake (Site W). Waterford Mott High School carried out water quality sampling in 1999 and 2000 on the Clinton River just east of Crescent Lake Road (Site X). The CRWC provides teachers with training in sampling protocols and analysis techniques to ensure the quality and consistency of the product.

MDNR Fisheries Data/Reports – A variety of Michigan Department of Natural Resources maps, reports, and databases were consulted in order to gain information on the status of the Upper Clinton subwatershed fisheries status. The consulted materials include the Trout Stream and Lake Map, Fish Atlas, and Fish Stocking Records.



Legend

- Upper Clinton Subwatershed
- Rivers/Streams/Drains
- Lakes
- Wetlands
- Municipal Boundaries

Sampling Stations

- Lake
- Stream / River

A Crooked Lk near Walters
B Clinton River at Bluegrass Dr
C Dark Lk-Central Basin
D Deer Lk near Clarkston
E Deer Lk Outlet at White Lk Rd
F Maceday Lk-Central Basin
G Square Lk near Lk Orion Heights
H Lk Sixteen near Lk Orion
I Voorheis Lk near Lk Orion
J Sashabaw Creek near Drayton
K Sashabaw Creek at Maybee Rd
L Lk Oakland near Drayton Plains
M Lk Oakland-Central Basin
N Lk Angelus near Clintonville
O Loon Lk in No-West Basin
P Clinton River at Hatchery Rd
Q Clinton River at M-59 Bridge
R N Clinton River at Pontiac Lk Rd
S Loon Lk in S. Central Basin
T Deer Lk in S. Central Basin
U Clarkston Mill Ponds
V Clinton River near Fowler & Sashabaw Intersection
W Clinton River north of I-75 off Dixie Highway
X Clinton River east of Crescent Lake Road

MAP 4

WATER SAMPLING STATIONS

UPPER CLINTON SUBWATERSHED MANAGEMENT PLAN

Carlisle/Wortman Associates, Inc.
Community Planners & Landscape Architects

0 1 2 Miles

PLOT GENERATION: AUGUST 30, 2005
SOURCE: OAKLAND COUNTY

Oakland County Health Division Beach Closure Reports – The Oakland County Health Division beach closing information for 2001, 2002 and 2003 was consulted for additional information related to fecal coliform levels in the subwatershed.

Local Municipal Water Quality Studies – A number of local municipal documents and studies/reports were consulted with regard to water quality of specific water bodies within those jurisdictions. These documents were all prepared within the last three (3) years.

Other Sources – Additional miscellaneous sources were utilized that contained information relevant to water quality in the Upper Clinton subwatershed. These sources include a Nature Conservancy report on freshwater mussels in the Upper Clinton River, an EPA report titled "Clinton River Area of Concern," and an MNFI Site Ecological Summary for an area within the subwatershed.

3.3.1 Water Chemistry

The only recent water chemistry data identified for the Upper Clinton subwatershed was collected by the USGS and CRWC's Stream Leaders water quality monitoring programs. The sampling sites for these sources are identified as Sites J, Q, V, W and X on the Water Sampling Stations Map (see Map 4). Where available, the following parameters were examined: pH, dissolved oxygen (DO), nitrates (N), phosphorus (P), turbidity (water clarity), fecal coliform bacteria (FC) and temperature. The water quality data and results are summarized in Table 3.5 on the following page.

pH – The pH of water is a measure of the hydrogen ion (H+) concentration in water. pH affects a wide variety of chemical and biological processes in streams and lakes. pH is measured on a scale from 0 to 14, 0 being a very acidic condition and 14 being a very basic condition. A pH of 7 is considered "neutral" and is the pH of pure deionized water. Michigan Water Quality Standards establish a pH standard of 6.5 to 9.0 for all waters of the State. This pH range will sustain the reproduction, growth and health of most aquatic organisms.

The data indicates that the pH for all water quality sample sites within the subwatershed fall within the desired range set by the State. It does not appear that high or low pH levels are a substantial problem within the Upper Clinton subwatershed.

Dissolved Oxygen (DO) – Dissolved oxygen is the quantity of oxygen that is contained in a body of water. DO is measured in milligrams of dissolved oxygen per liter of water or parts per million (ppm). The respiration of plants and animals, photosynthesis, natural chemical processes, and decomposition of organic matter within a stream or lake are all influenced by the concentration of dissolved oxygen. Dissolved oxygen levels of 5 to 6 ppm or greater are required for the normal growth and activity of most aquatic organisms. Levels of dissolved oxygen below 2 ppm for one (1) to four (4) days will kill many of the same aquatic organisms.

The data indicates that the dissolved oxygen levels for nearly all water quality sample sites within the subwatershed are above the 5 ppm threshold. It does not appear that low DO levels are a substantial problem within the Upper Clinton subwatershed.

Table 3.5
Summary of Recent Water Quality Data

Year	Month	Location	Temp (C)	Turbidity	Dissolved Oxygen (ppm)	pH	Nitrate (ppm)	Phosphorus (ppb)	Fecal Coliform (colonies/100ml)	Parameters of Concern
1973	May	Site Q	14	25	8.4	7.8	0.28	100	940	High P, High FC
	Sept.	Site Q	15	30	7	7.9	0.36	100	300	High P, High FC
1978	May	Site Q	17	2.8	9.1	8.2	0.159	24	30	High P
	Sept.	Site Q	19	4.9	5	7.7	0.25	20	900	High FC
1983	May	Site Q	15	3.7	8.8	8.3	0.085	25	NA	High P
	Sept.	Site Q	17	2.2	8.3	8.3	0.076	11	NA	None
1988	May	Site Q	18.5	2.3	8.4	8.2	0.098	21	NA	High P
	Sept.	Site Q	16	3.3	4.1	7.8	0.121	33	NA	Somewhat High P, Low DO
1993	May	Site Q	15	2.8	8.4	8.17	0.135	30	NA	High P
	Sept.	Site Q	20	1.6	7	8.15	0.062	19	NA	None
2001	June	Cranberry Lake							452	High FC
	July	Crooked L.							537	High FC
		Deer L.							488	High FC
	Aug.	Crooked L.							349	High FC
	Sept.	Site Q	13.5	NA	5.5	7	0.13	19	NA	None
		Site J	12.8	NA	7.8	7.6	0.11	10	NA	None
	Nov.	Site Q	8.9	NA	10.5	7.7	0.06	4	NA	None
		Site J	8.2	NA	10	7.8	3.33	4	NA	None
2002	Jan.	Site Q	0.7	NA	12.2	7	0.14	3	NA	None
	.	Site J	0.5	NA	12.6	6.8	0.12	4	NA	None
	March	Site Q	1.8	NA	13	7.6	0.15	4	13	None
		Site J	2.2	NA	13.2	7.4	0.12	4	3	None
	April	Site Q	8.2	NA	10.9	7.5	0.14	50	120	High P
		Site J	NA	NA	NA	8.1	0.04	60	46	High P
	May	Lake Oakland	105	Low	11	8.7	NA	24	NA	High P
	June	Site Q	15.1	NA	6.7	7.7	0.23	4	9,700	Very High FC
		Site J	7.6	NA	13.5	7.6	0.17	3	9,500	Very High FC
	July	Site Q	NA	NA	NA	7.9	0.07	4	NA	None
		Site J	NA	NA	NA	8.2	0.23	30	NA	High P
		Greens L.							510	High FC
		Eagle L.							452	High FC
		Pleasant L.							320	High FC
		Lake Oakland	26.5	Low	7	8.8	NA	11	NA	None
	Aug.	Site Q	NA	NA	NA	NA	0.13	13	850	High FC
	.	Site J	NA	NA	NA	8.1	0.23	54	770	High P, High FC
	Sept	Lake Oakland							687	High FC at Sashabaw Creek
2003	June	Eagle L.							1,621	Very High FC
	July	Maceday L.							332	High FC

Nitrogen – All plants and animals require nitrogen in order to build proteins. In water, nitrogen is usually measured as milligrams per liter (ppm) of nitrate (a water soluble ionic form of nitrogen). Excess nitrogen can cause rapid algal and aquatic plant growth if it is the limiting nutrient in a water body. Unpolluted waters usually have less than four (4) ppm of nitrate, and ten (10) ppm of nitrate is considered unsafe as drinking water. Nitrate concentrations above 2.5 to 5 ppm can also accelerate plant and algae growth and promote eutrophication.

The data indicates that the nitrate concentrations for all water quality sample sites within the subwatershed fall below four (4) ppm, and nearly all are below one (1) ppm. In addition, phosphorus, not nitrogen, is usually the limiting nutrient in aquatic ecosystems in this part of Michigan. Therefore, it appears that nitrogen levels are not a substantial problem within the Upper Clinton subwatershed.

Phosphorus – Phosphorus is an essential nutrient for all plants and animals. Phosphorus occurs in streams and lakes in the form of phosphates (measured in micrograms per liter or parts per billion, ppb). Typically, phosphorus is in short supply in lakes and streams, and is thus the limiting nutrient controlling plant growth in these aquatic systems. Artificial increases in the phosphorus level of a water body can create excessive algae and plant growth, which can in turn deplete the dissolved oxygen and cause fish kills or other associated problems. The excessive algae and plant growth can also cause reduced water quality, unpleasant swimming conditions, bad odors, algal blooms, and interference for boating activities. Excess phosphorus in water bodies typically comes from point sources such as sewage treatment plants, septic systems and industry or nonpoint sources like stormwater runoff from agricultural and urban/residential areas. Phosphate concentrations greater than 20 ppb are indicative of a eutrophic condition in which excessive algae and plant growth is likely.

Water quality samples in the last few years from Sashabaw Creek (Site J), the main branch of the Upper Clinton (Site Q), Clarkston Mill Ponds and Lake Oakland, indicate phosphorus concentrations that occasionally rise to the eutrophic level during the growing season. Fourteen (14) lakes in the subwatershed are confirmed to have problems with excessive algae or plant growth:

- Dixie Lake – Springfield Township
- Softwater Lake – Springfield Township
- Susin Lake – Springfield Township
- Waumegah Lake – Springfield Township
- Square Lake – Orion Township
- Lake Oakland – Independence and Waterford Townships
- Williams Lake – Waterford Township
- Scott Lake – Waterford Township
- Huntoon Lake – Waterford Township
- Pleasant Lake – Waterford Township
- Maceday Lake – Waterford Township
- Lotus Lake – Waterford Township
- Watkins Lake – Waterford Township
- Upper Mill Pond – Clarkston

Special Assessment Districts for the management of nuisance algae or aquatic plants have been implemented or are under consideration for most of the lakes listed above. The areas around these lakes are mainly occupied by single-family residences. It is likely that stormwater runoff from the surrounding residential properties, containing fertilizers and waterfowl feces, is contributing to the algae and weed problems. Both fertilizers and waterfowl wastes are known contributors to phosphorus pollution in many of Michigan's lakes and streams. Poorly maintained or failing septic systems are another potential source of phosphorus contamination found commonly in southeast Michigan. However, there are no confirmed cases of septic systems contaminating surface waters in the Upper Clinton Subwatershed. The lack of any systematic monitoring of septic systems makes it difficult to assess this as a pollution source. As the areas adjacent to many of the lakes and streams in the subwatershed are serviced by sanitary sewers, and some are still showing elevated phosphorus levels, direct inputs from stormwater runoff appears the most likely source of the contamination.

Turbidity or Sedimentation – Turbidity is a measure of water clarity. A high turbidity indicates a lower level of water quality that results from the suspended solids, or sedimentation, that reduce the penetration of light into the water. These suspended solids enter the water as a result of soil erosion, urban runoff, algal blooms, disturbance of bottom sediments, industrial discharges, and sewage. Excessive suspended solids can have a variety of negative impacts on a stream or lake, including but not limited to the following:

- Clogging fish gills
- Reducing growth rates
- Reducing disease resistance
- Decreasing photosynthesis
- Reducing dissolved oxygen levels
- Prevention of egg and larval development
- Increased heat absorption for sunlight (increased temperature)
- Increased sedimentation on the stream bottom (smothering important egg laying and habitat areas for fish and aquatic insects).

A variety of turbidity measures have been used within the subwatershed; including Jackson Turbidity Units (JTU), Nephelometric Turbidity Units (NTU), Formazin Turbidity Units (FTU), and Secchi Disk measurements. The most recent stream measurements do not indicate any substantial turbidity problems in Lake Oakland, Sashabaw Creek (Site J) or the main branch of the Upper Clinton (Site Q). Deer Lake and the Mill Ponds in Clarkston have recently shown some potentially problematic turbidity levels (clarity measurements consistent with a eutrophic lake condition). Recent turbidity measurements for other lakes in the subwatershed are not available.

While concrete data regarding sedimentation is currently unavailable, local residents and community leaders perceive it as a problem. One main source could be the gravel roads within the subwatershed. Sediments enter the stream at bridge crossings as a result of poor construction and maintenance practices, and via road ditches which convey sediment from gravel roads into the streams. Sedimentation is also increasing as stormwater flows increase, scouring the banks

and depositing sediments downstream. Construction sites adjacent to streams could be another potential source of sediments due to improper erosion and sedimentation controls. In addition, pollutants such as phosphorus enter waterways on eroding soils.

Fecal Coliform Bacteria (FC) – Bacteria are microscopic, single-celled organisms and are the most common type of organism on the earth. Fecal coliforms are a type of bacteria found in the digestive tract of humans and other warm-blooded animals. These bacteria are usually harmless in and of themselves, but are considered an indicator of contamination by human or animal wastes. Human and animal wastes may contain a variety of harmful bacteria or parasites that may infect those who have contact with the contaminated material. The species *Escherichia coli* is used as the specific indicator of waste contamination. A water sample is cultured and the number of growing bacterial colonies is counted to determine the level of contamination. The standards below are used to judge the contamination level.

- 0 total coliforms/100 ml for drinking water
- 300 *E. coli*/100 ml at any time or 130 coliforms/100 ml as a 30 day average for full body contact
- 1000 *E. coli*/100 ml at any time for partial body contact
- 200 fecal coliforms/100 ml as a monthly average or 400 fecal coliforms/100 ml as a seven (7) day average for discharges containing treated or untreated sewage.

In the last three (3) years, Lake Oakland, Crooked, Deer, Cranberry, Maceday, Greens, Eagle, and Pleasant Lakes have had *E. coli* levels above the full or partial body contact standards. In addition, the main in-stream sampling sites for Sashabaw Creek (Site J) and main branch of the Upper Clinton (Site Q) have both had *E. coli* levels in excess of the full and partial body contact standards in June and August of 2002. This data seems to indicate a recent problem with human and/or animal waste contamination of some of the surface waters in the subwatershed. As there is little or no livestock-based agriculture in the subwatershed, the source of contamination must be waterfowl, pet or human waste. Point sources such as sanitary sewer overflows and combined sewer overflows could be contributing to the problem and should be investigated. Nonpoint sources such as runoff from adjacent properties containing waterfowl or pet wastes are also likely contributors to the problem. The clearing of waterfront property for lawn creates ideal habitat for waterfowl such as Canadian geese. These birds can become resident in large numbers and can create substantial impacts on the water quality in an area. Illicit connections and poorly maintained or failing septic systems are also possible contributors to the problem, but there are no confirmed cases of either.

Temperature – Water temperature affects many of the chemical and biological characteristics of a stream or lake. Temperature affects the amount of dissolved oxygen in water, the metabolic rates of aquatic organisms, and the sensitivity of organisms to toxic waste, parasites, and diseases. Streams and lakes may be detrimentally impacted when their water temperature rises. Common sources of such warming include discharge of heated water by industrial operations, stormwater runoff from paved areas, heat absorption due to excessive suspended solids, and extra heating due to tree and vegetation removal. Generally, temperatures below 13 degrees centigrade during the warm season are required for a high quality cold water fishery and minimal plant life. Temperatures above 20 degrees centigrade lead to the development of a warm water

fishery and ample plant life. The streams in the Upper Clinton Subwatershed appear to fall in between these two (2) extremes, and should support some cold and warm water fish as well as some plant life. The available data on water temperatures beginning in the 1960's indicates that warm season surface water temperatures have tended to exceed 20 degrees centigrade.

3.3.2 Biological Community

An analysis of the macroinvertebrates, fish and mussels found in the streams and lakes of the Upper Clinton River can provide insight into the water quality of the subwatershed.

Macroinvertebrates – The *Stream Leaders* program run by the Clinton River Watershed Council includes three (3) sites within the Upper Clinton subwatershed. Two (2) of the sites are in the main branch of the Upper Clinton (Sites V and X) and the other is up stream of Deer Lake (Site W). In 2003, sites V and W were given a water quality index rating of good (3 on a 1-4 scale), based on the presence and abundance of pollution sensitive, and moderately pollution tolerant macroinvertebrates such as caddisflies, beetles and damselflies. Site V was given a water quality index rating of good in both 1999 and 2000. Since most macroinvertebrates do not move great distances, they cannot escape polluted environments. As a result, the presence of large quantities of certain pollution sensitive species indicates a relatively high-quality, unpolluted stream.

Fish – The Michigan Department of Natural Resources (MDNR) Trout Maps indicate that no trout streams are present within the Upper Clinton subwatershed. The lack of trout streams is consistent with the lack of coldwater streams noted in the water chemistry analysis. The temperature of a stream is primarily determined by its size, shading and water sources.

Only one (1) recent fish survey was found for the study area. This survey was done in Crooked Lake during 2002 (J. T. Francis, 2004, Crooked Lake, *Status of the Fishery Resource Report*, No. 2004-1, MDNR). The fish community consisted of bluegill, pumpkinseed, rock bass, green sunfish, and yellow perch, with largemouth bass, bullhead, and northern pike as the dominant predators. Least darter, blacknose shiner, grass pickerel, central minnow and brook silverside were also found in the lake. The fish community benefits from the lack of fish such as suckers and carp, which compete with game fish, and can have negative environmental impacts. The survey concluded that the lake "…supports a balanced fish community and provides a good fishery for panfish and largemouth bass."

The MDNR Fisheries Division has done substantial fish stocking in two (2) of the lakes through which the Upper Clinton River passes. Records of the fish stocking over the last ten (10) years are depicted in the table on the following page (see Table 3.6). Records of the MDNR actively stocking fish in these two (2) lakes extend back to 1981. The active level of fish stocking of these lakes raises the question of whether or not the existing fish communities in these lakes are self-sustaining. The need for stocking could be due to strong fishing pressure, environmental conditions that are impairing the native fish population, or a combination of these factors. The stocking records for Maceday Lake explain how it achieves its trout lake designation in an area otherwise devoid of trout lakes and streams, and an area that does not generally support a coldwater fishery.

The MDNR Fish Atlas catalogues the distribution of current and historic fish species in the State. According to the atlas, Maceday and Loon Lakes have supported a diverse fish community by supporting twenty-four (24) species of fish. These two (2) lakes, and the one (1) Clinton River site, all support some species of darters. Darters are a group of fish that are considered important indicators of biological integrity and water quality. Their presence indicates that both lakes and some portions of the river would have been considered good to excellent quality sites at the time the darters were sampled. In addition, the presence of various darter species was noted during a field survey performed for Waterford Township by Applied Science and Technology, Inc. in 2001.

Table 3.6
MDNR Fish Stocking History in the
Upper Clinton Subwatershed, 1994-2004

Site	Species	Date	Quantity
Loon Lake	Northern Pike	6/13/1995	2,000
Loon Lake	Northern Pike	5/25/1996	5,971
Loon Lake	Northern Pike	5/20/1997	2,483
Loon Lake	Northern Pike	5/21/1997	1,292
Loon Lake	Northern Pike	5/22/1997	150
Loon Lake	Northern Pike	5/29/1997	272
Loon Lake	Northern Pike	5/23/2001	510
Loon Lake	Northern Pike	5/14/2003	1,500
Loon Lake	Bluegill	5/23/2003	1,000
Loon Lake	Walleye	5/23/2003	1,000
Loon Lake	Yellow Perch	5/23/2003	1,500
Maceday Lake	Rainbow Trout	4/13/1994	20,000
Maceday Lake	Splake	4/26/1994	14,998
Maceday Lake	Lake Trout	11/1/1994	400
Maceday Lake	Splake	4/3/1995	11,500
Maceday Lake	Rainbow Trout	4/10/1995	18,000
Maceday Lake	Lake Trout	4/24/1995	1,400
Maceday Lake	Walleye	6/20/1995	23,372
Maceday Lake	Splake	4/11/1996	15,000
Maceday Lake	Rainbow Trout	4/18/1996	12,496
Maceday Lake	Lake Trout	5/17/1996	2,000
Maceday Lake	Rainbow Trout	4/8/1997	13,800
Maceday Lake	Splake	4/15/1997	10,320
Maceday Lake	Splake	4/6/1998	11,700
Maceday Lake	Rainbow Trout	5/7/1998	10,000
Maceday Lake	Splake	4/15/1999	15,000
Maceday Lake	Rainbow Trout	4/16/1999	11,600
Maceday Lake	Splake	3/27/2000	9,000
Maceday Lake	Rainbow Trout	4/13/2000	12,000
Maceday Lake	Rainbow Trout	4/2/2001	12,090
Maceday Lake	Splake	4/10/2001	10,550
Maceday Lake	Splake	4/2/2002	11,500

Maceday Lake	Rainbow Trout	4/3/2002	19,490
Maceday Lake	Splake	4/10/2003	11,000
Maceday Lake	Rainbow Trout	4/30/2003	7,200
Maceday Lake	Rainbow Trout	4/30/2003	12,000
Maceday Lake	Lake Trout	10/27/2003	250
Maceday Lake	Lake Whitefish	10/27/2003	50
Maceday Lake	Splake	3/31/2004	12,060

Although data on the fish community in the subwatershed is scattered and lacks depth, the available data implies a reasonably healthy and diverse community.

Freshwater Mussels – Freshwater mussels are considered a good indicator of water quality. The mussels filter water as they feed and are thus particularly sensitive to reductions in water quality. Three (3) surveys covering areas in the Clinton River near the outfall of the subwatershed indicate the presence of several mussel species, including two (2) State endangered, one (1) State threatened, and two (2) State special concern species. The surveys were performed by the Michigan Natural Features Inventory (1988), ASTI (2001) and the Nature Conservancy (2003). The identified species and their status are summarized in the following table:

Table 3.7
Freshwater Mussels in the Main Branch of the Upper Clinton

Scientific Name	Common Name	Status*
Villosa fabalis	Rayed bean mussel	E
Epioblasma triquetra	Snuffbox mussel	E
Lampsilis fasciola	Wavy-rayed lamp-mussel	T
Elliptio dilatata	Spike mussel	
Lampsilis siliquoidea	Fatmucket mussel	
Pleurobema sintoxia	Round pigtoe mussel	SC
Ptychobranchus fasciolaris	Kidneyshell mussel	
Strophitus undulates	Creeper mussel	
Villosa iris	Rainbow mussel	SC

*(E=State endangered, T=State threatened, SC=State special concern species)

The presence of these mussels near the outlet for the subwatershed indicates that water flowing out of the subwatershed must be of reasonably good quality.

3.3.3 Hydrology and Physical Conditions

Hydrology – Since 1960 the United States Geological Survey (USGS) has monitored stream flow at two (2) sites in the Upper Clinton subwatershed, one (1) near the outlet of Sashabaw Creek (Site J) and one (1) in the southern portion of the main branch of the Upper Clinton (Site Q). By looking at the monthly stream flows over the last four (4) decades it became evident that, on average, April was the highest stream flow month and August was the lowest stream flow month. The following figures (see Figures 3.2 and 3.3) show the April and August average daily stream flows since 1960.

Figure 3.2
Sashabaw Creek Site
Average Daily Stream Flow, 1960-2003

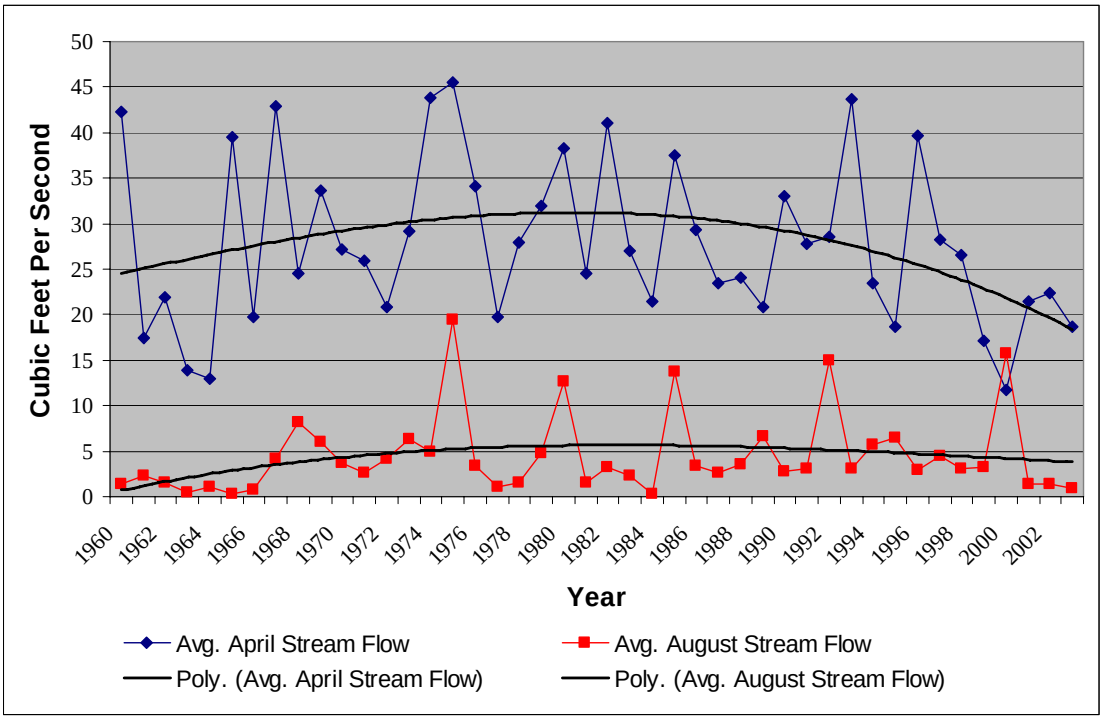
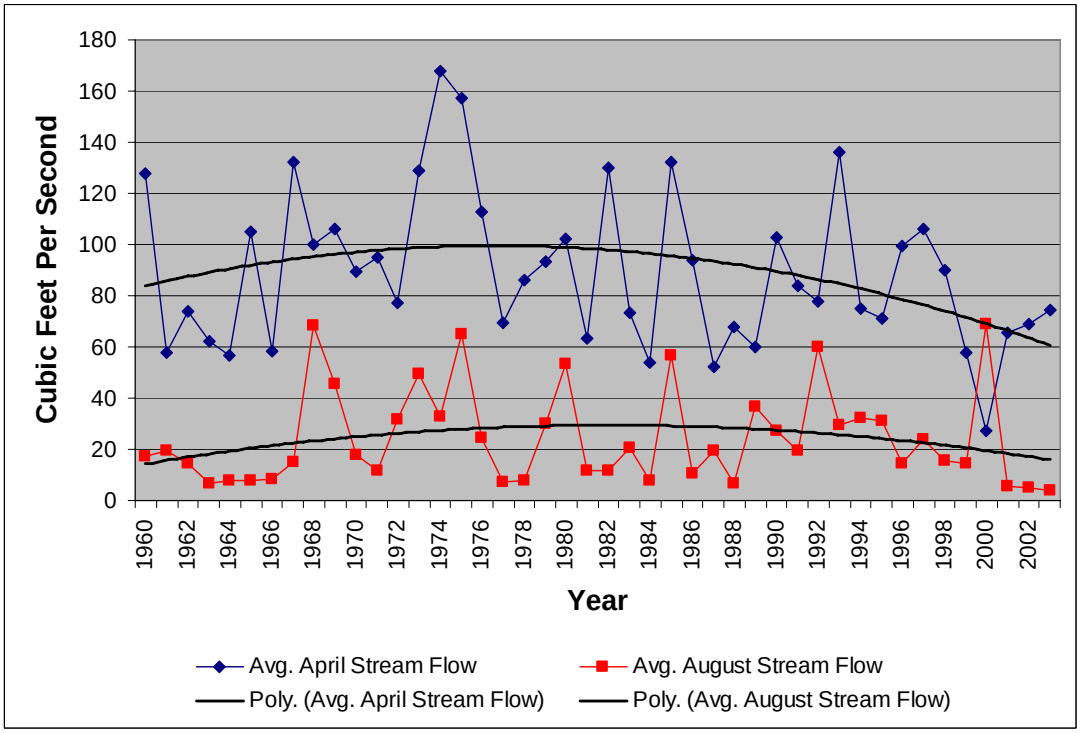


Figure 3.3
Main Branch Clinton River Site
Average Daily Stream Flow, 1960-2003



A second order polynomial regression was used to fit a line to the data in order to make the trends in the data more identifiable. It appears that stream flow increased after 1960, peaking in the late 1970's and early 1980's, and has declined in more recent years. A comparison of the stream flow data to precipitation was performed to determine if these trends were of any likely significance. The following figures (see Figures 3.4 and 3.5) depict the average daily precipitation for April and August over the same period from a weather station in Pontiac. It appears that the trends in average daily stream flow are generally tracking trends in average daily precipitation.

Figure 3.4
April Average Daily Precipitation, 1960-1998

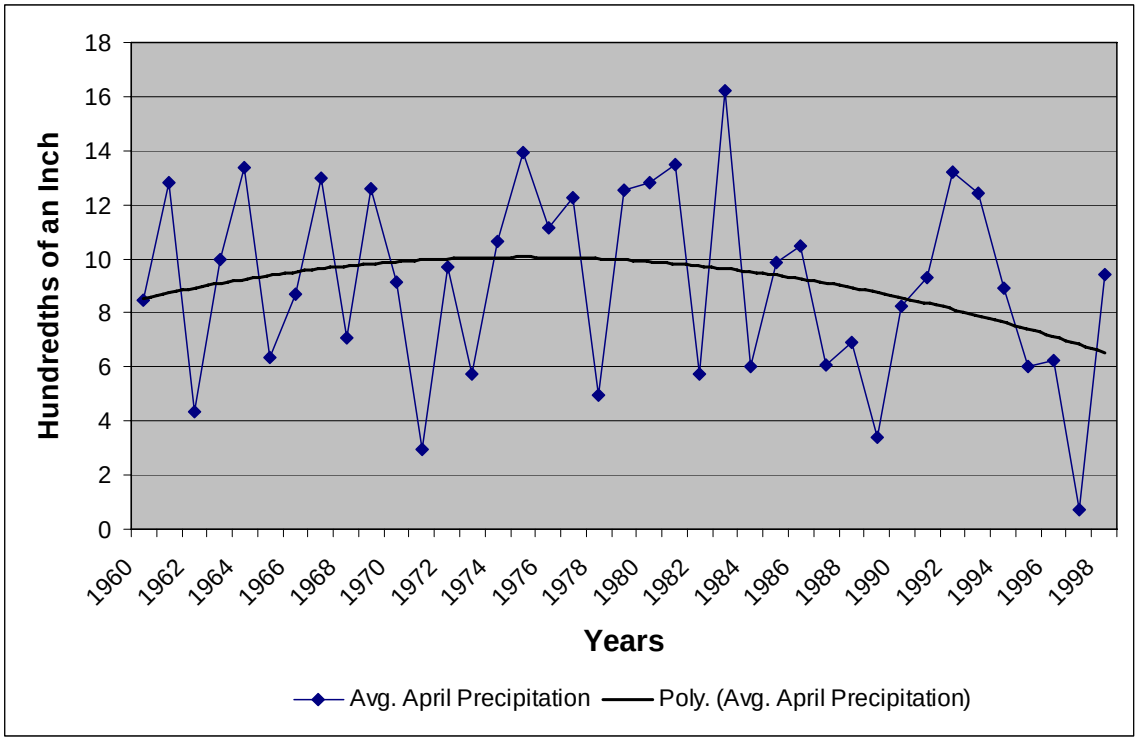
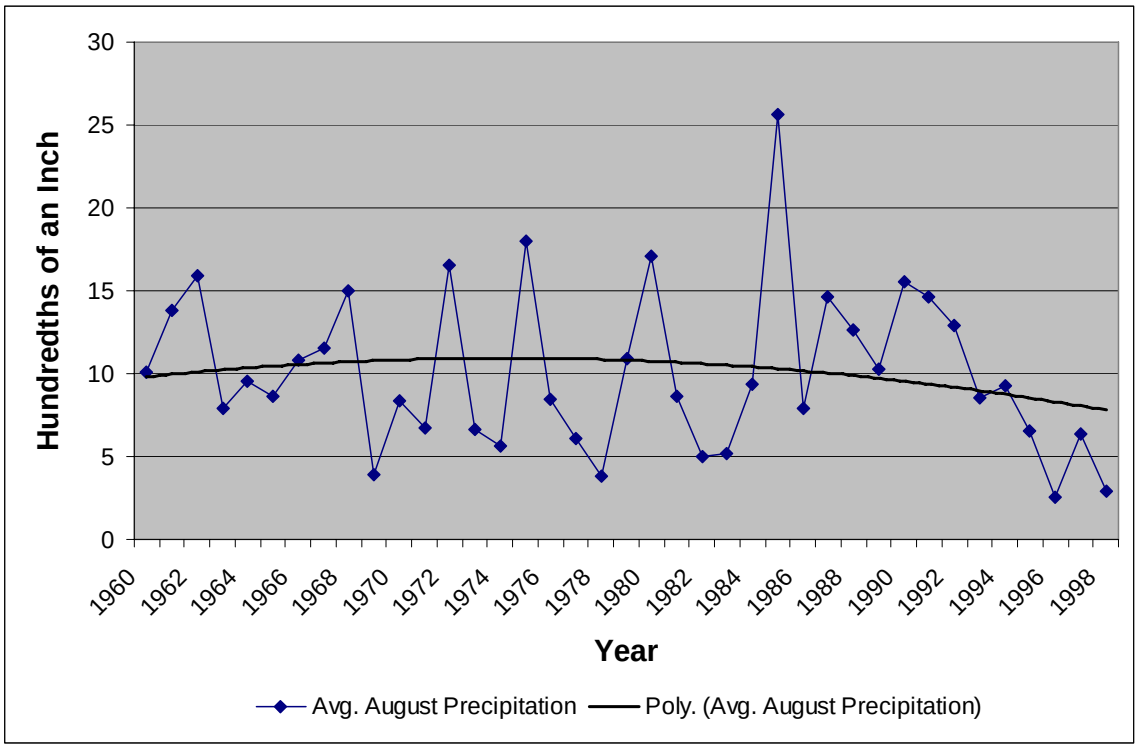


Figure 3.5
August Average Daily Precipitation, 1960-1998



An increase in stream flows following storms is a common problem in urbanizing areas, resulting from the increased quantity and speed of stormwater runoff reaching those streams. To examine the possibility that this might be an issue in the Upper Clinton subwatershed, peak stream flows were examined. Annual peak stream flows for the Sashabaw Creek and Main Branch sites are shown in the following figures (see Figures 3.6 and 3.7).

Figure 3.6
Sashabaw Creek Site
Annual Peak Stream Flow, 1960-2002

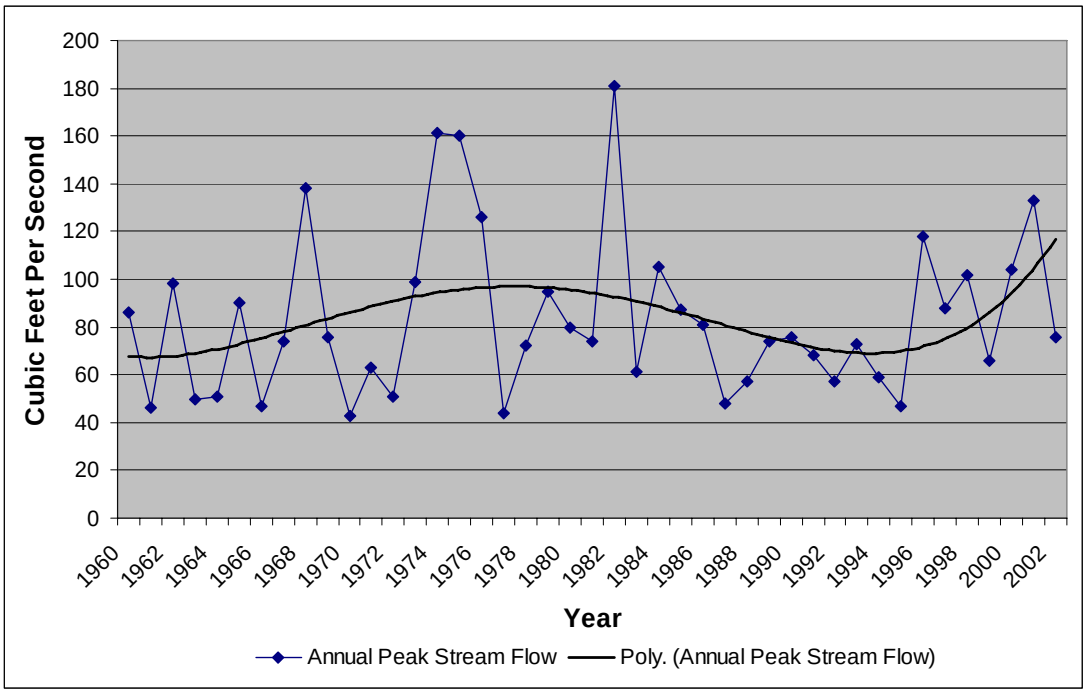
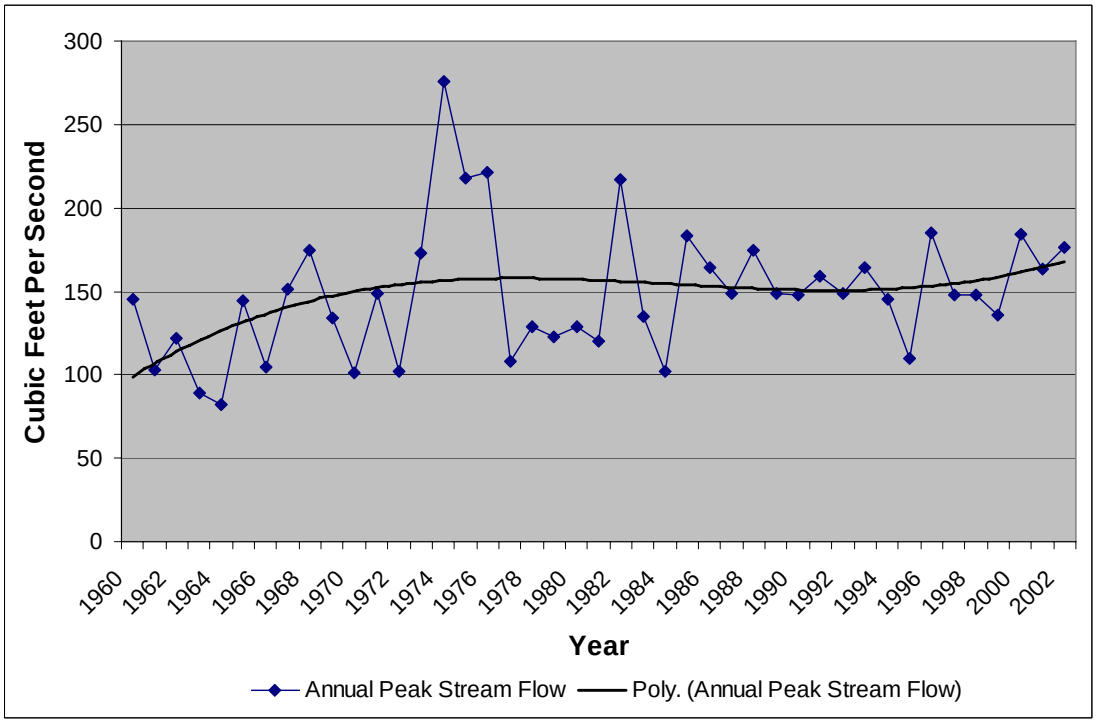


Figure 3.7
Main Branch Clinton River Site
Annual Peak Stream Flow, 1960-2002



When compared to average stream flow and precipitation, peak stream flow appears to show similar trends from 1960 until 1990. In the 1990's peak stream flow began an upward trend that is counter to the downward trends in average stream flow and precipitation. This indicates that the streams at these monitoring sites may be becoming more "flashy," i.e. experiencing increased stream flows following storms. This trend is consistent with the recent land use shift from a more agrarian to a more urban environment.

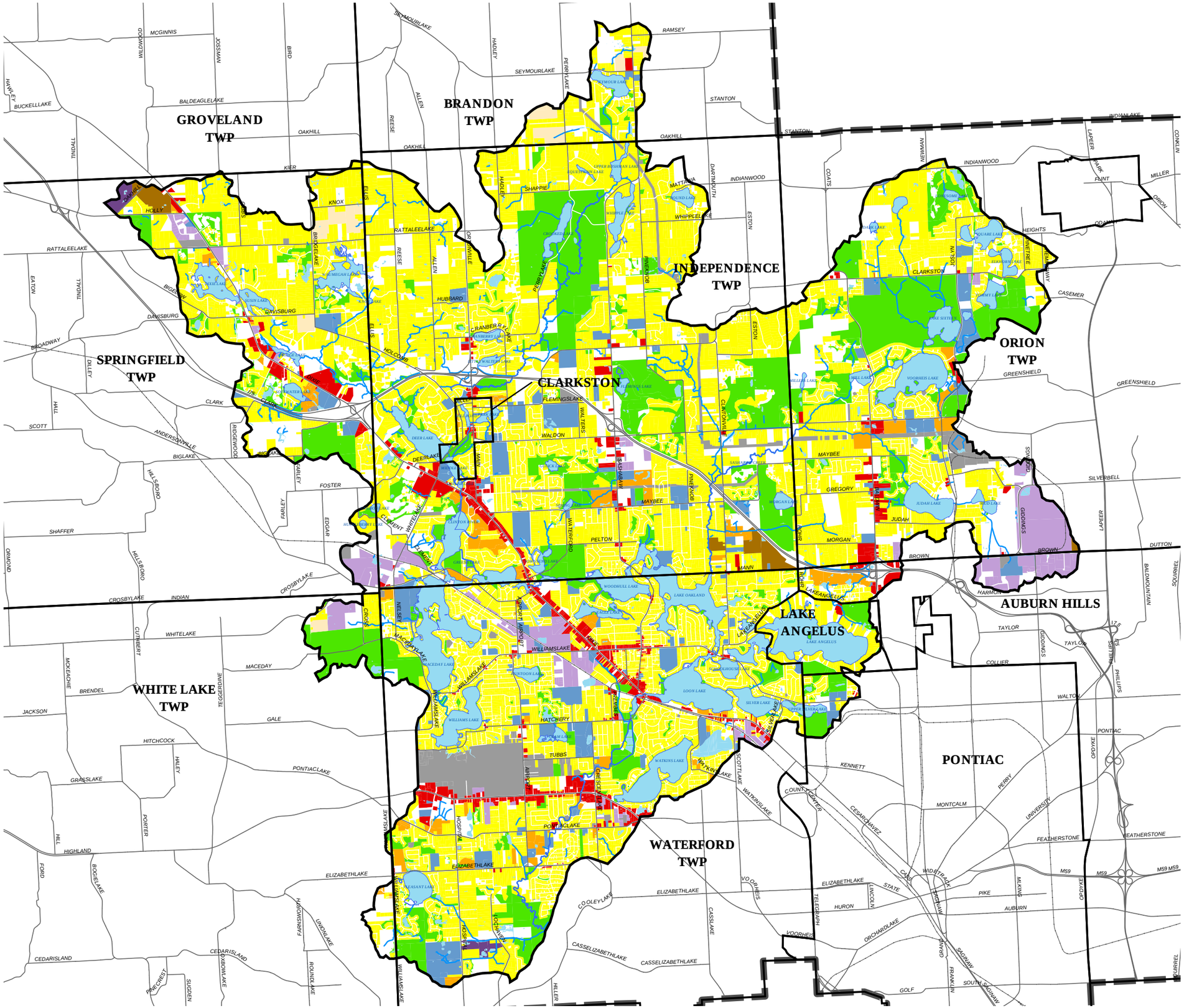
Physical Conditions – There are no recent surveys of the physical condition of the streams and lakes in the Upper Clinton. The generally high water quality noted in the water chemistry section, provide indirect evidence that stream bank erosion and undercutting are not substantial problems at present. On the other hand, the peak stream flow trends noted above indicate that the streams may be becoming more "flashy." This change would result in stream bank erosion, which undercuts banks and increases the frequency of flooding in these streams.

3.4 Environmental Context

3.4.1 Geology and Soils

The Upper Clinton subwatershed is located in an area of the State that was shaped by glaciers approximately 13,000 to 16,000 years ago. The subwatershed contains broad expanses of outwash sands that surround sandy and gravelly end and ground moraines. The moraines remain as coarse textured ridges and island-like hills surrounded by flat outwash. In addition, the area includes ice contact landforms such as kettle lakes, kames, eskers and segments of outwash channel. The soils of the moraines and upland ice contact areas tend to be well drained while kettles, outwash channels and some outwash areas tend to have less well drained to poorly drained soils due to the accumulation of fine textured till, lacustrine deposits or organic soils in low lying areas. This has been a key factor in the formation of the many lakes and wetlands that occur in the subwatershed.

Although forty-three (43) soil series are found within the Upper Clinton Subwatershed, only nine (9) are common. The figure on the next page (see Figure 3.8) summarizes the prevalence of the key soil types within the subwatershed.



Legend

- Upper Clinton Subwatershed
- Rivers/Streams/Drains
- Lakes
- Agricultural / Fallow Lands
- Single Family
- Multiple Family
- Mobile Home Park
- Commercial / Office
- Industrial
- Extractive
- Public / Institutional
- Recreation / Conservation
- Transportation
- Vacant

MAP 2

EXISTING LAND USE

UPPER CLINTON SUBWATERSHED MANAGEMENT PLAN

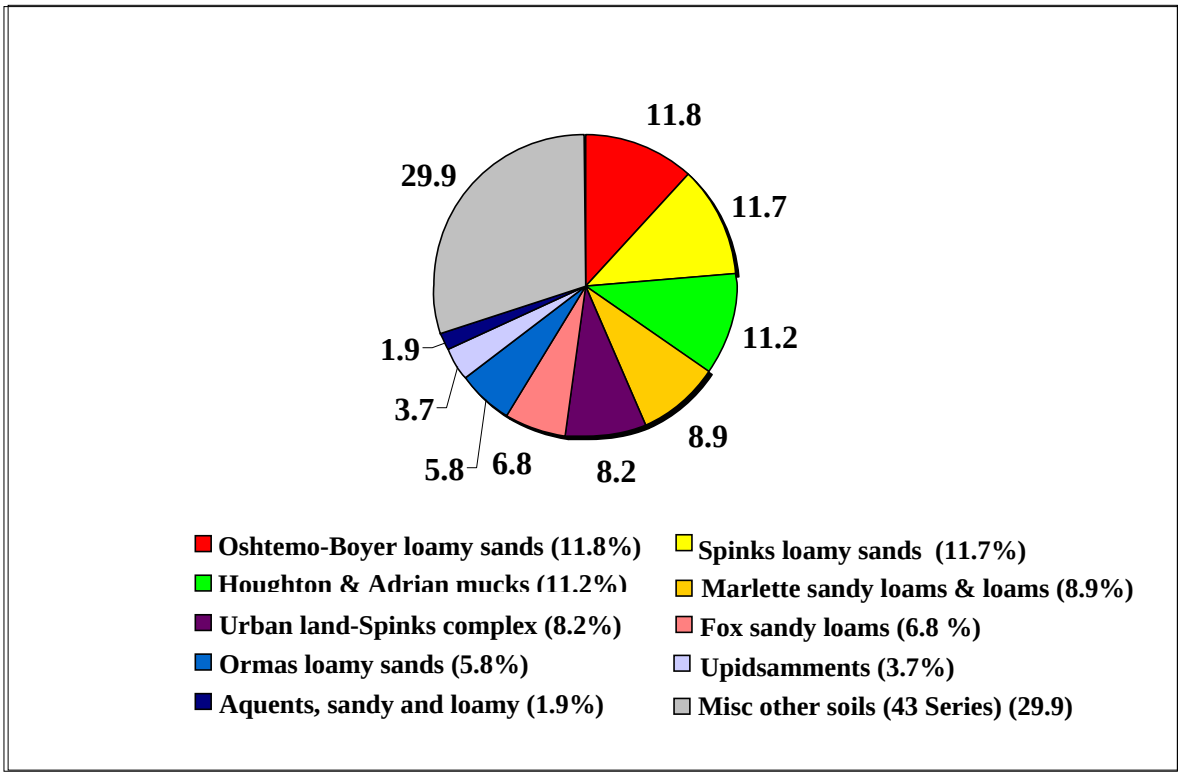
Carlisle/Wortman Associates, Inc.
Community Planners & Landscape Architects

0 1 2 Miles

0

PLOT GENERATION: AUGUST 31, 2005
SOURCE: OAKLAND COUNTY

Figure 3.8
Dominant Soils in the Upper Clinton Subwatershed (by Percentage)



Sands and loams are the most common soil textures, making up at least 47 % of all soils in the subwatershed. Their predominance explains the presence of soils with high to moderate infiltration rates as shown in the Hydrological Soil Groups map (see Map 5). The muck soils typically associated with wetlands are also relatively common (11.2 %), and help to explain the substantial quantity of wetlands found in the subwatershed.

3.4.2 Vegetation

The current extent of vegetative cover in the Upper Clinton subwatershed is shown in the Vegetative Land Cover Map (see Map 6). The percent coverage by type of vegetation is also summarized on a subsequent page (see Figure 3.9).

Legend

- Upper Clinton Subwatershed
- Rivers/Streams/Drains
- Lakes

Hydrological Soil Groups

- Group A - Sand, loamy sand, sandy loam (High infiltration rate)
- Group B - Silt loam or loam (Moderate infiltration rate)
- Group C - Sandy clay loam (Slow infiltration rate)
- Group D - Clay loam, silty clay loam, sandy clay, silty clay or clay (Very slow infiltration rate)
- Urban Land, Pitts, Disturbed Soils

MAP 5

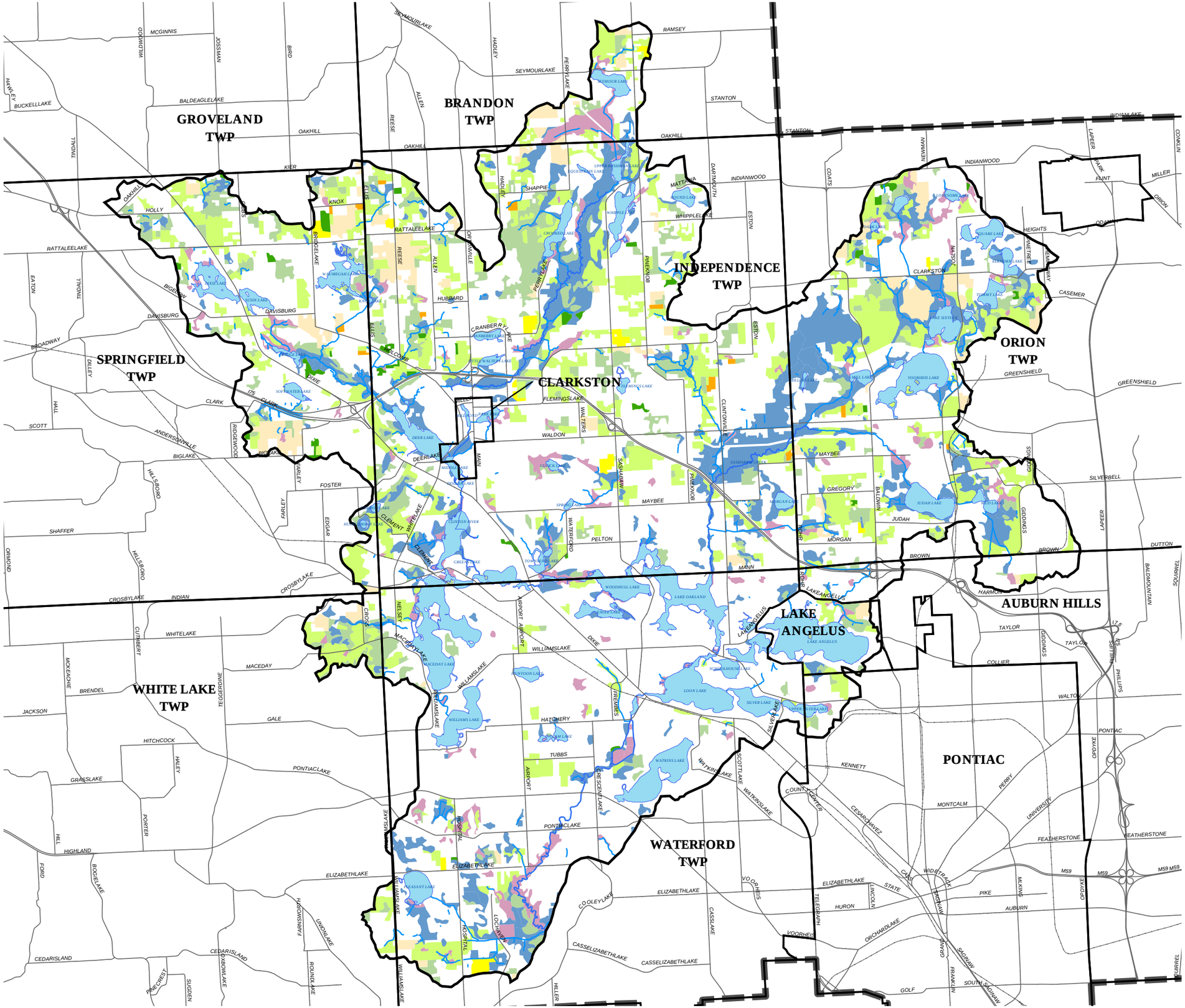
HYDROLOGICAL SOIL GROUPS

UPPER CLINTON SUBWATERSHED MANAGEMENT PLAN

Carlisle/Wortman Associates, Inc.
Community Planners & Landscape Architects

0 1 2 Miles

PLOT GENERATION: AUGUST 30, 2005
SOURCE: OAKLAND COUNTY



Legend

- Upper Clinton Subwatershed
- Rivers/Streams/Drains
- Lakes

Agricultural Vegetation

- Cropland
- Orchard, Vineyard & Ornamental Horticulture Areas
- Permanent Pasture

Upland Vegetation

- Non-Forested Lands
- Forest Lands
- Coniferous Forest

Wetland Vegetation

- Forested Wetlands
- Non-Forested Wetlands

MAP 6

VEGETATIVE LAND COVER

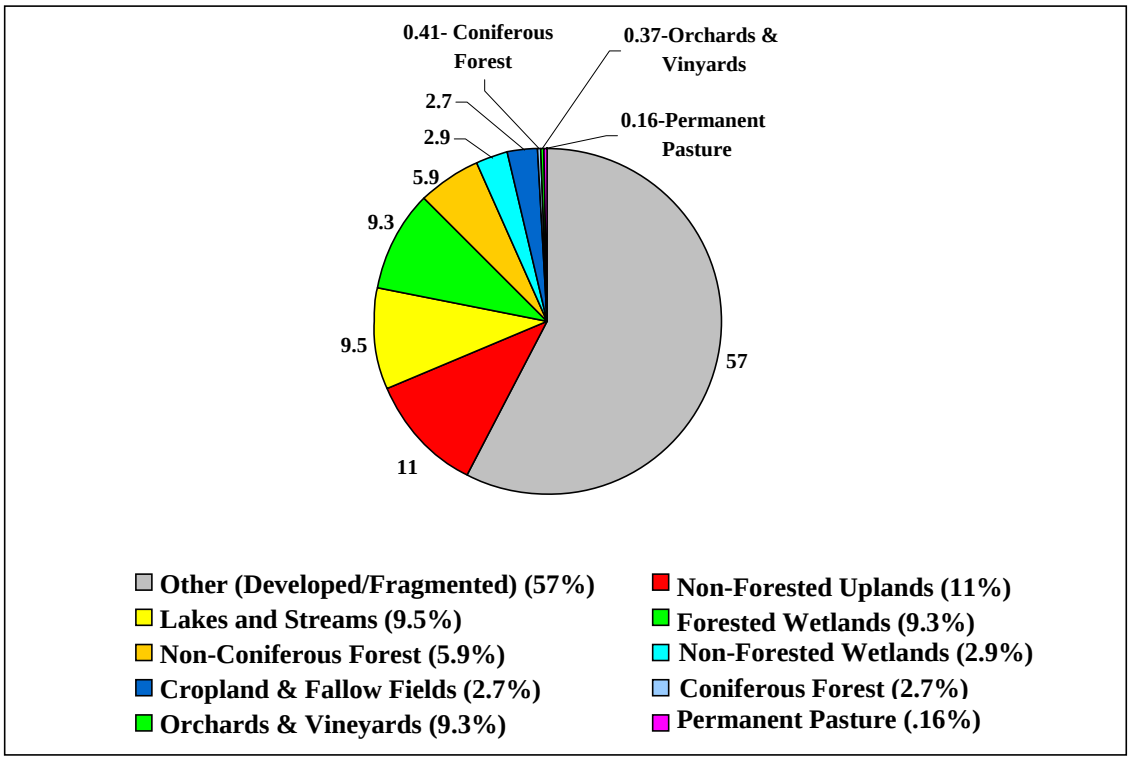
UPPER CLINTON SUBWATERSHED MANAGEMENT PLAN

Carlisle/Wortman Associates, Inc.
Community Planners & Landscape Architects

0 Miles 0 1 2

PLOT GENERATION: AUGUST 31, 2005
SOURCE: OAKLAND COUNTY

Figure 3.9
Percentage of Vegetative Land Cover in the Subwatershed



The above noted figure is based upon a very generalized analysis of the vegetative land cover. It focuses on large, contiguous areas of agricultural or natural vegetation. The existing woodlands make up approximately 6.3% of the land cover in the subwatershed and the existing wetlands make up approximately 12% of the land cover in the subwatershed. Much of the area falling in the "Other" category is clearly correlated with the developed areas of the subwatershed when compared to the Existing Land Use Map (see Map 2). Single family residential uses dominate in the areas classified as "Other" in the Vegetation Map (see Map 6), indicating that lawn and other manicured vegetation are common in these areas. An examination of the Existing Land Use Map (Map 2) indicates that a substantial portion of the large blocks of natural upland, forest, and wetland vegetation are associated with existing recreation and conservation areas within the subwatershed or are found along the Clinton River and its tributaries.

Historically, the presettlement vegetation of the subwatershed was closely tied to the glacially shaped landforms and soils. The sandy moraines of the subwatershed would have been dominated by black oak barrens and mixed oak savannas. The wetlands would have been, and for the most part still are, dominated by shrubs, mixed hardwoods, and/or mixed conifers.

3.4.3 High Quality Natural Communities and Unique Flora and Fauna

The Michigan Natural Features Inventory has completed an extensive analysis of Oakland County. The MNFI has identified potential conservation/natural areas and recording of the presence of endangered, threatened and special concern species. Natural areas within the county were ranked based on the following criteria:

- Size
- Core area
- Stream corridor
- Landscape connectivity
- Restorability
- Element occurrences (presence of quality communities and rare species)

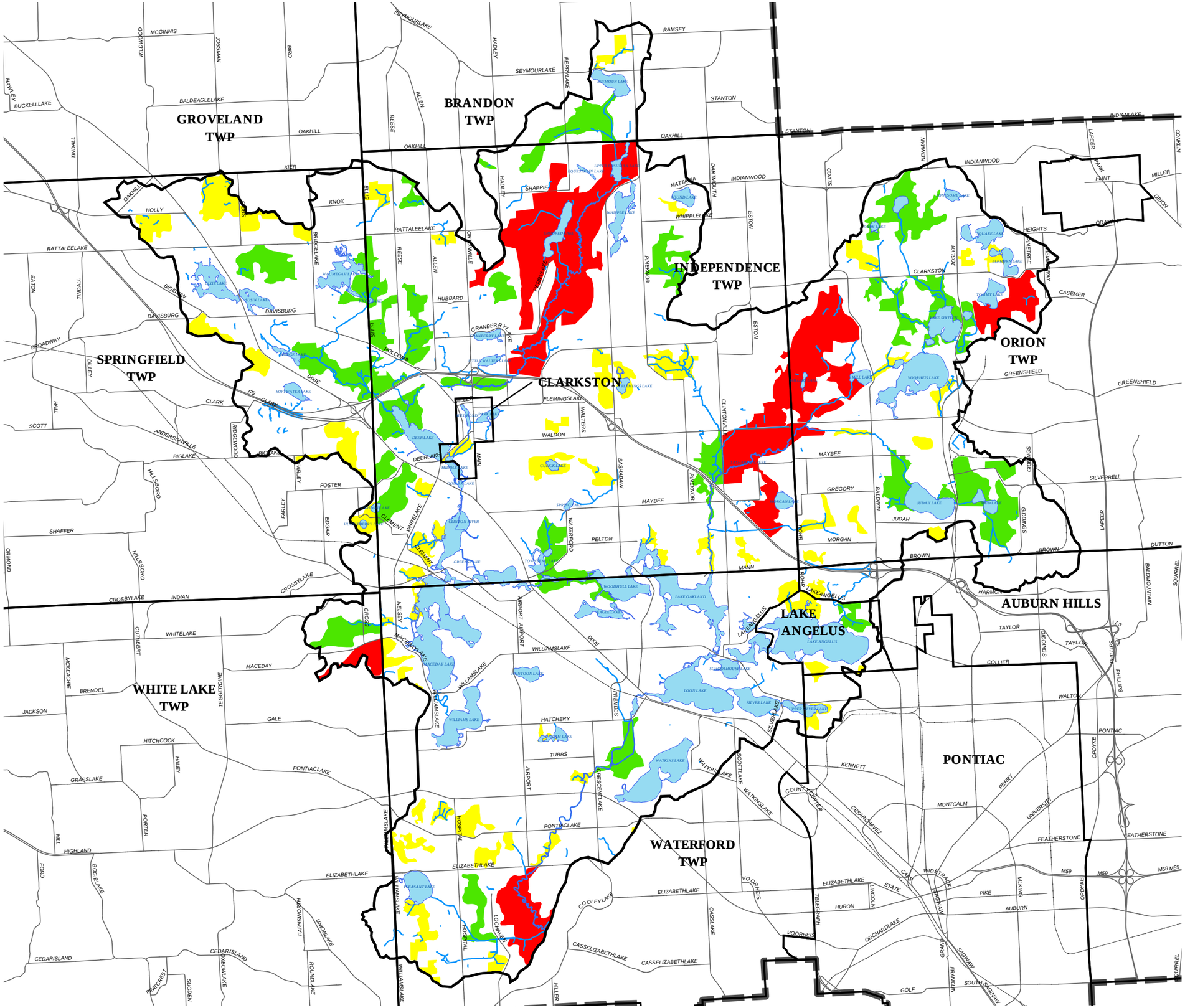
Upon determining the prominence of these criteria within the County, the sites were assigned a priority for consideration for conservation measures. The MNFI Natural Areas Map (see Map 7) illustrates all the Priority One, Two and Three sites in the Upper Clinton subwatershed. A substantial portion of the Priority One areas appear to have already received some protection by inclusion within existing recreation and conservation areas, although a significant portion of Sashabaw Creek does not have such protection. In addition, many of the Priority Two and Three areas lie partially or wholly outside the established recreation and conservation areas in the subwatershed.

A variety of threatened, endangered, and special concern species, and high quality natural communities have been identified by the MNFI to be located within the Upper Clinton subwatershed. The following tables (see Tables 3.8, 3.9 and 3.10) summarize the high quality communities and rare species known to occur within the subwatershed.

Table 3.8
Threatened, Endangered and Special Concern Plants in the Subwatershed

Scientific Name	Common Name	State Status*
Carex richardsonii	Richardson's Sedge	SC
Cypripedium candidum	White Lady-slipper	T
Drosera anglica	English Sundew	SC
Linum virginianum	Virginia Flax	T
Platanthera ciliaris	Orange or Yellow Fringed Orchid	T
Trichostema dichotomum	Bastard Pennyroyal	T

* (E=Endangered, T=Threatened, SC=State Special Concern)



Legend

- Upper Clinton Subwatershed
- Rivers/Streams/Drains
- Lakes

MNFI Natural Areas

- Priority One
- Priority Two
- Priority Three

MAP 7

MNFI NATURAL AREAS

UPPER CLINTON SUBWATERSHED MANAGEMENT PLAN

Carlisle/Wortman Associates, Inc.
Community Planners & Landscape Architects

0 1 2 Miles

0

PLOT GENERATION: AUGUST 31, 2005
SOURCE: OAKLAND COUNTY

Table 3.9
Threatened, Endangered and Special Concern Animals in the Subwatershed

Scientific Name	Common Name	Federal Status*	State Status*
Buteo lineatus	Red-shouldered Hawk		T
Erynnis baptisiae	Wild Indigo Duskywing		SC
Oecanthus laricis	Tamarack Tree Cricket		SC
Oecanthus pini	Pinetree Cricket		SC
Sistrurus catenatus catenatus	Eastern Massasauga	C	SC
Villosa fabalis	Rayed bean mussel		E
Epioblasma triquetra	Snuffbox mussel		E
Lampsilis fasciola	Wavy-rayed lamp-mussel		T
Pleurobema sintoxia	Round pigtoe mussel		SC
Villosa iris	Rainbow mussel		SC

* (FE=Federal endangered, C=Federal concern, E=State endangered, T=State threatened, SC=State special concern)

Table 3.10
High Quality Natural Communities and Unique Geographical Features in the Subwatershed

Name	Type/Description
Emergent Marsh	Community Type
Great Blue Heron Rookery	Habitat Type
Hardwood-conifer Swamp	Community Type
Mesic Southern Forest	Rich Forest, Central Midwest Type
Outwash	Geographical Feature
Prairie Fen	Alkaline Shrub/Herb Fen, Midwest Type
Relict Conifer Swamp	Forested Bog, Central Midwest Type
Southern Wet Meadow	Wet Meadow, Central Midwest Type
Submergent Marsh	Community Type

3.4.4 Wetlands, Woodlands and Riparian Corridors

The wetlands, woodlands and riparian corridors within the Upper Clinton subwatershed play a key role in determining the water quality in the Clinton River. This is particularly true in the Upper Clinton because it is one of the headwater areas of the Clinton River. The protection, enhancement, and restoration of these natural areas are central to any successful plan to improve or maintain the quality of the River and its tributaries.

Wetlands – Wetlands and water bodies cover approximately 21.5% of the Upper Clinton subwatershed. Wetlands serve a variety of recognized and valuable functions; the most important of these are listed below:

- Plant diversity and wildlife habitat
- Fishery, reptile, and amphibian habitat
- Flood and stormwater storage
- Runoff reduction

- Water quality protection
- Shoreline and stream bank protection
- Aesthetics and recreation

Given the prevalence of wetlands in the subwatershed, and the fact that the majority of them are associated with streams and lakes, it is likely that to some degree most of the wetlands serve all of the above noted functions. The majority of wetland areas within the subwatershed are forested and associated with streams, making them a significant component of the riparian corridor.

Woodlands and Riparian Corridor – Woodlands provide food, shelter and breeding grounds for a variety of wildlife, as well as providing important water quality benefits. Intact woodlands are extremely efficient at reducing stormwater runoff. The trees intercept rainwater as it falls and promote the infiltration of stormwater into the soil before it can reach nearby streams. Woodlands also provide aesthetic benefits and may be used for passive or active recreation. Woodlands and wooded wetlands along streams are commonly called riparian corridors. These corridors provide the previously noted benefits as well as maintaining a lower water temperature which is critical to fish survival.

3.5 Summary of Water Quality Impairments, Sources and Causes

The analysis of available water quality and environmental data for the Upper Clinton subwatershed indicates that the Upper Clinton River, its tributaries and associated lakes, make up a generally high quality waterway that has begun to show some signs of impairment. The noted impairments have been prioritized based on how widespread and consistent they have been, the degree of impact they are currently having or may have in the future, and how they interrelate. The sources and causes of the impairments were also prioritized based upon the level of certainty attached to each. The impairments are discussed below in order of priority and the impairments, and the sources and causes are summarized in a table at the end of this section (see Table 3.11).

3.5.1 Bacteria

Bacterial levels in the subwatershed have been high enough to limit full body contact in Sashabaw Creek (Site J), the main branch of the Upper Clinton (Site Q) and several other lakes (see Table 3.5). On at least one (1) occasion, the bacterial levels in the Sashabaw Creek (Site J), the main branch (Site Q) and one (1) of the lakes, were high enough to preclude safe partial body contact with the water. This has led to beach closures and has made other recreational uses of the streams and lakes more risky.

The prevalence of single family residential land uses in the subwatershed has led to substantial clearing of riparian vegetation along creeks, ponds and lakes. Open water bodies lacking natural perimeter vegetation can attract large numbers of Canadian geese. The overabundance of Canadian geese and their detrimental effect on water quality is well documented, and is considered a known source of bacterial contamination in the subwatershed. Similarly, though to a much lesser degree, pet wastes can also be a contributing factor to bacterial contamination of water bodies.

Poorly maintained or failing sanitary systems, either septic or sewer, can leak wastes into adjacent water bodies. There have been no confirmed cases of such systems contaminating adjacent water bodies in the Upper Clinton subwatershed; but given the very high levels of bacteria detected in a small number of locations, there may be some cases of leaking systems. Other possible sources of high levels of bacterial contamination include illicit connections, municipal sanitary sewer overflows, and combined sewer overflows. These are not known to exist within the subwatershed, but should be investigated further if localized areas of bacterial contamination are found.

3.5.2 Hydrology

The flow characteristics and quantity of water are critical determinants of the long-term health of rivers, streams and lakes. Changes in the flow and quantity of water can have substantial negative effects on water quality. In an undisturbed watershed, precipitation rarely enters waterways in large quantities as surface runoff. Precipitation would normally be intercepted by leaves, absorbed by roots, infiltrated into the ground, detained or retained in wetlands, and then be slowly released into the surface waters. As vegetation is cleared and replaced with buildings, pavement and lawns, much more of the precipitation is shunted directly to surface waters via surface runoff. This leads to large quantities of stormwater more rapidly reaching streams during storms, and causing the streams to flow faster and with greater depth than indicated by historic data. The existing form of the stream channels was created by the historic water flow levels and cannot accommodate the new faster and higher water flows. As a result, flooding, bank erosion and bank undercutting may occur as the extra water carves a new physical profile for the stream. Increased turbidity and sedimentation, along with a host of related secondary effects, may become substantial problems downstream of the impacted areas. Streams with this problem are typically described as having “flashy flow.”

In the Upper Clinton subwatershed, stream flow data indicates that over the past two (2) decades the streams have started becoming “flashy.” Examination of current and historic land use/land cover maps indicates that there has been an approximately one third (1/3) reduction in undeveloped open lands (from about 60% of the subwatershed to about 40%). Most of the lost undeveloped open lands have been converted to single-family residential uses. This has led to an increase in impervious surfaces in the Upper Clinton Subwatershed. Increases in impervious surface have been well documented as one of the most important causes of “flashy” stream flow. The removal of vegetation, particularly around streams and lakes, and poor stormwater management practices, typically accompany the type of development that has occurred in the subwatershed, are both known contributors to “flashy” stream flow.

3.5.3 Nutrients

Phosphorus is the primary nutrient of concern in the Upper Clinton subwatershed, and in southeast Michigan as a whole. It is the limiting nutrient controlling the growth of aquatic plants in most of the inland lakes and streams of southeast Michigan. Excess phosphorus can cause algal blooms and problematic growth in other aquatic plants.

At present Dixie Lake, Softwater Lake, Susin Lake, Waumegah Lake, Square Lake, Lake Oakland, Williams Lake, Scott Lake, Huntoon Lake, Pleasant Lake, Maceday Lake, Lotus Lake, Watkins Lake and the Mill Ponds in Clarkston are confirmed to have algal blooms and/or excessive aquatic plant growth. In addition, elevated levels of phosphate have been detected via recent water sampling in the Lake Oakland, Clarkston Mill Ponds, Sashabaw Creek (Site J) and main branch of the Upper Clinton (Site Q). The excessive weed growth and limited water sampling data indicate that phosphorus contamination may be a problem in several areas of the subwatershed. Common sources of phosphorus contamination include residential fertilizer use, stormwater runoff, and failing and/or poorly maintained septic systems. The elevated phosphorus levels indicate that some of these nutrient sources are present within the subwatershed, and may get worse as development continues. Illicit connections to streams or lakes are another possible source of nutrient contamination, but there are no confirmed reports of these in the subwatershed.

3.5.4 Sediments

While the existing data does not indicate that excess sedimentation is currently a serious problem within the subwatershed, residents and public officials have observed sedimentation problems in their own communities. Also, it is seen that this problem will only increase as development throughout the upper reaches of the subwatershed continue to increase. As a proactive measure, the subwatershed communities want to consider sedimentation in this watershed management plan so that the development that does occur is constructed in a way that mitigates the impacts of impervious surface, and focuses on effective soil erosion and sedimentation control measures.

Table 3.11
Upper Clinton Subwatershed
Pollutants, Sources and Causes

Pollutants	Sources*	Causes*
Bacteria	**Waterfowl (k)**	**Removal of vegetation (k)**
	Failing and/or poorly maintained septic systems (s)	**Improper construction/maintenance (k)**
	Illicit connections (s)	
	Combined sewer overflows (s)	**Combined stormwater and sanitary sewers (s)** **Inadequate capacity (s)**
	Sanitary sewer overflows (s)	**Inadequate capacity (s)**
Hydrology	**Stormwater runoff (k)**	**Increased impervious surface (k)** **Removal of vegetation (k)** **Poor stormwater management practices (k)**
Phosphorus	**Residential fertilizer use (k)**	**Improper or excessive application (k)**
	Stormwater runoff (k)	**Increased impervious surface (k)** **Removal of vegetation (k)** **Poor stormwater management practices (k)**
	Failing and/or poorly maintained septic systems (s)	**Improper construction/maintenance (k)**
	Illicit connections (s)	
Sediments	**Road-stream crossings (s)**	**Poor road/bridge maintenance (s)**
	Conveyance via road-side ditches	**Removal of vegetation (s)**
	Flashy flows and stream bank erosion (s)	**Increased storm water runoff (s)**
	Construction runoff (s)	**Improper erosion and sedimentation controls (s)**

* (k=known, s=suspected)

3.6 Identification of Critical Areas

In order to efficiently address the water quality issues identified in the watershed analysis, it is necessary to identify critical areas that will receive priority for the application of available resources. The areas of critical concern for the Upper Clinton subwatershed are classified as existing (those that address specific, known issues) and potential (those that address suspected, future or more general issues). The critical areas are shown on Map 8, and the factors used to identify them are summarized below.

Factors Defining the Existing and Potential Areas of Critical Concern:

- Existing Areas of Critical Concern.
  - Lakes with Known Impairments.
    - Lakes with beach closures due to high fecal coliform counts (bacteria).
    - Lakes with nuisance weed or algae growth (phosphorus).
  - Stream Sampling Sites.
    - Sites showing increasing peak flow (hydrology).

- Potential Areas of Critical Concern.
  - 250 Foot Areas Around All Lakes.
    - Contribution to known lake impairments (bacteria, phosphorus).
    - Possible contribution to other current or future lake impairments.
    - Contribution to increasing stream peak flow (hydrology).
  - 250 Foot Areas Around All Streams.
    - Contribution to increasing stream peak flow (hydrology).
    - Possible contribution to other current or future stream impairments.
    - Possible contribution to lake impairments (bacteria, phosphorus).
  - Priority One MNFI Areas.
    - Incorporate many headwater, woodland and wetland areas important to long term water quality.
  - Priority Two MNFI Areas.
    - Incorporate many headwater, woodland and wetland areas important to long term water quality.
  - Other Potential Areas of Hydrological Significance.
    - Includes wetlands not included in the MNFI Areas that appear to have some significance in the hydrological functioning of the subwatershed.

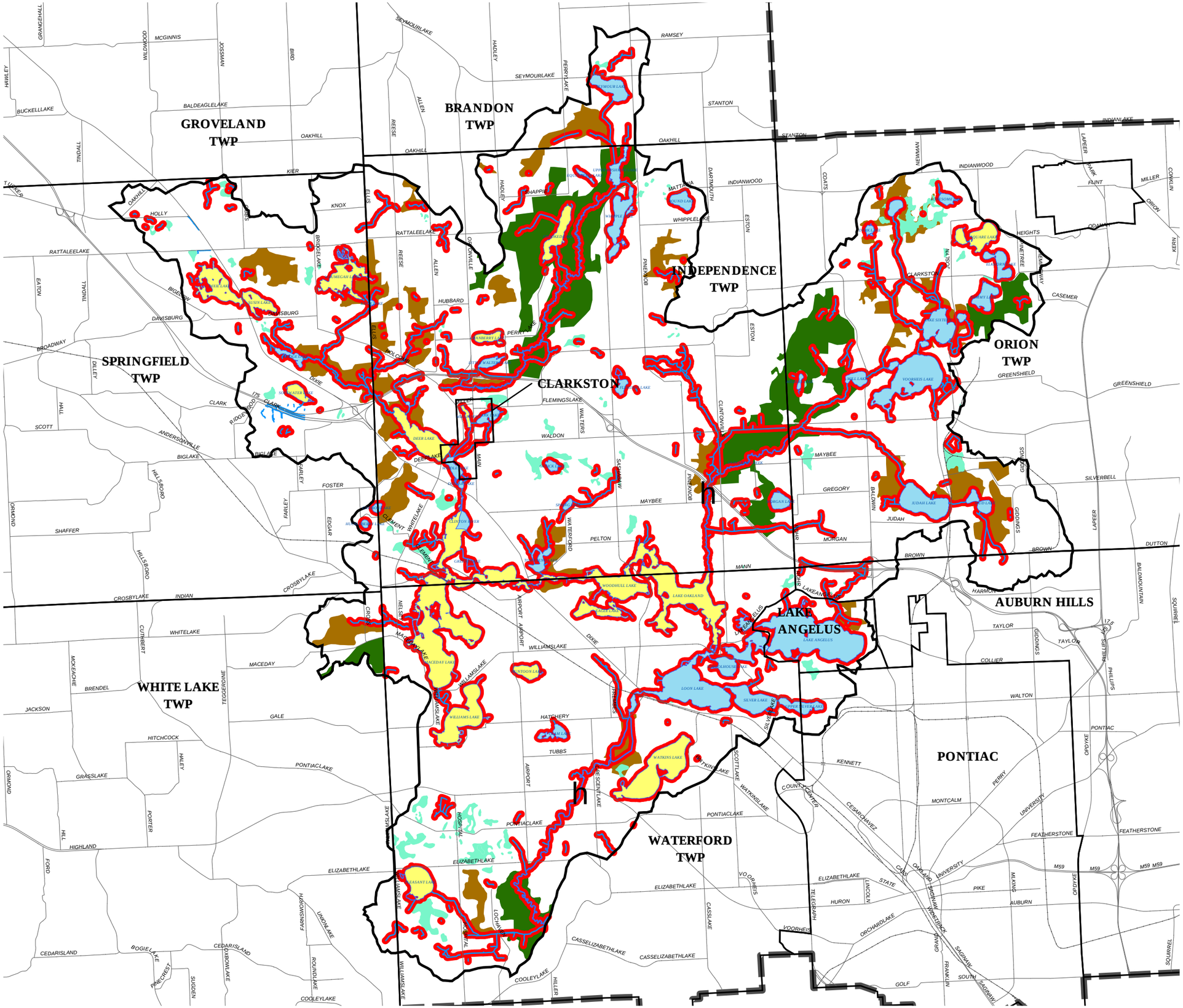
The inclusion of the potential areas of critical concern reflects an effort to address long term threats to the water quality of the Upper Clinton subwatershed while addressing the current issues. As a result, the inclusion of areas adjacent to streams and lakes and substantial natural resource complexes is considered important to the protection of the subwatershed's water resources.

Identifying the critical areas, and the character of these areas, points to tools and mechanisms that can be used to improve water quality and protect significant water resources. The table on the following page shows that the majority of critical areas are in the hands of private residential land owners. Knowing this indicates that subwatershed communities have an opportunity to impact water quality through resident education, volunteer participation in monitoring programs, and other mechanisms. Vacant lands also make up a significant portion of the critical areas. This shows how significant it will be for Communities to use their Zoning Ordinance and other development tools to protect these critical areas as the uplands are developed in the future.

Table 3.12
Upper Clinton Subwatershed
Land Uses in Critical Areas

Land Use Type	Acres	Percent of Critical Areas
Single-Family Residential	7,556	41%
Recreation/Conservation	5,600	30%
Vacant	3,440	18%
Water	516	3%
Public/Institutional	412	2%
Multi-Family Residential	347	2%
Transportation	281	2%
Commercial/Office	271	1%
Industrial	75	<1%
Agriculture	65	<1%
Extractive	20	<1%
Mobile Home Park	17	<1%

Data Source: Oakland County Planning & Economic Development.



Legend

- Upper Clinton Subwatershed
- Rivers/Streams/Drains
- Lakes

Factors Defining the Existing and Potential Areas of Critical Concern

- Lakes with Known Impairments
- 250 Foot Areas Around All Lakes & Streams
- Priority One MNFI Areas
- Priority Two MNFI Areas
- Other Potential Areas of Hydrological Significance
- h — Stream Locations with Known Impairments

MAP 8

EXISTING AND POTENTIAL AREAS OF CRITICAL CONCERN

UPPER CLINTON SUBWATERSHED MANAGEMENT PLAN

Carlisle/Wortman Associates, Inc.
Community Planners & Landscape Architects

0 1 2 Miles

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PLOT GENERATION: AUGUST 31, 2005
SOURCE: OAKLAND COUNTY

CHAPTER 4
WATERSHED PLAN GOALS & OBJECTIVES

4.0 Introduction

After the watershed analysis had been completed, the next step in the planning process followed by the group was to come up with goals and objectives for the Upper Clinton subwatershed. This chapter explains the process the group followed, describes who was involved, and presents the goals and objectives the group decided upon.

4.1 Determining Goals and Objectives for the Upper Clinton Subwatershed

The subwatershed group felt it was very important to solicit input from other people in creating the goals for this plan. The group held two meetings to accomplish this: one in August, 2004, and the other in February, 2005.

Steering Committee Meeting

The first meeting in August, 2004 was scheduled during the day, and members of the Steering Committee were invited to attend. As described in the Public Participation Plan, the Steering Committee involves a wide range of regional and county agencies, state environmental agencies, business organizations, and others who have information about the subwatershed and a unique perspective on water quality issues. Example invitees include Chamber of Commerce representatives, school district staff, lake associations, Oakland County divisions such as the Drain Commissioner's Office, Road Commission, Health Department, and Planning and Economic Development Department, as well as the Southeast Michigan Council of Governments (SEMCOG), the Michigan Department of Transportation (MDOT), and the Michigan Department of Environmental Quality.

Participants were asked to answer three questions after they heard a presentation describing the current state of the subwatershed. These questions were:

1) ***What do we know about our watershed?*** This question was asked to gather any additional information that should be added to the Watershed Analysis chapter. The meeting participants responded to this question by using information in the Impervious Study, and stated that redevelopment should focus on Best Management Practices (BMPs), increasing required landscaping, and limiting removal of riparian vegetation (mowing to the edge). The group also thought that MDOT needs to focus on drainage impacts, and environmental studies.

2) ***How do we use/value the water resources in the watershed?*** This was asked to determine if there were any additional uses of water resources valued by the participants that were not already included in the State's "Designated Uses" listing. Responses to this question resulted in the following information:

Table 4.1
Water Resource Uses 8-24-04 Steering Committee Meeting

Designated Uses	Desired Uses
1. Agriculture	
2. Industrial water supply	
3. Public water supply at point of intake	
4. Navigation	
5. Warmwater fishery	1. Fishing
6. Other indigenous aquatic life and wildlife	2. Nature observation
7. Partial body contact recreation	3. Boating (motor, sail, canoe, kayak)
8. Total body contact recreation between May 1 and October 31	4. Swimming 5. Jet skiing
	6. Trails
	7. Education
	8. Drinking water (ground)
	9. Aesthetics
	10. Maintain the function of rainwater and water resources (groundwater recharge, infiltration, open spaces, forested areas, wetlands, waters edge vegetation)

3) ***What goals do we have for the watershed and/or the watershed plan?*** This question was asked to gather input on how the participants view the future of the watershed. The group answered this last question with the following top five goals for the watershed:

   a) Provide tools for communities to protect sensitive areas (i.e. wetlands ordinance).

   b) Reduce the effects of commercial corridors/impervious impacts.

   c) Because forty-one percent of the subwatershed is designated as residential land use, we need to educate the public/residents.

   d) Because thirty percent of the subwatershed is used for recreation, we need to work with those in charge of operating and maintaining these properties.

   e) Regional drainage. Control flashy flows during storm events and during dry conditions.

Public Stakeholder Meeting

The second meeting, which was held in February, 2005, was scheduled during the evening. Because this meeting was intended to target residents and members of the public at large, each community created a list of potential stakeholders using the five stakeholder categories identified in the Public Participation Plan. These categories were as follows:

1) Developers/Builders/Home Builders Associations

2) Lake Boards/ Lake Property Owners/ Riparian Land Owners

3) Planning Commission/ Township Boards/ City Councils

4) Landscaping Industry (MNLA, Nurseries – especially Bordines)

5) School Districts/ School Environmental Programs

Each community member personally invited the people on their lists to the meeting. As a result, the meeting was well attended with 50 participants and all the above named categories represented. The meeting began with introductions of all participants, and a presentation outlining the results of the watershed analysis. Then the group was divided into six small groups, and each was asked to come up with goals for the subwatershed, based on the findings of the analysis and their own knowledge and understanding of water quality in their community. A worksheet was provided that listed a few "example" goals to get everyone started. A Core Group member from each community facilitated the small groups to ensure that everyone had a chance to share their ideas and to keep the conversation going. Once each group had created a list of goals, they were asked to prioritize these goals to come up with their "top" five. At the end of the meeting, each small group shared their top five goals with the large group. The top five goals for each group are listed in the following table. Complete results of each small group's discussion are included in the Appendix of this document.

Table 4.2
Goals per Group 2-1-05 Public Meeting

Group No.	Goal #1	Goal #2	Goal #3	Goal #4	Goal #5
1	Educate residents about fertilizers, alternative landscaping, pesticides	Update local ordinances to preserve natural areas and reduce stormwater problems	Change public attitudes about what is aesthetically pleasing	Educate developers	Locate old drains to determine where they go and how they may be contributing to problems
2	Create long range plans for storm drains.	Reduce waterfowl/seagull problems	Promote use of less damaging fertilizers	Improve water management on/along roads	Protect river corridors in Townships (100' buffers) include wetlands

Group No.	Goal #1	Goal #2	Goal #3	Goal #4	Goal #5
3	Contain storm water runoff	Conduct consistent monitoring and testing of lakes and streams	Create regional agency for lake boards for coordinated efforts	Review design standards in communities for consistency	Address phosphorus problem (reduce on residential properties, public education, buffer zones)
4	Educate developers and municipal officials on sustainable storm water management activities (BMPs)	Increase lake area/riparian residents' awareness and involvement: geese, fertilizer, landscaping	Preserve/keep intact as many high quality wetlands as possible	Educate residents on septic maintenance	Provide incentives to residents, developers & others for good practices (landscaping awards, etc.)
5	Land Use Planning: Increase buffers, BMPs ($), cluster developments, indigenous species, mitigation, decrease impervious areas	Fishery: control pollutants, address invasive species, identify species, identify location, water temperature control	Public Awareness: workshops, media coverage, publish data, organizations	Recreational Access: Evaluate lake access, lake reclamation, remove pollutants, geese control, timely septic maintenance	High Phosphorus: septic maintenance
6	Increase regulation of phosphorus	Promote use of native vegetation	Buffers within developments	Increase involvement of lawn care companies	Promote monitoring/ enforcement of septic fields and self-contained sewer systems

Core Group Input

The Core Group, made up of representatives from each subwatershed community, then consolidated this information to determine the desired uses, how these uses are impacted by pollutants within the subwatershed, and the top goals for the subwatershed plan. They then determined the objectives of each goal, oftentimes which reflect "goals" that were discussed at the Steering Committee or Public Input meetings.

4.2 Designated and Desired Uses of the Subwatershed

As described by the Michigan Department of Environmental Quality, the primary criterion for water quality is whether the water body 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. While not all of these uses may be attainable, meeting all of them is the ultimate goal. As described above, the "Desired" uses are additional uses for water resources identified by the subwatershed partners.

Based on the water quality data available, and existing land use patterns within the subwatershed, the following table describes how the designated uses are impaired by different types of pollutants.

Table 4.3
Relationship between Uses & Pollutants

Designated Use	Impaired or Threatened?	Pollutants/Threats
Agricultural water supply	No impairment identified	
Industrial water supply	No impairment identified	
Public water supply at point of intake	No impairment identified	
Navigation	Impaired in some areas (lakes) due to aquatic plants	Phosphorous (k)
Warmwater fishery	Impaired in some areas	Phosphorus (k)
		Hydrology (k)
		Sediment (s)
Other indigenous aquatic life and wildlife	Impaired in some areas	Phosphorus (k)
		Hydrology (k)
		Sediment (s)
Full body contact recreation	Impaired in some areas	Phosphorus (k)
		E-coli (k)
Partial body contact recreation	Impaired in some areas	Phosphorus (k)
		E-coli (k)
Desired Use		
Trails	Potential trail locations impaired in some areas	Hydrology (k) (Stream bank erosion)
Education		
Drinking water (ground)	Impaired in some areas	Hydrology (k) (Impaired infiltration into groundwater due to impervious surfaces)
Aesthetics	Impaired in some areas	Phosphorus (k) (Excessive plant growth & algae blooms)
		Hydrology (k) (Stream bank erosion)
		Sediment (s)
Maintain function of rainwater and water resources	Impaired in some areas	Hydrology (k) (Impaired infiltration into groundwater due to impervious surfaces)
		Sediment (s)

(k) = Known; (s) = Suspected

4.3 Upper Clinton Goals and Objectives

As described in the land use analysis portion of this document, the subwatershed ranges from undeveloped natural areas to urban corridors and suburban development. Because of this range, the main intent of the watershed plan is twofold: to protect water features and natural areas that have not yet been developed, and to restore areas that have already been developed. With this in mind, the Upper Clinton Subwatershed Core group used the data obtained through the stakeholders and public meetings and the watershed analysis to establish the goals for the watershed plan. These goals are intentionally broad to cover all the main areas of impairment, and also to provide flexibility in addressing the goals.

The goals are considered to be long-term goals, which will be accomplished beyond the five-year scope of this plan. Progress will be evaluated based on water quality data obtained through the sources identified in the watershed analysis, and by the success of programs implemented by the participating communities. The objectives provide a general list of activities, tasks or Best Management Practices (BMPs) that are recommended for addressing and ultimately reaching each long term goal. Note that all objectives will not be applicable or feasible for every participating community.

The goals have been listed in order of priority. Priority rankings were determined by the impact the issue was having on the subwatershed as determined by the watershed analysis data, and then opinions of stakeholders. Therefore, objective data was considered first in setting goals, and then subjective opinions were used to refine and finalize the goal priorities.

Long Term Goal 1: Restore and protect water quality in local waterways and lakes.

Objectives:

- 1-A: Identify and reduce sources of bacteria and illicit discharges.
- 1-B: Reduce nutrient loading contributing to excessive aquatic plant growth.
- 1-C: Reduce siltation from construction sites and road crossings.
- 1-D: Promote and implement pollution prevention programs.

Long Term Goal 2: Reduce flow variability.

Objectives:

- 2-A: Minimize the increase in impervious surfaces and mitigate the amount of existing impervious surface.
- 2-B: Restore and protect riparian vegetation.
- 2-C: Reduce the amount of stormwater runoff to predevelopment patterns and levels to stabilize stream flow.

Long Term Goal 3: Improve local regulations regarding protection of natural areas and water resources.

Objectives:

- 3-A: Develop natural feature inventories and/or assessments to create plans for preservation and/or restoration of natural features.
- 3-B: Develop goals and policies in the Master Plan regarding natural feature protection and management.
- 3-C: Develop ordinances for managing natural features to benefit stormwater quality and quantity.

Long Term Goal 4: Increase public understanding of their role in protecting water quality.

Objectives:

- 4-A: Develop and/or promote existing public involvement programs (workshops, events, etc.) to improve the public's understanding of their role in protecting water quality.
- 4-B: Develop and/or continue information and education programs (brochures, newsletter articles, etc.) to disseminate water quality messages to the public.

Long Term Goal 5: Protect and restore quality aquatic and riparian habitats.

Objectives:

- 5-A: Develop a habitat protection and/or restoration plan.
- 5-B: Reduce siltation from construction sites and road crossings.
- 5-C: Restore and protect riparian vegetation.
- 5-D: Develop natural feature inventories and/or assessments to create plans for preservation and/or restoration of natural features.
- 5-E: Develop goals and policies in the Master Plan regarding natural feature protection and management.
- 5-F: Develop ordinances for managing natural features to benefit stormwater quality and quantity.

Long Term Goal 6: Increase opportunities for passive and active recreational uses while at the same time protecting water resources.

Objectives:

6-A: Identify key areas to protect and restore, and plan for recreational and interpretive opportunities adjacent to lake shores and riparian corridors.

6-B: Develop recreation plans for key natural areas that are consistent with this Watershed Management Plan.

These goals relate to the Designated and Desired uses as follows:

Table 4.4
Relationship between Goals & Uses

	Designated and Desired Uses									
Goals	**N**	**F**	**WL**	**PR**	**TR**	**T**	**E**	**DW**	**A**	**FU**
1. Restore and protect water quality in local waterways and lakes.	X	X	X	X	X		X	X	X	X
2. Reduce flow variability.	X	X	X	X	X		X	X	X	X
3. Improve local regulations regarding protection of natural areas and water resources.	X	X	X	X	X	X	X	X	X	X
4. Increase public understanding of their role in protecting water quality.	X	X	X	X	X	X	X	X	X	X
5. Protect and restore quality aquatic and riparian habitats.		X	X	X	X		X	X	X	
6. Increase opportunities for passive and active recreational uses.	X	X	X	X	X	X	X			

N= Navigation
F= Warmwater fishery
WL= Other indigenous aquatic life and wildlife (Nature observation)
PR= Partial body contact recreation (Boating – motor, sail, canoe, kayak)
TR= Total body contact recreation between May 1 and October 31 (Swimming, jet skiing)
T= Trails
E= Education
DW= Drinking water (ground)
A= Aesthetics
FU= Maintain function of rainwater and water resources (groundwater recharge, infiltration, open spaces, forested areas, wetlands, waters edge vegetation)

CHAPTER 5
IMPERVIOUS SURFACE AND PLANNING ANALYSIS

5.0 Introduction

Different areas of the Upper Clinton Subwatershed have been developed to different degrees. In general, the northern portion of the watershed is less developed than the southern part. A significant amount of the land that is considered developed is large-lot residential, which could be split and further developed in the future. Therefore, the watershed communities currently have an opportunity to guide future development patterns (rather than retro-fit solutions) so that water resources are protected as the land is developed.

This watershed plan looks at two ways of doing this. The first way is through an "Impervious Surface Analysis," which uses existing land use data and community Master Plans to determine the amount of impervious surface (or surfaces that water cannot penetrate such as rooftops and pavement) within the watershed once it is fully developed as planned out by each community. The results of this analysis are provided in this chapter, and the entire report can be found in the Appendix to this document. The second way is by evaluating each community's planning documents to determine how well they are currently protecting water resources from development pressures, and recommending possible ways they could protect these resources even more.

5.1 Impervious Surface Analysis

The Oakland County Planning and Economic Development Services (OCPEDS) Department conducted an analysis to estimate the existing and potential impervious cover in the Upper Clinton Subwatershed. Impervious Cover (IC) can be defined as having two components: "the rooftops under which we live, work, and shop, and the transport system (roads, driveways, and parking lots) that get us from place to place" (Schueler, 1994). IC impacts stream ecosystems by increasing the proportion of stormwater runoff discharged from the watershed directly to the stream as compared with the proportion that infiltrates back into the ground or is detained in wetland systems. Negative effects of increased runoff to streams include hydrologic, structural habitat, and water quality impacts. Hydrologic impacts include disruption of natural water balance, increased flood peaks, increased stormwater runoff, more frequent flooding, increased bank-full flows, and lower dry weather flow. Structural habitat impacts include stream widening and erosion, reduced fish passage, degradation of habitat structure, decreased channel stability, loss of pool-riffle structure, fragmentation of riparian tree canopy, and decreased substrate quality. Water quality impacts include increased stream temperature, pollutants, and risk of beach closure.

The Center for Watershed Protection has developed an "Impervious Cover Model" (ICM) which predicts the quality and character of a stream based on the percentage of IC in the watershed. The ICM contains three categories (Schueler, 1994): a sensitive stream, an impacted stream, and a non-supporting stream, as shown in the following table:

Table 5.1
Stream Attributes According to the IC Model (Schueler, 1994)

Sensitive Stream	Impacted Stream	Non-Supporting Stream
0-10% IC	**11-25% IC**	**>25% IC**
High quality, stable flow regime	Signs of degradation, flow regime destabilizes	Low quality; stream is essentially a conduit for conveying stormwater
Stable channels are in stable equilibrium	Altered stream geometry	Severely eroded and incised stream channel
Excellent habitat structure	Degraded physical habitat in the stream	Structure needed to sustain fish is diminished or eliminated
Excellent water quality	Water quality degraded; contact recreation becomes an issue	Water contact recreation is no longer possible
Diverse communities of both fish and aquatic insects	Many sensitive fish and aquatic insects disappearing from the stream	Stream cannot support any but the most tolerant of life forms
Do not experience frequent flooding	Flooding becomes a more serious problem	Flooding becomes a serious problem requiring drastic engineering solutions

In conducting the imperviousness analysis, OCPEDS undertook four tasks:

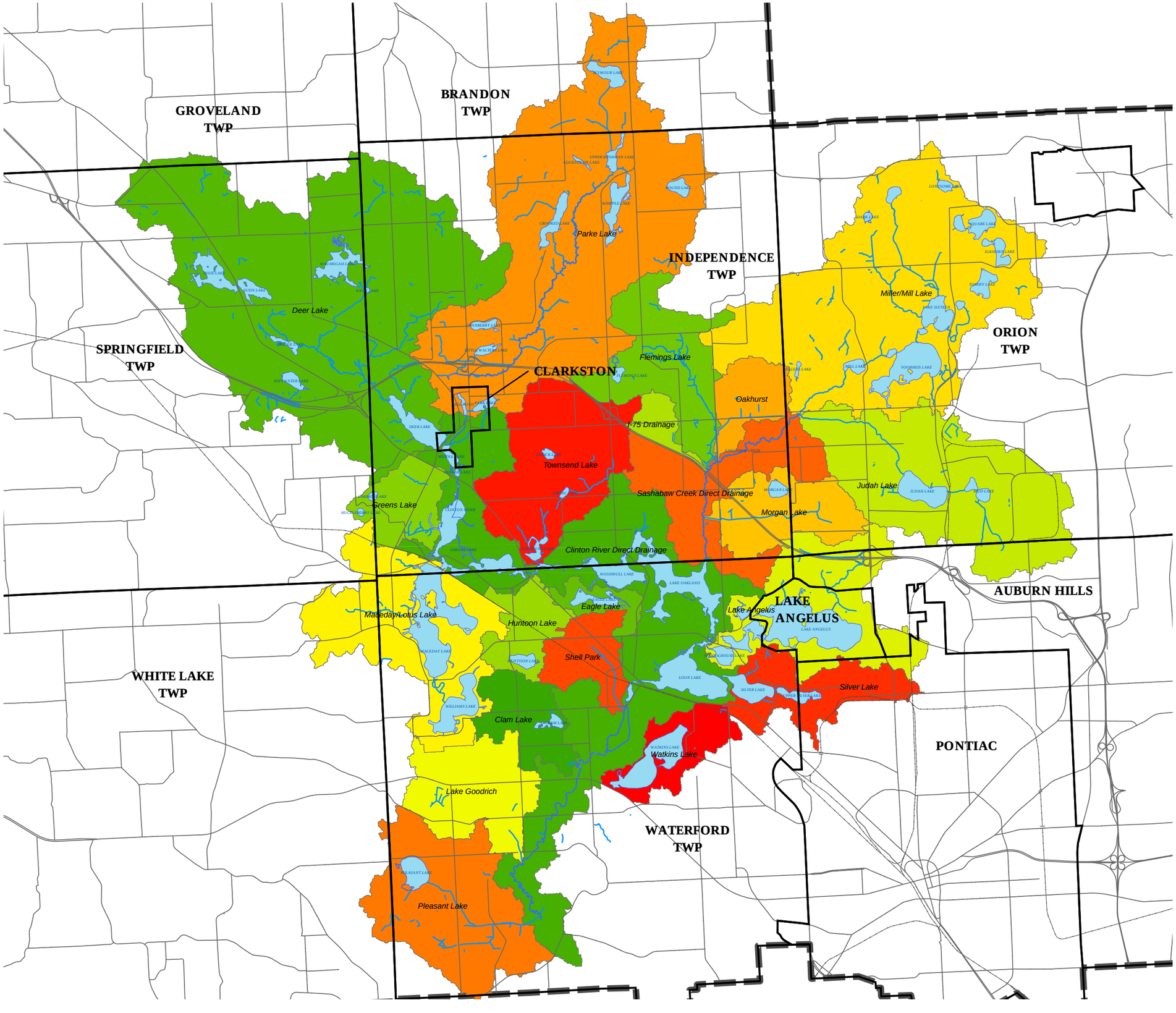
1) Catchments within the Subwatershed were delineated to provide a closer look at the impact of IC on small watershed areas.

2) The existing IC was estimated using Color Infrared Photography from the year 2000.

3) The potential future IC was estimated using community land use plans and estimated imperviousness coefficients associated with planned land uses.

4) An alternative potential future IC was estimated, using IC reduction factors that may be gained by implementing "Better Site Design" practices.

The results of the first task are shown in a map on the next page. This map breaks the Upper Clinton Subwatershed up into twenty-two "catchment" areas, or small sub-drainage areas.



Legend

- Upper Clinton Subwatershed
- Rivers/Streams/Drains
- Lakes

Catchment

- Clam Lake
- Clinton River Direct Drainage
- Deer Lake
- Eagle Lake
- Flemings Lake
- Greens Lake
- Huntoon Lake
- I-75 Drainage
- Judah Lake
- Lake Angelus
- Lake Goodrich
- Maceday/Lotus Lake
- Miller/Mill Lake
- Morgan Lake
- Oakhurst
- Parke Lake
- Pleasant Lake
- Sashabaw Creek Direct Drainage
- Shell Park
- Silver Lake
- Townsend Lake
- Watkins Lake

MAP 9

CATCHMENTS

UPPER CLINTON SUBWATERSHED MANAGEMENT PLAN

Carlisle/Wortman Associates, Inc.
Community Planners & Landscape Architects

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0 1 2 Miles

PLOT GENERATION: AUGUST 31, 2005
SOURCE: OAKLAND COUNTY

The existing IC was estimated using a semi-automated analysis of color-infrared photography taken in 2000. This analysis resulted in an IC estimate for the subwatershed at 17%, placing it in the "Impacted" category of the ICM. The IC was unevenly distributed in the Subwatershed, tending to concentrate along the commercial corridors of Dixie Highway, M-59, and Baldwin Road, as well as along I-75. Catchments within this Subwatershed had imperviousness values as low as 10% in the less developed areas and as high as 43% in more developed areas.

The potential future IC of the Subwatershed was estimated to be 23% under conventional development techniques, keeping the watershed below the "Non-supporting" category of the ICM. The analysis demonstrated that "Better Site Design" measures could lower the potential future watershed IC to 20%, retaining the "Impacted" category of the ICM. The possible savings in impervious cover by using Better Site Design techniques for each catchment is shown in the following table:

Table 5.2
Year 2000 and Potential Future IC Estimates of Catchments in the Upper Clinton Subwatershed

Catchment	Acres	Year 2000 Acres Imperviousness	Potential Additional Impervious Acres (Conventional Site Design)	Potential Additional Impervious Acres (Better Site Design)	% Impervious (2000)	% Future Impervious (Conventional)	% Future Impervious (Better Site Design)	BSD Savings
Clam Lake	843	202	251	242	24	30	29	1
Clinton River Direct Drainage	6567	1576	1749	1716	24	27	26	1
Deer Lake	9317	1025	2227	1453	11	24	16	8
Eagle Lake	342	99	109	107	29	32	31	1
Flemings Lake	1730	190	327	302	11	19	17	2
Greens Lake	778	109	209	166	14	27	21	6
Huntoon Lake	709	291	303	300	41	43	42	1
I-75 Drainage	286	54	68	65	19	24	23	1
Judah Lake	3682	921	1197	1111	25	33	30	3
Lake Angelus	2439	390	477	452	16	20	19	1
Lake Goodrich	1482	563	667	647	38	45	44	1
Maceday/Lotus Lake	2974	446	525	502	15	18	17	1
Miller/Mill Lake	6375	638	813	781	10	13	12	1
Morgan Lake	1218	171	250	235	14	20	19	1
Oakhurst	655	46	59	56	7	9	9	0
Parke Lake	7634	763	1056	1001	10	14	13	1
Pleasant Lake	2619	445	594	566	17	23	22	1
Sashabaw Creek Direct Drainage	1785	268	415	387	15	23	22	1
Shell Park	729	313	343	338	43	47	46	1
Silver Lake	1197	335	370	364	28	31	30	1
Townsend Lake	2325	488	759	552	21	33	24	9
Watkins Lake	862	155	173	170	18	20	20	0

The following conclusions can be made based on this analysis:

1. Overall, the Upper Clinton Subwatershed is currently an "Impacted" stream system based on the ICM (17% IC).

2. Because of the uneven development pattern across the Subwatershed, some areas are "Sensitive" while others are "Impacted" or "Non-supporting."

3. Potential Future IC (around 20-23%) will result in increased IC but overall the subwatershed will remain in the "Impacted" category.

4. Five catchments are classified as "Non-supporting" in 2000. Future development is projected to increase this number of catchments to 10, based on existing land use plans. "Better Site Design" measures may be able to prevent 2 catchments (Townsend Lake and Greens Lake) from progressing to the non-supporting category.

5. Eleven catchments are classified as "Impacted" in 2000. Future development is projected to increase this number to twenty-one, based on existing land use plans. "Better Site Design" measures will not prevent any of these catchments from moving into the "Impacted Category". Oakhurst catchment is the only catchment which will remain in the ""Sensitive" category.

The Center for Watershed Protection completed a review of the scientific literature pertaining to the application of the Impervious Cover Model (ICM) (*Source: Stony Creek Subwatershed Management Plan, Clinton River Watershed Council, 2003*). This review indicated that the influence of impervious cover in the 1-10% range is relatively weak when compared to other potential factors, such as percent forest cover, riparian buffer continuity, historical land use, soils, and agricultural use (CWP, 2003). The review warned that IC alone should not be used to classify and manage streams in watersheds with less than 10% impervious cover. IC seems to be a more reliable indicator of overall stream quality in watersheds that have greater than 10% IC. In addition, CWP found that a number of streams in high-IC watersheds that also had extensive streamside forest cover had unusually high-quality biological communities. In these cases, it appeared that forested stream buffers (defined as at least two-thirds of the stream network with at least 100 feet of forest width on either side of the stream) were influential in enhancing stream quality. In addition to these benefits, riparian forests shade and cool the water and aquatic habitat, reduce stormwater runoff, provide woody debris and leaf litter for instream habitat, and provide bank stability.

While the overall Upper Clinton Subwatershed's IC is above the "Sensitive" category, some of the smaller catchment areas are not. Even though the ICM points to minimizing impervious cover through low-impact development techniques, it may be even more important to maintain existing riparian forest cover to the greatest extent possible to protect water quality over the long term.

5.2 Checklist Evaluation

To help determine how well natural resources are currently being preserved and protected throughout the subwatershed, each community's planning documents were evaluated using a checklist created by Southeast Michigan Council of Governments (SEMCOG) and Carlisle/Wortman Associates Inc. Natural feature protection was the focus of this evaluation because of the positive impact natural features, such as wetlands, woodlands, and open space have on stormwater quality and quantity. The checklist includes the following sixteen topics:

- Stormwater Management Standards
- Impervious Surface Reduction
- Land Conservation and Development Techniques
- Erosion and Sedimentation Control
- Sanitary Sewer Planning and Infrastructure
- Groundwater
- Greenways
- Habitat Preservation
- Wetland Preservation
- Woodlands Preservation
- Stream Corridors and Flood Plains
- Capital Improvement Plan
- Watershed Issues
- Public Education
- Pollution Prevention and Housekeeping Practices
- The Development Review Process

The analysis evaluated the communities' Master Plans, Recreation Master Plans, Zoning Ordinances, Engineering Standards, and any other planning document that the communities use to protect natural features. Questions about the sixteen topics above were organized into three categories: Plans and Policies; Development/Re-development Regulations; and Design Standards. While not true for the other two categories, the "Plans and Policies" questions fell within four general themes under each topic listed above:

a) Identify the topic as an important community goal/policy,
b) Relate preservation of natural features (specific or general) to accomplish certain outcomes (such as to "help alleviate problems associated with stormwater," or "protect the quality of air, land and water resources while accommodating development"),
c) Relate the topic to the preservation of health, safety and welfare of residents, and
d) Provide existing conditions information in the Master Plan regarding the topic.

The themes are identified here to give the reader a general picture of the basic ideas or information that should be included in a Master Plan regarding natural features. This information will provide a complete picture of their natural features, and why and how the community wants them preserved.

The checklist questions are worded so that they imply the desirable action. For example, the question, "Do you regulate stormwater in your community?" implies that regulating stormwater can be a good thing. The questions also provide a continuum of possibilities that a community could adopt. Not all the suggestions will fit into all communities' existing planning approach.

Responses given to questions were "Yes," "No," "Yes/No," or "N/A." In many cases, the answers were qualified with notes in the "comments" column that explained why that response was given. This approach allows the reviewer to thoroughly evaluate how the community is addressing the question, and provides enough information to make viable recommendations to improve protection if desired.

The following provides a summary of the results for each community, and recommendations for further protective measures. The completed checklists are included in the Appendix of this document.

5.3 Planning Document Analysis

Each analysis provided below describes the strength's of each communities' Master Plan and Development/Re-development Regulations. It is important to acknowledge the effort that the subwatershed communities have made to protect natural features within their boundaries. Almost more importantly, though, describing what is currently being done also educates adjacent communities about programs and approaches to stormwater management that they could coordinate with to protect water resources on a subwatershed basis, rather than only in one political boundary.

City of Auburn Hills

Master Plan

The City's Master Plan is expressed on a poster with a future Master Land Use Plan map and text describing the City's vision for its future. The City has plans to update this document within the next few years, and could possibly change the format to allow more space for additional information about Auburn Hills. The current Plan calls for respecting natural areas in its future vision. In addition to discussing natural feature preservation in the Master Plan, the City also discusses this topic in their Recreation Master Plan, and documents created for their Phase II permit through the Rouge Watershed Project (1998). The Recreation plan describes how their existing pathway system connects natural areas together, and the City's paths to greenways in adjacent communities. The Plan also has a goal to build on this pathway system, constructing new linear parks and trails that connect parks to neighborhoods. The Recreation Plan also provides inventories of important natural features, including wetlands and woodlands, and describes how floodplains are important for stormwater infiltration and wetlands are important for stormwater storage. An Illicit Discharge Elimination Plan was developed by the City to identify and eliminate illicit discharges to the community drainage system. It also maps the location of all drainage facilities throughout the community.

If the Master Plan were revised in a more expansive format, many of the topics in the checklist could be addressed. This format would also allow the City to extend each goal into policy statements and more specific objectives of how a goal can be reached. Suggested topics include identifying the specific natural features (wetlands, woodlands, floodplains, watershed boundaries, riparian buffers, native plants, wildlife habitat, and groundwater) as important to the community, calling for their protection, and tying them to the protection of residents' health, safety and welfare. While many provisions of the City's Zoning Ordinance require ways to protect natural features, it is important to have a policy basis in the Master Plan to ensure community regulations are defensible.

To support goals and policies about natural feature preservation, a Master Plan should inventory the community's resources (in addition to wetlands and woodlands) and identify them on a map. If summarized on a single map, the City could see where natural features overlap, and create "ecosystems," rather than isolated natural features. High quality ecosystems could then be prioritized for conservation. A conservation plan, or guidelines, could also be developed and put in the Master Plan. Wetlands could also be called for preservation on a watershed basis.

Another important idea to communicate in the Master Plan is tying natural feature preservation to stormwater infiltration and management. For instance, preserving the vegetated riparian buffers provides water quality benefits, and woodland preservation improves infiltration of stormwater. Other stormwater topics that the Master Plan could discuss are the importance of stormwater management to the City, a discussion on the quality and quantity of stormwater generated by impervious surfaces, and how stormwater management can protect the health, safety and welfare of residents. Calling for the use of Best Management Practices (BMPs), to improve infiltration and treat stormwater before it is discharged into natural water bodies are also important ideas to consider. Lastly, the Master Plan could discuss the importance of minimizing impervious surfaces, and include ways that developers could incorporate infiltration of stormwater in both new and redevelopment proposals.

Development topics could also be addressed in the Master Plan to help protect surface waters. For instance, policies on infill development or redevelopment of degraded areas could be included. Sanitary sewer planning is a particularly important topic, since 99% of the City is served by sanitary sewers. How the City proposes to maintain the system, fix problems, and replace aging or failing segments are all topics the Plan could address, as well as how these activities will be financed over time.

The pathway/trails discussion in the Recreation Master Plan could be expanded to include wildlife habitat and animal transportation corridors as important goals of the trails/pathway plan. The trails/pathway plan could also be identified in the Recreation Plan as a way of preserving natural areas. Community acquisition of open space could also include goals for nature study and wildlife habitat as well as active recreation.

Development/Redevelopment Regulations

The City's regulations currently provide a broad range of mechanisms that help protect water resources. During the development design stage, natural drainage patterns are required to be maintained and an Environmental Impact Statement is required to confirm that natural resources

are being preserved to the greatest extent possible. The City's Cluster Option, Open Space Preservation Option, and Planned Unit Development regulations provide flexible design criteria to reduce setbacks, helping to limit impervious surfaces and preserve open space. Resulting open spaces must be managed in a natural condition and protected by a conservation easement or other mechanism. Other natural feature preservation ordinances include a wetlands ordinance, which protects wetlands less than five acres and less than two acres if the wetland meets the criteria in the ordinance. The City also has a woodlands preservation ordinance, as well as a floodplain district that has specific design criteria for this sensitive area.

The City's site design criteria include regulations for stormwater systems, parking, roadways, and landscaping. The ordinance provides fully detailed design criteria for stormwater systems that require sedimentation basins for sites without detention, and maintenance requirements. It also allows developers to install permeable pavement in parking lots, and parking lot islands to break up the expanse of pavement. The parking regulations give the City flexibility in allowing less parking if warranted than the ordinance requires. This is done through land banked parking, and shared parking facilities if the hours of operation for the multiple users do not overlap. Street design is also regulated to all the minimum required widths and right-of-ways to limit clearing and grading. The City also has a list of prohibited plant species, one that could be easily updated to include exotic-invasive species. Lastly, one effort that the City has undertaken to protect water resources is an extensive program to disconnect footing drains from the sanitary system. This helps to minimize the impact stormwater has on the sanitary system, making overflows less likely.

While the City doesn't have a stormwater ordinance per se, it does have design standards for stormwater facilities. To enhance the current standards, a stormwater management ordinance could be added to communicate the desired approach to managing stormwater to developers. For instance, the ordinance could limit land grading and clearing, maintain naturally vegetated buffers adjacent to all natural features to increase infiltration, minimize impervious surfaces, encourage the use of infiltration devices, and recommend using native plant species in stormwater facilities. This ordinance could also encourage the use of Best Management Practices (BMPs) which keep stormwater above ground (rather than piped away) and prohibit direct discharge of stormwater to any natural water feature (in addition to wetlands) without pre-treatment. The ordinance could provide examples of infiltration devices, or design criteria for infiltration methods could be included in the current design standards.

The current Wetlands Ordinance requires a 25' vegetated buffer adjacent to wetlands. The ordinance could allow the size of this buffer to be increased if warranted by the conditions on the site. The buffer idea could also be extended to include buffers for streams, lakes, and ponds. For further streamside protection, development along streams could be restricted to limit degradation of water quality and alterations to the stream corridor. Where streams have floodplains, these regulations could require that flood management projects assess their impact on water quality, and that Best Management Practices be added to existing projects.

The intent of development options, such as the Planned Unit Development and Open Space Preservation Option, could be expanded to include reduction in impervious surfaces. Open space created by these provisions could be required to be consolidated with adjacent open spaces, and/ or be of a minimum size or width. The City could also include provisions specifically directed at

re-development projects, such as coordinating new facilities with existing facilities and infrastructure. Infill development proposals could also be encouraged to promote conservation of existing natural features, reducing the site's environmental impact.

Miscellaneous items that could be considered relate to downspouts, groundwater, and site plan review procedures. The City has made a great effort to disconnect footing drains from the sanitary system. In the same vein, it could also prohibit connecting downspouts to the stormwater system. While Auburn Hills does not depend on groundwater for its drinking water, groundwater is connected to streams and lakes, and provides flow to these features during dry periods. The importance of groundwater could be enhanced by considering groundwater recharge areas in zoning decisions, and including additional requirements for site plan submittals in groundwater recharge areas. The information site plans provide could be improved by requiring that all natural features be shown. Currently, the City requires drainage courses and woodlands/trees. Lastly, it is a helpful practice to ensure that Best Management Practices (BMPs) be clearly labeled on site plans so that they can be easily evaluated in the field.

Brandon Township

Master Plan:

The main policy approach for Brandon Township's Master Plan (called the *Land Use Plan*) is to address natural feature preservation through an Overlay District, which provides policies for site plan review of properties within the District. While the District has supportive maps identifying the Township's various natural features, more detailed information is provided in a separate report called *The Natural Features Report*, which was recently completed. The purpose of this report is to provide the basis for a "Natural Areas Plan," to be included as a chapter in the Township's Land Use Plan. By adopting such a plan, the Township would incorporate many of the ideas listed in the checklist evaluation into their Land Use Plan. For instance, the Natural Features Report relates checklist topics to the protection of health, safety, and welfare, which is a basis in law for many environmental regulations. The ideas communicated through the checklist could also be used in development of the Natural Areas Plan. *In any event, it is important to include this information in the Land Use Plan to create a defendable position for development regulations.*

There are checklist topics that are not discussed in the Natural Features Report, but could also be added to the Land Use Plan. These topics include encouraging the use of Best Management Practices (BMPs) for stormwater management, minimizing impervious surfaces, identification and mapping of groundwater recharge areas and discussion of the importance of groundwater, categorize wetlands regarding their suitability as stormwater storage, protecting natural features on an ecosystem basis, and consideration of a capital improvement plan.

Development and re-development regulations are strong in the areas of land conservation techniques, woodlands preservation, public education, and the development review process. The cluster provisions could be fortified by requiring that open space be managed in a natural condition, and protected through permanent mechanisms such as a conservation easement.

Development/Re-Development Regulations

The main challenges for Brandon's development and re-development regulations are related to stormwater Best Management Practices (BMP's) and reducing impervious surfaces. These two topics are important for the Township to consider now because of its relatively undeveloped state. It is much more efficient and cost effective to implement stormwater BMPs and minimize impervious surfaces as a parcel is being developed, rather than try to retrofit a property with these features. A Stormwater Ordinance is one way to address these issues. These ordinances typically encourage the use of BMPs such as above ground stormwater conveyance systems, pre-treatment of stormwater before it is discharged into a wetland or other water resource, and periodic monitoring of BMPs. They also generally provide site development standards such as preserving natural drainage patterns, limiting land disturbance and grading, and encouraging the use of infiltration devices. Minimizing impervious surfaces and infiltration could also be discussed in a Stormwater Ordinance. The checklist evaluation describes many ideas to minimize impervious surfaces in regards to parking lots, streets and access ways, and lot setbacks, widths, and coverage requirements. Standards for stormwater facilities should also be developed and/or added to any existing Engineering or Design and Construction Standards.

Another challenge identified in the checklist was also mentioned in the Natural Features Report. One of the goals in the report is to develop buffer or setback regulations that maintain the native vegetation along riparian wetland systems. The report suggests 75 to 100 feet off the centerline of a creek, stream, or drain. It has been scientifically proven that the larger the vegetative buffer, the more effective it is. However, the Township could strive to meet these standards in the future, while implementing a less strenuous requirement to start with. These regulations may also be combined with development of a Greenway Plan, which could establish priority stream corridor/wetland systems for buffers and potentially non-motorized recreation as well.

The checklist evaluation also acknowledged groundwater protection as an area where Brandon could strengthen its regulations. The Township has no water supply system, and groundwater provides all the drinking water for its residents. As the Township continues to develop, groundwater recharge areas will come under increasing development pressure, potentially impacting the Township's water supply. Identification and mapping of groundwater recharge areas will provide the background needed to amend the zoning map, and improve protection of this important resource.

Lastly, it was noted that Brandon doesn't have a Wetlands Ordinance. While this type of ordinance is not the only way to protect wetlands from development, it was not evident from the plan evaluation that the Township had other measures that specifically protected wetlands. Therefore, this is a topic the Township may want to consider in future ordinance revisions.

City of the Village of Clarkston

Master Plan

The City is currently almost built out, and has significant natural features, such as the Mill Pond and Parke, Deer, and Middle Lakes, that help to define its character. The Master Plan reflects this character by discussing both "urban" and "environmental" issues. The environmental topics include land conservation, enhancing the City's water features, the possibility of requiring an environmental impact statement for development and re-development proposals, and sanitary sewer planning. All of these topics are important considerations in regards to water quality.

The Master Plan calls for acquisition of the property at the intersection of Main Street and Waldon Road. This parcel contains the Clinton River, wetlands, and other important natural features. Because so few undeveloped parcels are left, this piece affords a rare opportunity to forever protect a stretch of the Clinton River within the City. If acquisition is not currently in the works, emphasizing this opportunity and making it a priority for the community in the Master Plan could improve the chances that the acquisition would happen. Conserving the natural features on this site would help to preserve the water quality (and many other) benefits that this parcel provides Clarkston.

Since the City is almost built-out, some of the ideas in the checklist for site design may not be applicable. However, the City will most certainly begin to receive re-development proposals. Re-development is where the City could concentrate its efforts in improving stormwater management. Important topics to discuss in the Master Plan would be goals for stormwater management (such as discussing the importance of stormwater management to protect the City's character, as well as both the quality and quantity of stormwater exiting re-development sites), encouraging the use of stormwater Best Management Practices (BMP's) (such as catchbasin inserts to capture sediments, automobile fluids, and trash, and underground storage of stormwater), and improved stormwater infiltration.

Because the Mill Pond and other water features are so important to the City's character, the Master Plan could emphasize these features, and provide a strategy for improving the water quality, such as resident education about fertilizers and other landscaping chemicals, pet waste, and most importantly, vegetated buffers.

Another topic that could be strengthened in the Master Plan is the identification and mapping of the community's groundwater recharge areas. Almost the entire community is dependent on groundwater wells for their drinking water. Therefore, proper management of recharge areas is critical to resident's health and continued viability of wells.

Inventory and mapping of natural features provides the regulatory basis for policies in the Master Plan and prepares a defendable position for development regulations. Therefore, the Master Plan should provide inventories and maps of the following natural features: wetlands, woodlands, riparian (stream and lakeside) areas, floodplains, and watersheds. Goals for protecting these areas should be considered, as well as goals for restoring or enhancing these areas. Restoration could include removal of invasive species and sedimentation removal, and enhancement could include protective measures such as riparian buffers.

Development/Re-Development Regulations

The City has flexible provisions for both parking and setbacks through various ordinances. This is a strength of the Zoning Ordinance because these practices work to reduce impervious surface, and therefore the amount of stormwater generated by these surfaces. The parking regulations could be further strengthened by allowing small car parking, and infiltration areas within parking lot islands.

In responding to re-development and infill proposals, the City should have stormwater regulations on the books to take advantage of the new techniques and technology available to reduce the amount of stormwater, and treat the runoff before it reaches a natural waterbody. This could be accomplished through a Stormwater Ordinance that encourages the use of Best Management Practices (BMPs), and provides guidance on how to manage stormwater for the least impact on the environment. An ordinance could be enhanced through Engineering or Design and Construction Standards that provide specifics on how stormwater facilities should be constructed. Infill regulations should also address conservation of natural features to the greatest extent possible.

The current Master Plan includes goals to development regulations that protect the City's groundwater, and the City's natural features. These regulations would be built upon the inventories and policies included in the Master Plan. They should address wetlands, woodlands, and stream corridor protection. Separate ordinances could be used to accomplish this task, or a Natural Features Overlay District could be used to identify and protect specific areas that have high-priority natural features. Buffer or setback regulations would also help to preserve water resources by keeping pollutants in runoff from reaching waterbodies until it has been filtered through the buffer.

The City has some provisions regarding open space. However, they could be improved by requiring that open space be managed in a natural condition, and protected through conservation easements. There may not be many opportunities for this, but if these requirements were considered for re-development or infill proposals, application may be expanded. Natural land management could also be applied to appropriate areas of City-owned open spaces. Also, the plans for greenways within Clarkston could be expanded to include wildlife corridors (stream corridors, tree rows, natural beauty roads, utility easements) and call for natural feature protection while providing opportunities for non-motorized transportation and recreation.

Independence Township

Master Plan

Independence Township's Master Plan is composed of two documents, the Background Studies document, and the Strategic (or Master) Plan document. One main focus of these two documents is the natural environment and its preservation. The "Historic, Rural, and Open Space Preservation" chapter of the Strategic Plan recognizes the importance of natural features and open space, and has goals and strategies to preserve open space while accommodating development through alternatives to residential land development patterns. The Strategic Plan also talks about coordinating open space between residential developments, and acquiring more public parkland, as well as working with land conservancies and conservation easement.

The Strategic Plan also discusses the importance of stormwater management, connects this topic to the health, safety and welfare of residents, and has goals and policies for updating the Township's Stormwater Management Plan, and improving water quality. One such effort is the Township's plan for a regional stormwater management system that collects, stores, and discharges stormwater for 330 acres of the Township. The emphasis of this system is stormwater quality and natural feature preservation. Rather than requiring on-site stormwater detention, stormwater is directed to the regional system through storm sewers and open drains where possible. On its way to discharge points, it is filtered through a constructed six-acre wetland, which doubles as a storage area and wetland mitigation bank. To implement this program, the Township is developing a stormwater management plan for this area in addition to a plan detailing the construction of the related infrastructure.

Another chapter of the Plan discusses the important topic of sanitary sewer planning. This chapter covers both septic systems and sanitary sewer systems. The Township has developed a Sewer and Water Master Plan that relates to existing zoning. It states that higher densities should be concentrated closer to public services and utilities. It also identifies areas that are suitable for septic systems, and calls for Township-wide water quality testing program for bodies of water in areas served by septics.

The Township's Plan also discusses the importance of groundwater and calls for its protection. Further protection of groundwater is covered by the Township's Wellhead Protection Plan, which identifies areas that contribute to the community water supply, identifies sources of contamination and includes methods to cooperatively manage the area and minimize threats.

Another planning initiative the Township has undertaken is a Greenway Plan. This plan talks extensively about preserving natural greenways for habitat and natural feature protection, as well as man-made greenways for non-motorized transportation and other recreational opportunities. The Plan looks to connect natural features and community amenities within the Township, as well as to other areas.

In the Background Studies document, the Township has inventories of wetlands, woodlands, and watersheds (drainage areas). The document discusses the importance of wildlife habitat, wetlands, and watershed areas, and calls for their preservation and protection. The watershed discussion provides possible alternatives for protection, two being reduction of impervious surfaces and floodplain protection. Several environmental topics, wildlife habitat and riparian buffers, are related in the Plan to the protection of the community's health, safety and welfare, an important link to justify protective regulation. The Plan also calls for development of a River Conservation Overlay District for the Clinton River, and Sashabaw Creek and other stream resources.

In regards to stormwater, the few areas where the Township could strengthen their Strategic Plan is to connect natural feature preservation with alleviating problems with stormwater by providing infiltration and storage. More specific strategies concerning stormwater "quantity," stormwater Best Management Practices (BMPs), infiltration, and minimizing impervious surfaces would also help guide future stormwater efforts. Note that some of these topics are touched upon in the Strategic Plan and/or Greenway Plan, but discussion of them could be expanded. Other

stormwater-related topics could discuss the goal of prohibiting downspout connections to storm drains, and footing drain connections to sanitary sewers.

Other topics that could be added include a discussion about the importance of soil erosion control. The groundwater recharge areas within the Township could be identified and mapped, and then this information used in the Master Planning and Zoning process. Wetlands appropriate for stormwater storage could also be identified and mapped in the Strategic Plan, as well as policies that call for wetland protection on an ecosystem basis. The Strategic Plan could include a discussion on the importance of woodlands for residents' health, safety, and welfare, and how they contribute to stormwater attenuation. Floodplain protection could also be added in the Strategic Plan, including its importance for residents protection, and ways the Township could coordinate with other communities to control flood events. The role of native plants in natural feature preservation could also be added to the Strategic Plan's environmental goals, including their possible use in stormwater management facilities.

The Strategic Plan calls for development of several additional planning tools. All of these tools could improve the Township's current standard of protecting water quality. These tools include:

- Updating the Stormwater Management Plan,
- Developing a program to conduct Township-wide water quality monitoring of water bodies in areas that are served by septic systems, and
- Creating a River Conservation Overlay District.

Lastly, the Historic, Rural, and Open Space Preservation chapter of the Strategic Plan could be updated by adding areas identified by the Michigan Natural Features Inventory (MNFI) as environmentally significant.

Development/Re-Development Regulations

The Township's development/re-development regulations include stormwater provisions in several areas. The Drainage Management Ordinance, Environmental Performance Standards, and Development Design Standards all discuss stormwater management, including limits to grading, maintaining existing vegetation, encouraging infiltration, encouraging use of above-ground BMPs, pre-treatment of stormwater before discharge, and maintenance of BMPs over time. Other provisions under the Site Plan Review requirements also call for preservation of natural features.

The Zoning Ordinance provides for flexibility in parking requirements, and requires landscaped islands in parking lots. These islands may be used for stormwater infiltration. Other provisions that reduce impervious cover (and improve infiltration) are the flexibility in setbacks in the Cluster Ordinance and Planned Residential Development (PRD) provisions.

This document also includes erosion control standards, a Wetlands Ordinance that protects wetlands 2 acres or more in size, and watercourse protection standards. The Township also considers groundwater resources in zoning decisions, and requires that septic systems be at least 100' from a water body.

While the development/re-development regulations are comprehensive, there are some new ideas that could be considered to further strengthen natural feature, and particularly water resource,

protections. The Township does require a 25' buffer adjacent to water bodies in development review, however, it has been shown through scientific study that the larger the buffer the better. The stormwater management standards could be expanded to include a discussion about reducing impervious surfaces in development proposals. Ways this could be accomplished include opportunities for shared parking facilities, or space for compact cars in parking lots.

Provisions to require periodic monitoring of stormwater BMPs could be added to the stormwater regulations, as could requiring the use of native vegetation in above-ground stormwater facilities. The Cluster and/or PRD provisions could require that open space be consolidated with adjacent open space (if applicable), as mentioned in the Strategic Plan, and protect these open spaces with a formal mechanism, such as a conservation easement. Woodland/tree protection ordinance language, and floodplain protection language could be added and/or expanded in the Zoning Ordinance. Rather than depending on the Army Corps of Engineers standards for floodplain "flood proofing," the Township could incorporate more rigorous standards to limit development in floodplains.

City of Lake Angelus

Master Plan

The current Master Plan for Lake Angelus allots considerable space to discussing natural feature preservation. The document includes a "Conservation Plan," that is a separate chapter in their Master Plan. The plan acknowledges the importance of the community's existing natural features, including wetlands, woodlands, stream corridors, and groundwater. It provides inventories, maps them, and has policy goals for their preservation. The Conservation Plan also states that City-owned open space should be managed and maintained in a natural condition. It also calls for a "greenbelt" around the lake that is a combination of public and private properties to help maintain open space around the City and preserve its natural character. Lastly, this is one of the few plans that discusses the importance of stormwater management, and the role of natural feature preservation to properly manage storm drainage.

Several additional environmental topics could be included in the Conservation Plan such as groundwater recharge areas, flood hazard areas and watersheds. These topics would complete the environmental section of the Master Plan with inventories, maps, and preservation/ conservation goals. Another important topic that the Master Plan should address is on-site sanitary disposal (OSDS) systems. The community completely relies on septic systems to treat sanitary sewerage. While currently there are no significant problems, policies focused on preventing problems should be discussed in the Plan. The City's current voluntary inspection program is a positive move, but it should be backed up by the City's position on septic maintenance, further coordination with the County Health Department, and plans for future program improvements.

The greenbelt concept discusses voluntary efforts on private property to preserve greenspace. To encourage ways of making the greenbelt a reality, the City could include in the Master Plan different potential methods of open space preservation. These could include the use of voluntary riparian buffers, or a Natural Feature Preservation Overlay District with special guidance on how property owners could improve their environmental impact on the Lake.

The Master Plan's discussion about stormwater could be expanded to include ways of reducing the amount of runoff from residential properties, such as rain gardens or other ways of increasing infiltration. Another important topic is the use of Best Management Practices (BMPs), which should be encouraged through policies in the Master Plan. This would coordinate with the City's current policy to mitigate impacts of new development on natural features. Retro-fitting BMPs into existing development or re-development proposals could also be discussed. Another related topic is striving to reduce the amount of impervious cover throughout the City. Policies to accomplish this could encourage pervious pavements for driveways, and other methods of reducing the amount of stormwater runoff.

Development/Re-Development Regulations

The approach to development/re-development regulations in Lake Angelus needs to be slightly different than in a more typical community. The purely residential nature of the City requires that improvements in development techniques need to happen one parcel at a time. Also, because of the City's built-out status, these techniques will be applied to re-development projects rather than development on raw land.

Because of the unique character of Lake Angelus, their Zoning Ordinance does not include many of the regulations mentioned in the checklist. Many simply wouldn't apply. However, an ordinance dealing with stormwater management may be tailored to fit re-development proposals. This ordinance should included Best Management Practices (BMPs) for single residential sites (lakeshore/riparian buffer, rain gardens, slope new driveways into grass, etc.), improvements to infiltration (pervious pavements, stormwater infiltration devices such as French drains, native plantings), and reduction in impervious surfaces (driveway widths, lot coverage).

Another water quality effort the City could put forth to its residents is the importance of a vegetated buffer along water resources, such as streams, wetlands and lakes. While a view of the lake is one main reason for living in Lake Angelus, low native plantings can be added along parts of the shoreline that allow both physical access and views to the lake. These vegetated buffers help to slow stormwater runoff, allowing the sediments to fall out and pollutants to be absorbed by the vegetation before the water reaches the lake. This is particularly important if adjacent lawns are fertilized or pesticides have been applied. This would be a voluntary program, but could be aided by education and other services (one-time site evaluation or design consultation) to help sell the idea.

While the City doesn't have a great deal of single-topic ordinances, it may want to consider a woodlands or tree preservation ordinance to help protect the significant trees within the City during re-development of parcels. Another topic that is not address in the Zoning Ordinance is groundwater protection regulations. Whether this ordinance is viable could be determined once the groundwater recharge information has been investigated for the Master Plan.

Orion Township

Master Plan

The Orion Township Master Plan is strong in several areas. It discusses the Township's desire to preserve natural features in parks, through new development, and to preserve the character of the Township. It also refers to its Stormwater and Erosion Control Ordinance as another way of protecting natural features. The Plan has identified high-priority natural areas, as well as inventoried and mapped Township wetlands and woodlands. Statements that recognize the importance of wetlands and woodlands, and their potential for stormwater attenuation and infiltration are also included in the Plan. Another important topic that the Plan addresses is Sanitary Sewer Planning. The Master Plan calls for development of sewer and water service area maps, and for using these maps in zoning decisions. They currently have a Sewer Map showing existing facilities, and have policies to use this information to discourage sprawl.

The Township's discussion of natural feature preservation could be enhanced by adding a discussion about the ecological importance of open space as a way to protect the health, safety, and welfare of Township residents, protect vital air, land, and water resources, buffer air and noise, etc. Other topics that could be connected to the health, safety, and welfare of residents are wildlife habitat preservation, and floodplain protection. The Plan could also recognize the importance of native vegetation and their role in ecosystem functioning, as well as the importance of stream corridors and associated riparian buffers. A specific plan to protect identified high-priority natural areas could also be included in the Master Plan (a Natural Areas Plan).

To create more policy support for the Township's Stormwater Ordinance, the Master Plan could make a stronger connection between open space preservation and alleviating problems with stormwater and improving infiltration. It could also acknowledge stormwater management as an important community goal, and include managing for stormwater "quantity" as well as "quality" (as included in the Stormwater Ordinance). Other concepts that would strengthen support for stormwater reulations include encouraging the use of Best Management Practices (BMPs), and the goal of reducing impervious surfaces.

The Sanitary Sewer Planning section of the Master Plan is thorough. However, additional discussion regarding suitable areas for septic systems, and community involvement in maintenance of these systems could be further explored.

Other important topics that should be considered for the Master Plan are groundwater, greenways, and wetlands. New ideas for groundwater protection include identifying and mapping groundwater recharge areas and adding policy statements about the importance of groundwater and calling for its protection. The greenway discussion could be enhanced by identifying natural greenways that act as transportation corridors for wildlife (such as stream corridors, tree rows, natural beauty roads, and utility corridors), and acknowledging that creating a greenway system is another way of protecting natural features. Lastly, additional information about wetlands could be added to the Master Plan. Categorizing wetlands in regards to their suitability for stormwater storage would provide the Township with important details about the level of protection needed for specific wetlands. Also, the Master Plan could call to protect wetlands within an "ecosystem" context (protecting the hydrology to the wetland, as well as

adjacent uplands that direct water to the wetland) to ensure that the wetland continues to function.

Development/Re-development Regulations

Consistent with the Master Plan, the Township's Zoning Ordinance requires developers to preserve natural features to the greatest extent possible. The community has also adopted wetlands and woodlands protection ordinances.

The Township has a Stormwater Management and Erosion Control Ordinance that meets many of the checklist criteria. This ordinance limits land grading, requires a riparian buffer strip, encourages infiltration devices, and has regulations to protect wetlands through management of stormwater quality and quantity. It requires the use of Best Management Practices (BMPs), and requires that stormwater facilities be maintained over time. The erosion control provisions of this ordinance also accomplish many of the checklist criteria; however, new State laws (effective 2000) should be incorporated into the ordinance language.

To help minimize impervious surfaces, Orion has incorporated flexibility in their parking standards, and allows smaller lot setbacks through the Cluster Ordinance. The Cluster provisions also require that any resulting open space be maintained in a natural condition, protected through a conservation easement.

Specific natural feature preservation ordinances provide significant protection for wetlands and woodlands. One small issue is that the Woodland Ordinance calls for the preservation of Norway Maples (*Acer platanoides*). However this is an exotic invasive species, and if preserved, will take over any wooded area it inhabits. Additional natural feature preservation ordinances that should be considered include language to better manage development adjacent to stream corridors, and provide floodplain protection. In addition, a groundwater protection ordinance could be built on the background information added to the Master Plan.

The Storwater Management and Soil Erosion Control ordinance could be updated to provide guidelines on riparian buffer width. If a specific width does not provide enough flexibility, a range of widths based on the quality of the feature being buffered could be considered. The ordinance could also contain guidelines on how to reduce impervious surfaces. The soil erosion part of this ordinance could be strengthened by requiring that control measures be installed in the field before a building permit is issued. Engineering design standards for stormwater facilities would help in outlining the types of modern stormwater facilities (BMPs that minimize, pre-treat and filter stormwater) the Township is trying to encourage. Other ways of reducing the amount of stormwater is to prohibit downspout connections to storm sewers, and footing drain connections to sanitary sewers.

Miscellaneous topics include parking, sewer service areas, and native vegetation. The checklist highlighted that that Township could expand on mitigating on the impact of impervious surface by allowing a certain amount of compact car parking or stormwater infiltration areas in parking lot islands. The Master Plan calls for developing sanitary sewer and water service areas, which would help guide development decisions throughout the community. Recommendation for using native vegetation in stormwater facilities could be incorporated into any stormwater Engineering Standards, and encouraging the use of native vegetation in landscaping could be added to the

Landscaping Ordinance language in the form of guidelines. Note that the Township's list of noxious weeds lists Goldenrod (a native, and not listed in the State's Noxious Weed definition), and prohibits grasses 12" or taller. Many native grasses grow beyond this height.

City of Pontiac

Master Plan

The Master Plan reflects the urbanized nature of Pontiac. The City is almost completely built out, and has been this way for many years. Planning and development regulations will only have so much impact within this environment. However, there are certain topics the City could concentrate on to ensure that *re-development* projects work to protect water quality, and reduce stormwater runoff. In addition, the City could consider restoration projects, such as riparian buffers, that would improve both the quality of stormwater reaching waterways, and how much stormwater gets there.

Even with this urban environment, the current Master Plan states that natural areas within parks should be retained for environmental reasons and ease of maintenance. It also identifies parts of the City where additional parks are needed. Where development standards could play a major role is to help meet the Master Plan's goal of infill development, which is a high priority for the City. The City's Capital Improvements Plan (C.I.P.) also addresses stormwater. It provides design standards for stormwater and sanitary systems, and includes capital improvements for installation, maintenance, and replacement of these systems. Other programs that have a positive impact on the City's surface waters are its maintenance program for regularly cleaning out and inspecting its stormwater facilities. The City also has a landscape maintenance program, regularly sweeps the streets, evaluates the amount of deicing chemicals it uses in the winter, and provides leaf pick up during the fall.

All natural features and open space help to alleviate problems with stormwater runoff. While an extensive discussion of the City's existing natural features may not be warranted, providing an inventory of these features (such as wetlands, woodlands, native plants, wildlife habitat, water features such as lakes, ponds, rivers and streams and their watersheds, floodplains, steep slopes, and groundwater recharge areas), in the Master Plan would provide valuable information for future planning efforts, as well as for assessing the impact of infill developments or prioritizing utility maintenance projects. The discussion should also include a description of the important functions these features play (such wetland flood attenuation), and a goal to preserve them to the greatest extent possible. These features, and their preservation, should also be related to protecting the health, safety and welfare of the community.

Another way to address natural feature preservation is through a Greenway Plan, that could both create stream and river-side trails, but also protect these natural systems. Greenway plans also create an infrastructure for wildlife movement and animal access to different types of habitat. Goals of this plan could include increasing natural areas through maintenance practices (such as allowing a woodland to take over a mown area), or re-vegetate areas by planting native species along the riverfront where banks are eroding. Any new parks within the greenway system could also include small "natural" or "wooded" areas that will work to infiltrate stormwater.

Topics that an urbanized community should address in their Master Plan include stormwater management, infiltration, and impervious surface mitigation. The Master Plan could give the reader the City's approach to stormwater management, and how proper management reduces the amount of stormwater, and filters or cleans stormwater of pollutants before it reaches a natural water body. These actions help to protect the health, safety and welfare of residents. Another policy is to encourage the use of stormwater Best Management Practices (BMPs) in re-development projects to reduce and clean stormwater. Improving infiltration and reducing impervious surfaces should be other goals for an urbanized area. As properties are re-developed, infiltration facilities such as porous pavements, landscaped areas *within* parking lot pavement, landscaped greenbelts with deep rooted native plants, or vegetated riparian buffers are examples that give guidance about how to reach this goal. Green roofs are also being used more and more in industrial and commercial applications to reduce the amount of stormwater runoff.

Development/Re-development Regulations

The City currently does not have Engineering Design Standards for stormwater management systems that require pre-treatment of stormwater before it is released. These standards could also include guidelines that require limited land disturbance and grading, maintaining vegetated buffer strips adjacent to water features, encouraging impervious surfaces and use of infiltration devices. These regulations could be strengthened by requiring maintenance agreements for BMP facilities, storm water performance standards, and design guidelines for making storm water facilities more aesthetically attractive while increasing their functionality. Pontiac is probably the most densely developed community within the subwatershed. For this reason, it is also most likely to be the community with the most impervious surface. A few mechanisms that could be used to reduce imperviousness is the use of infiltration BMPs in parking lots, or allowing setbacks and lot frontages to be reduced to minimize the amount of pavement necessary in new developments. The City should also look at ways that storm water infiltration could be retrofit into urban areas, or included in re-development projects.

Another closely related subject is reducing the amount of storm water. Many communities have had success in disconnecting downspouts to storm water facilities, drastically reducing the amount of runoff that enters the system. Another consideration is that the City currently does not have a wetlands ordinance, nor does it have tools to protect riparian zones (except floodplains). Protection of these two features could be combined to improve the quality of water coming off of properties adjacent to streams and lakes. Concepts such as variable building setbacks or naturally vegetated buffers could be used among other protections. The City could also work with riparian land owners to educate them about water quality, and ways in which they can manage their property to help protect this natural asset.

Springfield Township

Master Plan

The Township has a unique approach to protecting water resources in its Master Plan. The document has a chapter called the "Natural Areas Plan" that is devoted to identifying areas that should be preserved in their natural state (high-quality areas), and areas where natural features can be integrated into development. While this is not the only place in the Master Plan where natural features are discussed, this chapter highlights environmental preservation as being a main

focus for the community. The Natural Areas Plan identifies and maps important environmental resources within the Township, including riparian systems (rivers/streams, floodplains, lakes, wetlands, and watershed boundaries), landscape fabric features (woodlands, tree rows/forest patches, and severe slopes), and MNFI (Michigan Natural Features Inventory) sites. Then the Plan goes on to provide actions that the Township can take to protect these specific ecosystems from threats identified in field inventories. The Huron, Shiawassee, and Clinton River headwaters are a focus of this Plan, and specific protective actions have been identified for each of these resources.

More general environmental preservation goals and objectives are also included in the Master Plan. The Master Plan recognizes the importance of all natural features including groundwater, wetlands, riparian corridors, woodlands, trees, tree rows, native plants, and steep slopes. The Plan calls for their preservation on an "ecosystem basis," discussing how these features are interdependent on one another, and how preserving an ecosystem will help preserve the individual elements' functions. The Plan also calls for preserving the "functions" of natural features by avoiding ecological fragmentation. Maintaining the diversity of habitats within the overall ecological system, and identifying and mapping groundwater recharge areas are other goals of the Master Plan.

In regards to development, the Master Plan gives guidance as to how environmental features can be preserved. It first states that density of the community's Master Plan is based on the land's ability to support that density. Instead of imposing a development pattern on the environment, the Township is letting the environment guide its development pattern. The Plan also talks about the importance of stormwater quality and quantity, and encourages the use of Best Management Practices (BMPs) to reduce, collect and treat stormwater. It also discusses how preserving natural features, such as woodlands and grasslands, can limit the amount of stormwater by increasing infiltration and reducing runoff. This extends to the Plan's discussion on reducing impervious surfaces in development projects. The Plan also challenges development professionals to maintain steep slopes to reduce erosion, preserve natural drainage patterns and vegetation, and keep grading at a minimum. To avoid environmental fragmentation, the Plan talks about the importance of coordinating open spaces with each other to create larger, contiguous open areas. Conservation easements, and other preservation tools, are also discussed as options for environmental preservation.

Additional topics that the Township covers include sanitary sewer planning, greenway planning, and tree preservation. The Township has no plans to connect to a regional sanitary treatment facility. The Master Plan talks about the use of septic systems. A "greenway plan" (part of the Natural Areas Plan) identifies wildlife corridor connections, and connects natural areas to one another and the Township to other communities. A separate Pathway Plan coordinates with this plan for non-motorized human transportation opportunities. Lastly, the Tree Preservation Plan, a separate document from the Master Plan, works to protect rural character by preserving the tree-lined roads throughout the Township.

While the Township's Master Plan covers much of the current thinking in natural feature preservation, there are a few details that could improve this document's impact on water resource protection. Regarding stormwater topics, the Plan could specifically discuss stormwater management as an important community goal, and relate management of stormwater to the

health, safety, and welfare of its residents. Associated with this, the Plan could also have a goal or objective to reduce impervious surfaces, and reduce erosion to protect *all* water and soil resources (not just stream corridors). It could also beef up its discussion on riparian corridors by mentioning flood control, shading streams, and scenic and recreational values as other functions of healthy riparian corridors. Preservation of open space and woodlands could also be connected to stormwater infiltration, alleviating problems with too much stormwater runoff. The Plan could also consider community acquisition of additional open space. Lastly, areas suitable for septic systems could be identified and mapped (possibly in conjunction with groundwater recharge areas), and wetlands could be evaluated and mapped for their suitability as part of a stormwater management system.

Development/Re-development Regulations

The main topics addressed by the checklist are stormwater management, impervious surface mitigation, erosion control, sanitary wastes, natural feature preservation, site plan review, and construction coordination processes. Springfield has addressed each topic in their Zoning Ordinance and Engineering Design and Construction Standards.

The Township has adopted Stormwater Management/Impervious Surface Mitigation provisions within the Zoning Ordinance and has updated design standards for stormwater Best Management Practices (BMPs) that cover all the ideas expressed in the checklist. Both tools regulate stormwater using specific standards that reduce the amount of runoff and improve runoff quality. Specific standards limit grading, maintain buffer strips to improve infiltration, preserve natural drainage patterns, minimize impervious surfaces, and encourage infiltration devices. These standards also require the use of Best Management Practices (BMPs) such as above ground stormwater facilities and pre-treatment of runoff before it enters a natural water system, and require that BMPs are maintained over time. Another detail required by these standards is that native plants be considered for vegetating stormwater facilities. These species improve infiltration through their deep root systems, and help to remove pollutants from stormwater as it seeps into the ground.

Infiltration is also addressed by this ordinance. It calls to increase a site's infiltration possibilities, and limit the amount of impervious surfaces. Minimizing impervious surfaces are also handled by the Parking, Cluster, and Planned Unit Development (PUD) provisions in the Zoning Ordinance, and Private Road standards in the Engineering Design standards. The Township has included flexibility in their parking regulations to require only the amount of parking needed for a certain proposal. Some portion of parking lots are required to be planted with trees in landscaped islands. The ordinance also encourages shared parking and allows for small-car parking spaces. The Private Road provisions allow developers to build private roads in subdivisions that have smaller right-of-way and pavement widths, and steeper slopes (based on American Association of State Highway Transportation Officials (AASHTO) standards) if the goal is to preserve natural features. This allows roadways that require less grading and clearing. Other ways impervious surfaces are minimized is through the Cluster and PUD provisions. These provisions allow for relaxed setbacks and clustering of construction to reduce the amount of roadway required to serve the development. They also allow for shared driveways, and require open space that improves a site's infiltration capacity.

Other topics included in the Zoning Ordinance and Engineering Design Standards are erosion control and sanitary systems. The Design Standards require that a Soil Erosion and Sedimentation Control plan be submitted during site plan review, which is evaluated by the Drain Commissioner's Office for compliance with their rules. An additional requirement of the Zoning Ordinance is that any onsite sanitary discharge system (OSDS or septic system) be located at least 100' from any water feature.

The Township's approach to natural feature preservation ordinances is atypical in that it doesn't have an ordinance for each feature it wishes to protect (such as a Wetlands Ordinance, or Woodlands Ordinance). Instead, the environment is considered as an entire "ecosystem," understanding that each feature depends on the adjacent lands to maintain its functioning. Therefore, the Zoning Ordinance has general standards for natural feature preservation as part of its Concept Review process, as well as protective mechanisms in the Engineering Design and Construction Standards and the Stormwater ordinance. Lastly, the Township has a Resource Protection Overlay District that imparts special development requirements and standards on property that has been identified as environmentally sensitive. One feature of this District is the requirement for a field study and resulting Environmental Characterization. This report identifies where the high-quality natural features are located on the site, and directs development away from these features.

Lastly, the Township follows a comprehensive Site Plan Review process that emphasizes actions that preserve natural resources. These standards include a statement that natural features are to be preserved to the maximum extent possible. The applicant must also identify all natural features on a site plan (including native plant communities), label BMPs so that they can be reviewed against the Township's standards, and begin construction with a "pre-construction" meeting. The Township also charts the progress of construction projects to ensure they comply with the approved site plan.

The few modifications that could be considered include buffer adjustments, monitoring of BMPs, and requirements for groundwater recharge areas. The Design and Construction Standards currently require a 20' buffer adjacent to all water features. The Township does have the ability to make this buffer larger (or smaller) if they feel it is necessary. Scientific research has proven that the larger the buffer, the better it will protect a natural water feature. It is often the case that it's difficult to adjust a standard once it has been presented. Since there are no guidelines for when the buffer should be wider (or narrower), it could be argued that a larger standard would produce more consistent protection. Therefore, the buffer width suggested by the Design Standards could be gradually increased to improve the buffer's performance. The next topic, periodic monitoring of BMPs to ensure they are working, could be added as a requirement through the Master Deed and Bylaws of the Homeowner's Association to periodically monitor the system. The last topic may be able to be addressed as long as groundwater recharge data is available from Oakland County. This GIS data could be mapped, and used to guide the next Master Plan/Zoning Map update.

Waterford Township

Master Plan

The Waterford Township Master Plan is strong in several checklist areas. The Plan has a thorough discussion of the community's natural features, identifying each as important and calling for their preservation. This includes groundwater, wetlands, riparian corridors, woodlands, native vegetation, and watershed boundaries and features. Of these, they have mapped groundwater recharge areas (through the Wellhead Protection Plan), wetlands, and watershed boundaries. The Township also has a "Sensitive Natural Resource Area" map that shows the MNFI (Michigan Natural Features Inventory) areas provided by the County. The discussion on native plants encourages using these species in landscaping, and the discussion for wetland and woodland preservation talks about wildlife habitat preservation.

Open space preservation is another focus of the Master Plan. The text encourages private preservation through promoting open space developments, conservation easements, and other methods. Community acquisition of open space is covered in the "Recreation" section of the Master Plan. Another aspect talked about in the Plan is the important role open space plays in stormwater infiltration. The Plan continues its discussion on stormwater by proposing development of a Master Storm Drainage Plan to evaluate the current stormwater system, outline ways of not overtaxing this and any future systems, and discussing maintenance strategies and methods. Best Management Practices (BMPs) to reduce the quantity and improve the quality of stormwater are also discussed. All these topics are used to meet the Plan goal of managing stormwater to protect local streams.

The Master Plan also has other "plans" within it, such as a Sanitary Sewer Plan, a Greenway Plan, and a Capital Improvements Plan. A Wellhead Protection Plan also exists, and is an associated document that coordinates with the goals of the Master Plan. Sanitary sewer planning efforts have mapped the location of existing lines, which is used in the review of zoning decisions as well as a basis for determining density. Essentially, density is calculated on whether or not a sanitary line is available for hook up. The Greenway Plan provides guidance on development of the Waterford Riverwalk Pedestrian Pathway, a pathway that provides residents the opportunity to traverse the Township using non-motorized methods such as walking, biking or roller bladeing. This Plan connects the natural areas in the Township, as well as the Township to neighboring communities. The Capital Improvements Plan also contributes to water quality preservation by recommending a detailed study of stormwater drainage, including investigation of funding for implementation and maintenance of an improved stormwater system. The Wellhead Protection Plan identifies the area that contributes to the community water supply, identifies sources of potential contamination, and provides direction on how to manage the supply areas to minimize threats.

Areas where the Township's Master Plan could be augmented relate to stormwater management, impervious surfaces, and several natural feature topics. As the new thinking in stormwater management has become more main-stream, ways of managing stormwater through natural feature preservation could guide development in this positive direction. For example, the Master Plan could specifically relate stormwater management to the health, safety, and welfare of residents by describing all the positive water quality benefits that are attained through natural feature preservation. Also, natural feature preservation could be considered on an "ecosystem"

basis, rather than just working to preserve single features in isolation of their surroundings. A different approach to natural feature preservation is to have priorities for in-fill developments and re-development areas to encourage the use of sites that have already been disturbed rather than build in "green" sites. Another current stormwater-related topic is minimizing impervious surfaces. The Master Plan could state the importance of this through a goal, and provide guidance of how to reduce impervious surfaces in future developments or re-development.

The "Sensitive Natural Resource Area" map is a good start to preserving important natural areas within the Township. Currently, there is not a specific plan in place to address these sites; however, the Township does call for preservation of land through creative development techniques. A more proactive approach may be called for here through creation of a plan that prioritizes important natural areas, and sets some goals, objectives, and action items to actively preserve the remaining environmental features of the Township.

Discussions of several natural feature types could also be enhanced to improve guidance for the Township's development regulations. The Township could meet the goal in the Master Plan to survey and map existing wetlands to determine their type and function, and develop a comprehensive wetland map that could provide more details during development reviews. The Pathway Plan could be expanded to identify potential wildlife corridors, and prioritize these areas for recreation development and preservation. A woodlands inventory could be added to the Master Plan, as well as include the importance of woodlands as stormwater infiltration areas. Riparian corridors and floodplains could be identified in the document as important natural features worthy of preservation. These linear natural features could also become part of the Pathway/Wildlife Corridor Plan.

Lastly, the Capital Improvements Plan (CIP) could be broadened to include standards for the design of stormwater and sanitary systems, and include capital planning for installation, maintenance, and replacement.

Development/Re-development Regulations

The Township has given developers many options in their Zoning Ordinance to preserve open space and natural features. Waterford has an Open Space Preservation Plan, a Subdivision Open Space Plan, a Detached Single Family Cluster Subdivision Option, and a Single Family Clustering Option. All of these options allow for clustering of residential units. The Subdivision Plan requires that for each square foot gained by a smaller lot, that area shall be dedicated to common open space. The Detached and Single Family clustering options require that land resulting from lot reductions be put into open common space that abuts the smaller lots. The Open Space option requires that resulting open space be connected with adjacent open space if feasible, and that the open space be maintained undeveloped, in a natural state. These options also help to reduce impervious surfaces by allowing smaller setbacks and lot widths, and clustered lots, which reduces the amount of necessary roadway.

Other ways the Township encourages infiltration of stormwater is through parking lot islands, and allowing leaching basins in storm sewer systems. It also has comprehensive storm water regulations that fully details design criteria for constructing these systems. Even though it is not supported in the Township's Master Plan, infill and re-development projects are encouraged

through the development regulations, and the ordinance requires that new development coordinate with existing facilities.

Stream corridors, wetlands and woodlands have special protections. The Township requires a 25' buffer strip between a stream corridor and proposed development. Floodplains are also protected using specific building restrictions provided through the National Flood Insurance Program. The Township has also adopted a wetlands ordinance that protects wetlands less than five acres in size (the minimum protected by the State), and a woodlands ordinance that goes beyond protecting only the trees, but protects the shrub and groundlayer of a woodland as well. This ordinance also has tree replacement requirements.

The Township has a solid base of regulations to protect water resources. However, they could be updated using some of the modern ideas presented in the checklist review. Particular subjects include stormwater guidelines, site development standards, floodplain regulations, and site plan review procedures. Regarding zoning, because the Township has already mapped groundwater recharge areas, this information could be used in zoning properties. Additional protective requirements for site development could also be added to properties in the groundwater recharge area.

The stormwater ordinance could require developers to preserve the natural drainage patterns on a site as a criteria of site plan review. These regulations could also include water resource protection guidelines such as limiting the amount of grading, maintaining a *naturally vegetated* buffer, requiring the use of native plants in stormwater facilities, minimizing impervious surfaces and improving infiltration, and encouraging the use of Best Management Practices. Possible BMPs include encouraging above-ground stormwater management (vs. putting it in a pipe and directing it off site), prohibiting direct discharge into a natural water body without pre-treatment, periodic monitoring of stormwater systems, and regular maintenance activities to ensure the stormwater facilities are functioning properly. Another option is to prohibit residents from connecting down spouts to the stormwater system. The buffer strip requirement could also be increased in size, and allow for modifications if the site warrants it (wider or narrower, using a set of guidelines to determine if necessary and which way to go).

Site design options are also suggested by the checklist. It is difficult to determine the right amount of parking (not too much, not too little) when applying static parking regulations to various site plans. Adding the ability for the Planning Commission to approve less parking, if warranted by the use, could eliminate excess parking and impervious surfaces. Other ways of reducing pavement include allowing shared parking and a percentage of small parking spaces for compact cars. Another site design option would be to improve floodplain protections by requiring any development (or re-development) within the floodplain to assess the impact of the project on water quality and quantity. Finally, site plan review procedures could be modified to require developers to protect natural features to the maximum extent possible as a site design criterion. Also, the review requirements could necessitate that BMPs be clearly labeled on the plans so that they could be adequately reviewed.

White Lake Township

Master Plan

White Lake Township's Master Plan has several strengths that make it an effective tool to protect water quality. The document is strong in describing its goals for open space preservation, and how different development patterns should be matched with the land's ability to support that development. Woven throughout this Plan are references to White Lake Township's participation in the Shiawassee and Huron Headwaters Resource Preservation Project, which also details many ways that communities can preserve open space.

The Master Plan first talks about how the community itself can preserve open space and natural features by acquiring natural areas themselves, or by encouraging donation of land, conservation easements, and open space development designs. It goes on to describe other techniques as well, such as transfer of development rights, deed restrictions, open space/cluster zoning, and connecting natural areas to allow wildlife movement. It also describes the importance of working with developers in public/private partnerships to preserve open space. Another unique idea in the Plan is development of a local land conservancy to concentrate its efforts on preserving open space in the community. The Plan also suggests that the Zoning Ordinance should include incentives to encourage open space preservation and making open space a requirement of new subdivisions.

Related to this, the Master Plan has explanatory material and other goals and policies about how natural features should be preserved. The Plan states that development should be accommodated without negative impacts to the natural environment. Inventories of the community's wetland, woodland, and watershed resources are included in the Plan, along with statements that describe how the Township values these resources and sees them as important. A specific goal for water resources is that they all have a vegetated buffer zone to ameliorate the effects of development. They also relate these features (and groundwater) to protection of residents' health, safety and welfare, an important provision in the land use enabling legislation to justify development regulations for these features. Another natural feature that the Plan deems important is groundwater. The Plan protects this resource through the goal of primary and secondary containment of hazardous materials, and shows potential sources of contamination on a Wells and Aquifers vulnerability map.

Another main strength of the Master Plan is the information provided about sanitary treatment, and the goals and policies the Township has regarding this important topic. The Plan has an inventory and map of the existing sanitary system, and shows areas that are unsuitable for septic systems. The goals of the Township are to provide sanitary utilities to areas that are the most densely populated, or areas with the most sensitive natural features, such as wetlands, rivers and lakes. Another priority for sanitary systems is areas with polluting septics. The Plan also ties the location and maintenance of sanitary sewers and septic systems to the health, safety and welfare of the community.

While the Township does not have a Greenway Plan specifically, the Master Plan does call for development of a pathway system throughout the Township for non-motorized transportation. There is also a Highland Road (M-59) Corridor Plan and the Recreation Master Plan calls for development of non-motorized pathways.

While the Master Plan has many positive provisions, there are several areas where the Plan could be improved. A specific discussion about the importance of stormwater management could be added. This is particularly important since the Township has no County drains, and all stormwater drains to existing natural waterways. This discussion would include goals regarding stormwater quality and quantity, connecting stormwater management to the protection of the residents' health, safety and welfare and natural features, and encouraging the use of Best Management Practices (BMPs) to minimize, collect and treat stormwater. Related to this would be a discussion about reducing impervious surfaces in development, and preserving natural features for improved stormwater infiltration. Another topic that impacts stormwater quality is soil erosion and sedimentation control. The Master Plan should talk about how sediments are the most prevalent pollutant today, and controlling the flow of sediments into our water features can protect the health, safety and welfare of a community.

Details that could be added to the Master Plan's sanitary treatment discussion include development of a program to identify sanitary systems or septic systems that are seeping into stormwater, surface waters, or groundwater. The Plan could also map the location of groundwater recharge areas, and identify the location of community well fields in relation to groundwater resources.

The "natural area preservation" sections of the Master Plan could be augmented with a "Natural Areas Plan" that identifies and maps the Township's important natural features (such as the MNFI sites from the Headwater's Project), and discusses the important benefits they provide. This Plan could also outline how preservation of natural features such as water bodies, wetlands, floodplains, woodlands, wildlife habitat, native plant species, and naturally vegetated riparian buffers protect the health, safety, and welfare of residents. A Natural Areas Plan could also talk about natural feature preservation on an "ecosystem" basis rather than preserving each feature in isolation. This way, the Township will help preserve the functioning of these features by maintaining their relationships to adjoining landscape components. Additional topics on wetlands, such as categorizing them by their suitability for stormwater retention, could also be included.

Development/Redevelopment Regulations

As in the Master Plan, White Lake Township's development regulations pertaining to water resources are strong in several areas. The Zoning Ordinance requires that developers preserve natural drainage patterns and the Township provide many ways of doing this. Cluster provisions (Special Land Use), and an Open Space Preservation Option (by right) both allow a developer flexibility in design to cluster development so that natural areas can be preserved. These regulations require that open spaces be consolidated with adjacent natural areas, that they be preserved in natural condition, and be protected by a conservation easement. If a development is proposed of a certain intensity, the regulations require that a Community Impact Statement be submitted, which describes the existing natural features on the site and the pollutants expected to be emitted into the air and groundwater by the proposed use.

Groundwater protection standards are also a positive part of the Zoning Ordinance. These standards are part of a Wellhead Protection Overlay District. It identifies areas of critical concern for the existing community wells, and provides standards for groundwater and wellhead

protection through the site plan review process. Groundwater is also considered in determining the zoning designation of a parcel. Another water-related program that the Township participates in is the National Flood Insurance Program, which has development provisions to protect floodplains from undesirable development.

Site design criteria in the Zoning Ordinance also contributes to water resource preservation through the parking lot and roadway design standards. The parking lot standards require that trees be planted within parking lot islands, breaking up the expanse of pavement and improving the infiltration of stormwater. Some reduction in required parking is achieved through provisions that allow shared parking under certain circumstances. The Township will also allow a private roadway if the County's design standards would destroy significant natural features.

Another strong aspect of the Township's development documents are in the Township's Engineering and Design Standards, where they provide rules for designing and installing stormwater management systems. These standards provide detailed stormwater design criteria, and require that retention and detention basins are maintained. The Zoning Ordinance further prohibits any stormwater from entering surface waters without pre-treatment.

The Township's site plan review procedure also is a strength of the community's water resource protection programs. This process is tied to receiving the appropriate permits from the State and County before work begins on the site. It also requires that developers preserve natural features to the greatest extent possible, and show all natural features on a site plan.

The main items in the checklist that are not addressed in the Township's development and re-development regulations generally pertain to stormwater management, impervious surface reduction, and infiltration enhancement. Many of these ideas are relatively new, and could be incorporated into the Zoning Ordinance or Engineering Design Standards during a regular document up-date.

Additions to the stormwater management provisions could include language requiring Best Management Practices (BMPs) that reduce the amount of stormwater a development generates, and then filters any that is generated before being outlet into a natural system. Examples include above-ground facilities such as swales, manufactured wetlands (where water infiltrates into the ground, or evaporates), and retention basins. Above ground facilities allow for infiltration, where piping stormwater to one point generally does not. Additional ideas that increase infiltration through natural feature preservation include limiting land clearing and grading, minimizing impervious surfaces, and encouraging the use of infiltration devices. Requiring monitoring and regular maintenance of all stormwater facilities should also be considered.

Riparian buffer strips provide many benefits to a water-based resource, such as a wetland or stream. They slow stormwater runoff so that it can infiltrate the ground and be filtered of pollutants, rather than carry pollutants directly into the water. A buffer stabilizes the stream banks, reducing erosion from flashy stream flows. It provides shade and habitat through fallen branches and leaves for aquatic organisms. And it provides habitat for terrestrial wildlife who all need to be able to safely access a water source. Adding a buffer requirement to the development regulations would also meet a goal of the Township's Master Plan.

Other ways to reduce stormwater runoff and increase infiltration include

- Prohibiting connection of downspouts to stormwater systems
- Prohibiting connection of footing drains to sanitary systems
- Requiring a 100' setback of septic systems to any water feature
- Requiring an isolation distance between septic systems and private or community wells
- Limiting or prohibiting disturbance within a required riparian buffer
- Requiring use of native plant species in stormwater facilities to uptake and filter pollutants from stormwater
- Adopting a woodlands and/or tree preservation ordinance, which provides for significant update and infiltration of stormwater
- Incorporate flexibility in parking requirements, including encouraging shared parking, providing spaces for small cars, and using parking lot landscape islands as stormwater infiltration areas.

5.4 Planning Summary of the Subwatershed – Overall Challenges

Each community within the subwatershed is strong in some of the available techniques to protect water quality and water resources. However, some checklist items came forward as the most important challenges for the subwatershed overall.

Relative to the NPDES Permit, stormwater management is a main topic that most communities could concentrate more on. Most of the Master Plans evaluated do not discuss how they view stormwater, the impacts stormwater can have on natural and man-made systems, nor how they intend to improve stormwater quality or minimize its quantity. As part of this discussion, and in development standards and guidelines, a community could encourage the use of Best Management Practices (BMPs), and require that stormwater be minimized and/or treated before it is released into the environment.

Another main topic that should be considered by many of the subwateshed communities is impervious surface mitigation and infiltration enhancement. Few of the Master Plans mention the impact that impervious surfaces have on water quality, nor have ordinances to control or reduce the amount of impervious surfaces. New goals and policies should be added to Master Plans to address these concerns through specific techniques for both sites to be developed, and sites already developed. The Zoning Ordinance or Engineering Standards could be used to provide guidance on stormwater Best Management Practices for developing sites, and the community, through public education and demonstration projects, encourage existing residents to incorporate techniques into their yards, such as French drains, rain barrels, rain gardens, and similar methods.

Many areas of the subwatershed still have natural features that have not been removed by development. Where this is the case, these communities could enhance their preservation of these features, and justify this protection by linking natural feature preservation with improved stormwater infiltration. Woodlands, wetlands, and riparian buffers absorb a great deal of stormwater, recharging groundwater that feeds streams during dry periods, among many other benefits.

Because this subwatershed has a considerable amount of stream and lakefront property, community efforts should also be directed at preserving and creating riparian buffers of native vegetation along these shorelines. Goals and policies should be adopted to ensure that public riparian property is protected, and if necessary, re-vegetated as much as possible to demonstrate the water quality benefits of plants near water. Residents should be encouraged to re-vegetate their own riparian areas as well. And the Master Plan goals and zoning regulations (through Natural Feature Setbacks for example) should be used to protect existing riparian vegetation in each community.

A relatively easy but important addition to local plans and codes is encouraging the use of native plants in landscaping. This one element is an important feature of reducing the amount of stormwater (through infiltration), and providing vegetative buffers to lakes and streams. While communities cannot require the use of native vegetation, they can demonstrate the aesthetic qualities of these plants on municipal properties, and educate property owners about the benefits native plants provide.

Lastly, the communities within the subwatershed are going to become more urbanized as populations continue to shift to the north and west in Oakland County. Each community should begin to plan for in-fill development, as well as re-development of properties with stormwater quality and quantity, and natural feature preservation in mind.

CHAPTER 6
WATERSHED ACTION PLAN

6.0 Introduction

This chapter of the Watershed Management Plan brings together the other sections of the Plan through potential solutions to the identified water quality issues. The following discussion describes Best Management Practices (BMPs) that could be implemented to address each goal and objective of the Plan.

6.1 Best Management Practices (BMPs)

Stormwater "Best Management Practices" or BMPs are structural, vegetative, or managerial practices used to minimize or eliminate stormwater runoff and pollutants from entering surface and ground waters. When we understand the sources ("where" pollutants come from) and causes (conditions that create the "source") of a stormwater pollutant, we can determine which BMPs can be used to address these water quality problems.

BMPs cover a broad range of activities that vary in cost, effectiveness, and feasibility, depending on a set of complex factors. BMPs can be either engineered and constructed systems (structural practices) or institutional, educational, or managerial practices (vegetative or managerial practices). Structural BMPs directly improve the quality and/or control the quantity of runoff such as detention ponds and constructed wetlands. Vegetative or managerial practices are 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 type 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 to groundwater, etc. Careful consideration of these factors is necessary to select the appropriate BMPs for a particular location.

The Upper Clinton Subwatershed Core Group evaluated a broad list of possible BMPs based on their potential effectiveness, cost, and feasibility. At several Watershed meetings, the group considered which BMPs would (1) best address their priorities for the subwatershed in their locality, (2) be the most environmentally effective in their community, and (3) be the most likely to be implemented in the short term (initiated within five years), and the long term (initiated in more than five years) in their community. These discussions resulted in the following list of BMPs for the Upper Clinton Subwatershed.

Effectiveness and Location of BMPs

As mentioned above, different BMPs have different levels of pollutant-removal abilities. The following chart (compiled for the Mill Creek Subwatershed Management Plan, by the Huron River Watershed Council, 2003) shows the removal potential of several different types of stormwater BMPs:

Table 6.1
BMP Pollutant Removal Efficiencies

Management Practice	Pollutant Removal Efficiencies				
	Total Phosphorus	Total Nitrogen	TSS	Metals	Bacteria
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	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%		
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 Stormwater Phase II.

It should be noted that information regarding the pollutant removal efficiency, costs, and design for structural stormwater BMPs is constantly evolving and improving. As a result, information contained in the above table is dynamic and subject to change.

Quantitatively evaluating the success of managerial BMPs is much more difficult. Research demonstrates that these BMPs have the largest impact on changing policy, enforcing protection standards, improving operating procedures, increasing public awareness, and changing behaviors to improve water quality and quantity over the long term. Because many of these BMPs are applied over a large land area, it is even more difficult to quantify their collective impact. However, intuitively, we know they work.

Generally, the location of structural BMPs is dependent on the particular site and site conditions. However, the following table provides general guidelines for common sense placement of BMPs. The following location guidelines are adapted from the rapid watershed assessment protocol of the Center for Watershed Protection and were obtained from the Mill Creek Subwatershed Management Plan. The "Amount of Development" heading generally describes today's conditions. "Developing" areas implies areas that have some older and some newer approaches to stormwater management. "Developed" areas imply that these areas have been developed for several decades, and contain older approaches to stormwater management.

Table 6.2
Location Parameters of Structural 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 and channel stability	Maintain key elements of stream quality	Minimize pollutant loads delivered to downstream waters

Table 6.2
Location Parameters of Structural BMPs (Continued)

Amount of Development	Undeveloped	Developing	Developed
Water quality objectives	Sediment and temperature	Nutrients and metals	Bacteria
	Maintain pre-development hydrology	Maintain pre-development hydrology	Maximize pollutant removal and quantity control
BMP selection and design criteria	Minimize stream warming and sediment	Maximize pollutant removal, remove nutrients	Remove nutrients, metals and toxics
	Emphasize filtering systems	Emphasize filtering systems	

Sequencing of BMPs

A key consideration when planning to implement BMPs is how the various BMPs will be phased or sequenced in relation to one another over time. For example, it is not ideal to implement a stream bank restoration project before the cause of flashy flows is addressed if it can be avoided.

A phasing approach has been developed for BMPs that assists in clarifying the BMPs that should be considered at various stages in the watershed management process (Middle One Subwatershed Advisory Group, 2001). This approach has been slightly altered for this watershed plan, and is a recommendation only, as specific site conditions may warrant alternative sequencing.

Phase I: BMPs that can be initiated right away, require minimal cost or planning, and/or address the upstream sources / causes of a downstream problem. Usually non-structural BMPs such as source controls, education, good housekeeping activities, etc. However, some structural measures, such as swales or riparian buffer preservation, could also be included in this phase.

Phase II: BMPs that require significant planning and development or design specifications, require major costs, address sources / causes of a problem. Can be structural or non-structural BMPs, including ordinances, new projects / programs, studies, construction of detention ponds or manufactured wetlands, etc.

Phase III: BMPs for which success may depend on the success of a previously implemented BMP. Usually structural, such as in-stream habitat improvements after flow improvements have been made; pond or lake dredging after watershed-wide nutrient or sedimentation reduction efforts are in place, etc.

6.2 Action Items to Address the Upper Clinton Subwatershed Goals and Objectives

Long Term Goal 1: Restore and protect water quality in local waterways and lakes.

Objectives: 1-A: Identify and reduce sources of bacteria and illicit discharges.

Action 1: Implement waterfowl and pet waste management programs. Effective nuisance waterfowl and pet waste management programs can reduce bacteria and nutrient sources within the subwatershed. Programs to reduce waterfowl waste may include installation of native plantings to replace turf grass along ponds and lakes, or detention basin retrofits that incorporate taller native vegetation to help curtail nuisance waterfowl. Pet waste receptacles and educational signage can be placed in community parks or other pedestrian areas where residents walk their dogs.

Action 2: Support County inspections and/or enforcement of Health Department regulations regarding on-site sewage disposal systems. Proper on-site sewage disposal maintenance can significantly reduce nutrient loading, especially near lakes and impoundments. Many areas around existing lakes and impoundments do not have access to sanitary sewer systems, so maintenance programs that include regular pumping of septic tanks and evaluation of the septic fields may not only improve the quality of the adjacent water resources, but may also educate home owners about the potential impacts OSDS, if not functioning properly, have on their water resources. Oakland County, which contains all the communities within the Upper Clinton subwatershed, is currently evaluating a time-of-sale inspection and maintenance ordinance for on-site sewage disposal systems (OSDS) that will provide these benefits. While inspection and enforcement of the Health Department's OSDS rules are within the County's jurisdiction, local municipalities can support these efforts by reporting problematic systems to the County, and then follow up on these sites if the County fails to do so in a timely manner. The community can also, under the Building Code, write citations for failure to comply with the Health Department's standards, and begin legal action if necessary. Communities can also adopt rules that allow it to fix a problem system, and then assess the property owner for the costs.

Action 3: Promote and participate in existing annual watershed education and outreach events, such as River Day and the Clinton Clean-Up.

Action 4: Promote and/or participate in the watershed education and outreach activities of local organizations as outlined in community Public Education Plans. These organizations include the Clinton River Watershed Council, MSU Extension, MDEQ, North Oakland Headwaters Land Conservancy, Oakland Land Conservancy, SEMCOG, etc.

Action 5: Promote and participate in the Clinton River Watershed Council's stormwater education program, as outlined in community Public Education Plans. This program is designed to educate the public about the following six topics, as required by the Phase II stormwater permit:

- The public's responsibility for stewardship of their watershed.
- The location, function, and potential pollution impacts of separate stormwater drainage systems.
- How to identify and report illicit discharges or improper disposal of materials into stormwater drainage systems.
- The need to minimize wastes from residential activities washed into stormwater drainage systems (including car washing, pesticide and fertilizer use, and lawn and pest waste disposal).
- How to dispose of household hazardous wastes, travel trailer sanitary wastes, yard wastes, and motor vehicle fluids.
- Management of riparian lands to protect water quality.

Action 6: Promote, encourage, and/or participate in educational opportunities for land use decision-makers offered by the organizations listed in Action 4. Educating land use decision-makers is a critical component to the successful implementation of the subwatershed plan. These individuals are responsible for implementing many of the actions identified for protecting and restoring the Upper Clinton Subwatershed. Thus, they must stay on top of the most current stormwater and watershed management tools and techniques.

Action 7: Develop comprehensive sanitary sewer infrastructure plans and/or maintenance plans. Some of the municipalities in the Upper Clinton Subwatershed should develop comprehensive sewer plans that are consistent with their zoning and master plans. Local sewer plans identify areas where

sanitary sewer service is or will be available, areas where on-site disposal systems will be used for wastewater treatment, and areas where sewers and on-site systems are not appropriate (i.e. environmentally sensitive areas, floodplains, etc.). These service areas should be developed based on the sewer system's capacity to collect, transport, and treat wastewater flows at the density levels allowed in the zoning map and master plans and/or the ability of soils to accommodate on-site disposal systems. A related plan that should also be considered is a sanitary sewer maintenance plan. This plan would lay out actions to monitor the existing system, and provide schedules for inspections, maintenance/repair, and possibly replacement of system components. It could also address staffing and funding of these tasks.

Action 8: Establish maintenance programs for stormwater management facilities. Short-term maintenance of detention basins, catch basins, swirl concentrators, and other stormwater facilities during construction as well as long-term maintenance by the property owner after construction is as important as implementing BMPs in the first place. Without regular inspections and maintenance, these systems will not provide effective pollutant reduction. These systems, if properly maintained, reduce sediment loading as well as nutrient loading because nutrients bind to soil particles. Catch basins also fill with debris, and if fitted with special inserts, organic compounds. All these materials must be removed for the facility to function properly.

Maintenance of stormwater management facilities should be handled by the agency with jurisdiction over the facility, such as the municipality or road commission. Maintenance of private systems should be required of the property owner or, if appropriate, the homeowners association. Requirements for minimum maintenance measures could be included in the Master Deed and Bylaws, including a provision for the community to do the work and assess the association if not conducted on a regular basis. These requirements could also be contained in the community's Engineering Standards as a condition of site plan approval.

Action 9: Establish detention basin retrofit and enhancement programs in re-development projects. In areas planned for re-development where stormwater facilities were originally designed only for flood control, opportunities exist for various enhancements or retrofits to incorporate sediment and

nutrient removal capabilities. Outlet structures may be reconfigured to handle the small storm events provided adequate volume still exists in the basin for the design storm event. These improvements, combined with native plantings and buffer strips along the basin will reduce nutrient, sediment, and bacteria loadings, discourage geese from congregating, encourage populations of other types of wildlife such as birds, fish, and insects, and ultimately create a more aesthetic environment for the property owner. Such enhancements may also provide passive recreation opportunities.

Action 10: Identify and eliminate illicit discharges. As part of their Phase II stormwater permits, municipalities and counties in the Upper Clinton Subwatershed must develop and implement Illicit Discharge Elimination plans (IDEP). These plans include conducting a thorough inventory and mapping of outfalls into surface waters, water quality monitoring of outfall discharges, and follow-up when problems are identified. IDEP programs typically identify nutrient and bacteria sources such as cross-connections between sanitary and storm sewers or failing on-site sewage disposal systems, but can also identify hazardous waste discharges, or connections from a property's sump or footing drain.

Action 11: Develop and implement a long-term monitoring strategy. Continued monitoring of chemical, biological, and physical parameters is critical to evaluating the long-term success of this subwatershed plan. Monitoring is especially critical to identify and respond to illicit discharges such as hazardous waste and sewage discharges. The historical monitoring data and stream inventory results provide a baseline for future assessment. The Oakland County Drain Commissioner's Office and the Clinton River Watershed Council currently engage in various monitoring activities in the Clinton River watershed, including the Upper Clinton Subwatershed. The subwatershed group should continue to track monitoring activities by these agencies and entities and pursue additional funding opportunities for monitoring as they arise.

1-B: Reduce nutrient loading contributing to excessive aquatic plant growth.

Action 12: Implement lawn care education programs for residents and businesses. Programs that address specific practices on individual properties can have a major impact on nutrient reduction. Lawn care education programs, particularly

for riparian land owners, should include information about fertilizer, watering, and mowing practices. In addition, assistance can be provided on reducing turf grass through the establishment of native plant alternatives. Organizations such as the Clinton River Watershed Council, land conservancies, MSU Extension, and Wild Ones currently offer some materials and programs. Lawn care programs should focus on residential and commercial lawns as well as maintenance of common areas and landscaped areas around detention basins. These areas often require different types of maintenance to keep them functioning properly.

Action 13: Encourage golf course management programs that protect water quality. Encouraging golf courses to develop and implement plans to minimize nutrient loading will help preserve the high quality of the Upper Clinton Subwatershed. These efforts may include educating golf course staff about the importance of protecting the water resources located on the golf course. Education may also include training appropriate staff on proper fertilizer, watering, and mowing techniques to protect water resources. In addition, identifying areas for suitable native plant establishment will also help slow and filter stormwater runoff prior to it entering local tributaries. The MSU Extension Turf grass Stewardship Program is a good source of information for this purpose and offers a certification program for golf courses.

Action 14: Research and evaluate the effectiveness of a fertilizer ordinance. Fertilizer ordinances, standards, guidelines, and/or resolutions in community regulations or as part of a subdivision's Master Deed and Bylaws that regulate application of nutrients by both private landowners and/or commercial applicators can minimize nutrient loading, specifically of phosphorus, to waterways. These guidelines can supplement existing public education and involvement programs. Several communities within the Rouge River watershed have adopted or are currently drafting fertilizer ordinances that require licensing and/or permits from the local community prior to any fertilizer application.

Action 15: Review land use planning and management practices to promote Low Impact Development (LID). Because many areas within the Upper Clinton Subwatershed are still undeveloped, opportunities exist for reviewing the effectiveness of existing land use planning and management practices. Land use planning involves a comprehensive planning

process and can promote LID techniques that control or prevent runoff from certain developed land uses into areas with sensitive water and wetland resources.

Action 16: Minimize directly connected impervious surfaces from new development through the implementation of Low Impact Development Plans. Utilizing LID techniques for new developments can minimize directly connected impervious surfaces. LID techniques combine a hydrologically functional site design with pollution prevention measures to compensate for land that is now being used for buildings, parking lots and other human uses. The result will minimize or eliminate impacts of peak discharge, runoff volume, and stormwater pollutants as compared to typical development impacts. LID can apply to new residential, commercial, and industrial developments. In urban communities, especially older areas, opportunities exist to disconnect impervious areas through downspout and sump pump disconnection, and installation of rain gardens and other bioretention areas.

Action 17: Develop and implement native vegetation guidelines. The use of native vegetation in landscaping and in conjunction with other stormwater best management practices can improve stormwater absorption and filtration. Communities should develop guidelines to preserve and restore native plant communities in open space, buffer zones, and parklands, encourage the use of native landscaping on both municipally-owned and private lands, and utilize native plants in constructed wetlands and stormwater management systems such as detention and retention ponds. It may also be necessary to revise weed ordinances to accommodate native plantings. Establishing native plants, including prairie and wildflower meadows, within new developments as opposed to grass seed or sod can also greatly enhance stormwater infiltration and nutrient uptake.

Action 18: Establish and/or support street sweeping programs. Street sweeping not only reduces sediment loads, but is also effective at reducing nutrient loading because many nutrients bind to soil particles. Because many communities within the Upper Clinton Subwatershed do not have jurisdiction over paved roads, or have many unpaved road segments, street sweeping may not be suitable on all roadways; however, encouraging property owners of large parking lots to regularly maintain their paved surfaces without washing debris into the storm sewers will also reduce nutrient and sediment loading.

Street maintenance programs may be implemented by the appropriate jurisdictional agency or even by property owners. Homeowners' associations should be encouraged to contract with a company to regularly maintain their streets and catch basins if these areas are not under the jurisdiction of the local community or county.

Action 19: Educate municipal staff and/or contractors on "good housekeeping" practices, including proper fleet and service yard maintenance and landscaping activities. These activities are a requirement of the Phase II stormwater permit. Not only do good housekeeping practices reduce stormwater impacts from municipal properties, they also set an excellent example for residents and can be used as a public education tool.

Other actions that will address nutrient loading include Actions 3, 4, 5, 6, 7, 10, 11.

1-C: Reduce siltation from construction sites and road crossings.

Action 20: Implement soil erosion and sedimentation control (SESC) ordinances or standards. Within the Upper Clinton Subwatershed, statewide soil erosion and sedimentation control (SESC) regulations are managed primarily by county agencies. All SESC plans must meet state requirements. Communities may also consider adopting and overseeing a local SESC ordinance or standards, which must be approved by the Michigan Department of Environmental Quality Water Division. In addition, requiring SESC permits prior to allowing any construction work on a site will help to minimize soil erosion and sedimentation. Soil erosion and sedimentation control plans should also include stabilization measures for construction activities. These plans should show preservation of trees and vegetation along wetlands and streams. Clearing and grading schedules shoul be identified early in the review and permitting process should be staged to minimize the amount of exposed earth at any time.

Once mass grading of a site is complete, stabilization of areas should occur as soon as practicable. For example, detention basins should be stabilized once the outlet pipes are installed to minimize sediment from escaping the basins. Road right-of-ways within residential areas can also be stabilized as soon as the roads are complete. Areas where rear yard drainage systems are present should also be stabilized. These measures will minimize

the amount of sediment runoff from individual lots before the building process begins.

Action 21: Implement soil erosion and sedimentation control education programs. Although many communities do not currently have jurisdiction over soil erosion and sedimentation control, improving municipal staff's understanding of soil erosion impacts will have a positive impact on the overall site plan review process. Staff from local planning and engineering departments, or their consultants, will be able to identify opportunities for minimizing soil erosion and sedimentation impacts during site plan review. Many videos and other education materials are available about SESC.

Action 22: Improve soil erosion inspection and enforcement practices. County agencies, in most cases, are the jurisdiction responsible for SESC inspection and enforcement in the Upper Clinton Subwatershed. These agencies are often understaffed for this purpose, especially given the rate of construction and development in many communities. Municipalities concerned about the need for more frequent and reliable inspection and enforcement should work with the counties to stress the importance of inspection and enforcement and explore opportunities to improve these services.

Action 23: Improve maintenance of unpaved roads, particularly at road-stream crossings. Many roads within the Upper Clinton Subwatershed are under the jurisdiction of the county road commission. Because many roads in the subwatershed are unpaved, it is important that the local communities and county work cooperatively to implement road maintenance techniques that reduce soil erosion and sedimentation impacts on the water resources. Opportunities that may be evaluated include quickly vegetating roadside ditches to slow and filter stormwater runoff, removing accumulated sediment from roadside ditches, and only re-grading ditches during dry weather.

Action 24: Develop or modify private road ordinances or standards to incorporate impervious surface minimization techniques. Roads are a significant contributor to sediment loading. A private road ordinance can allow small developments to construct narrower roadways with less clearing, grading, and impervious surface than public roads. The layout of the development can also often be altered during site plan review to reduce the amount of impervious surface.

Action 25: Cooperate with the County, other Clinton watershed groups, or agencies on stream bank stabilization projects. In some cases, stream bank erosion can be a direct source of sedimentation within streams. However, stream bank erosion is often related to peak storm flows. Therefore, it is important to address stream flows upstream of any site to be stabilized if the projects are to succeed over the long term. Conducting a geomorphology study in advance of stabilization work will assist in understanding the stream's flow dynamics and identifying the highest priority sites.

Natural channels exist in two or more stages. Restoration to existing channels should explore the opportunity to return the channel to a two-stage cross section. This will help reduce the shear flows at bank-full conditions that lead to high shear stresses and erosion. Stream bank stabilization measures work by either reducing the force of flowing water and/or by increasing the resistance of the bank to erosion. Vegetating stream banks also provides important ecological benefits such as shading water and providing crucial habitat for both terrestrial and aquatic wildlife species.

Three basic types of stream bank stabilization methods exist: engineered structures, bioengineering methods, and biotechnical methods. Engineered structures include riprap, gabions, deflectors and other "hard" revetments. Bioengineering refers to the use of live plant materials that are embedded in the ground, where they serve as soil reinforcement, hydraulic drains, and barriers to earth movement. 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. Whenever possible, bioengineered or biotechnical methods should be implemented in lieu of engineered methods to increase habitat, nutrient uptake, and aesthetic values.

The Upper Clinton subwatershed communities may cooperate with the County, other Clinton River watershed groups, or other agencies that are interested in working together to identify or address stream bank problems. Level of participation will

depend on each community's financial and staffing resources available at the time.

Other actions that will address soil erosion and sedimentation control include Actions 3, 4, 5, 6, 9, 11, 18

1-D: Promote and implement pollution prevention programs.

Action 4: Promote and participate in the watershed education and outreach activities of local organizations as outlined in community Public Education Plans. (Described above.)

Long Term Goal 2: Reduce flow variability.

Objectives:

2-A: Minimize the increase in impervious surfaces and mitigate the amount of existing impervious surface.

Action 26: Create and adopt local Impervious Surface Minimization/Mitigation provisions. Because the Upper Clinton subwatershed is still developing, some of the communities have an opportunity to minimize the amount of impervious surface in new developments. These standards can also be applied to re-development in more urbanized areas as well. Reducing impervious surfaces can be accomplished through site plan review standards, ordinances, or Engineering standards and guidelines. Some examples include flexibility in parking regulations, requiring landscaped/infiltration islands in parking areas, private road standards that allow narrower pavement and right-of-way widths than County road standards, and cluster or open space development provisions that minimize setbacks and increase open space for stormwater infiltration.

Other actions that will address impervious surfaces include Actions 15 and 16.

2-B: Restore and protect riparian vegetation.

Action 27: Create and adopt local regulations requiring a buffer along riparian corridors. Development and re-development sites that are adjacent to streams, lakes, or wetlands can preserve or improve the water quality of these natural resources by either maintaining the natural buffer that currently exists, or re-creating a buffer for areas that had been previously cleared. This can be done through provisions in the Zoning

Ordinance or in existing Engineering Standards. Existing riparian land owners can also be educated about the benefits of riparian vegetation for water quality, wildlife habitat, and soil erosion control, and encouraged to re-vegetate their properties to receive these benefits.

Other actions that will address protection of riparian vegetation include Actions 3, 4, 5, 6, 12, 13, 15, 17, 23, 25.

2-C: Reduce the amount of stormwater runoff to predevelopment patterns and levels to stabilize stream flow.

Action 28: Develop and implement local stormwater management document(s), including stormwater management ordinances or standards, and/or maintenance programs. Comprehensive stormwater management documents address development, implementation, and enforcement of controls to protect designated uses in all receiving waters. They include the development of ordinances or other regulatory measures to address post-construction stormwater runoff from new development and re-development projects.

Stormwater management ordinances or standards outline specific requirements for constructing structural BMPs to minimize the flow and water quality impacts associated with new development. An example of a specific requirement is to modify parking ordinance standards to minimize impervious surfaces. Parking lots contribute a significant amount of impervious surface in commercial areas. As the Upper Clinton Subwatershed continues to develop, it will become important to analyze parking standards and identify opportunities to reduce parking lot size and allow for "banked" parking to reserve space for future parking if needed.

Implementation of stormwater standards is often complicated by overlapping jurisdictions and conflicting goals and priorities. Where there are overlapping jurisdictions within individual communities, especially between townships, it is imperative that municipalities work cooperatively to understand the unique issues specific to each. This will ensure successful implementation of stormwater management ordinances and standards.

Other actions that will address predevelopment stormwater runoff patterns and levels to stabilize stream flow include Actions 8, 9, 15, 16, 17.

Long Term Goal 3: Improve local regulations regarding protection of natural areas and water resources.

Objectives:

3-A: Develop natural feature inventories and/or assessments to create plans for preservation and/or restoration of natural features.

Action 29: Inventory natural features (e.g. wetlands, floodplains, steep slopes, woodlands, unique ecosystems, etc.) and develop Natural Areas Resource Protection Plans. The first step in protecting a community's natural resources is identifying what resources a community has, where they are located, what benefits they provide the community, and which resources should be protected. After an inventory, it is often helpful to design an assessment of these natural features so that they can be prioritized in terms of their importance to the community and their relative need for preservation.

Communities should also consider developing a Natural Area Resource Protection Plan that identifies natural feature areas, including wetlands, woodlands and riparian corridors, within their jurisdictional boundaries and also describes each features' unique functions and opportunities for preservation, enhancement, and restoration. This type of plan will identify areas unique for high-quality stormwater management, habitat enhancement, water quality enhancement, aesthetics, and recreational opportunities. It is often not feasible to protect all of the natural features in a community; however, an inventory and assessment can provide scientific rationale to support a location protection ordinance and/or the basis for avoiding the feature during site design and development. Community-wide inventories and assessments can also provide future opportunities to preserve greenways for wildlife as well as recreation. This plan can easily complement land use, water resource, and stormwater management ordinances.

3-B: Develop goals and policies in the Master Plan regarding natural feature protection and management.

Action 30: Update community Master Plans to enhance natural feature preservation and create a basis for environmental protection ordinances.

3-C: Develop ordinances for managing natural features to benefit stormwater quality and quantity.

Action 31: Develop water resource and natural feature protection standards, ordinances and/or programs. Protecting existing natural features such as wetlands, woodlands and riparian corridors in the subwatershed is a key goal, especially in less developed communities. These guidance documents can create opportunities to minimize impacts associated with new developments as well as identify opportunities for preservation and enhancement. These documents can also help guide re-development of an area with existing natural features.

Action 32: Cooperate with the County, other Clinton River watershed groups, or agencies to identify, prioritize, and implement projects to construct, restore, and enhance wetlands. In addition to preserving existing wetlands through the practices outlined above, there could be opportunities to restore and enhance wetlands in the Upper Clinton Subwatershed. Constructed wetlands, as an alternative to detention basins, could also serve as excellent stormwater treatment facilities and improve wetland functions within the subwatershed.

Working with the County, other watershed groups, or other agencies, the Upper Clinton subwatershed group may cooperate on projects that would enhance the wetland resources within the subwatershed. Level of participation will depend on each community's financial and staffing resources available at the time.

Long Term Goal 4: Increase public understanding of their role in protecting water quality.

Objectives:

4-A: Develop and/or promote existing public involvement programs (workshops, events, etc.) to improve the public's understanding of their role in protecting water quality.

Actions to promote existing public involvement programs include Actions 3, 4, 5, 6.

4-B: Develop and/or continue information and education programs (brochures, newsletter articles, etc.) to disseminate water quality messages to the public.

Actions to develop/continue public education and information programs to the public include Actions 3, 4, 5, 6.

Long Term Goal 5: Protect and restore quality aquatic and riparian habitats.

Objectives:

5-A: Develop a habitat protection and/or restoration plan.

Action 33: Cooperate with the County, other Clinton River watershed groups, and agencies to identify, prioritize, and implement projects to restore and enhance instream habitat. 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, wedge and "K" dams. The majority of these structures can be installed with hand labor and tools. After construction, a maintenance program should be implemented to ensure long-term success of the habitat structure.

The Upper Clinton Subwatershed communities may cooperate with the County, other Clinton River watershed groups, or agencies on projects that will improve instream habitat within the Upper Clinton subwatershed. Level of participation will depend on each community's financial and staffing resources available at the time.

5-B: Reduce siltation from construction sites and road crossings.

Actions that will reduce siltation from construction sites and road crossings include 3, 4, 5, 6, 8, 10, 11, 18, 20 - 25.

5-C: Restore and protect riparian vegetation.

Actions that will address protection of riparian vegetation include Actions 3, 4, 5, 6, 12, 15 - 17, 23, 25, 27. (Note that "restoration" activities include land-owner education activities.)

5-D: Develop natural feature inventories and/or assessments to create plans for preservation and/or restoration of natural features.

Action 29: Inventory natural features (e.g. wetlands, floodplains, steep slopes, woodlands, unique ecosystems, etc.) and develop Natural Areas Resource Protection Plans. (Described above.)

5-E: Develop goals and policies in the Master Plan regarding natural feature protection and management.

Action 30: Update community Master Plans to enhance natural feature preservation and basis for environmental protection ordinances. (Described above.)

5-F: Develop ordinances for managing natural features to benefit stormwater quality and quantity.

Actions that create ordinances to manage natural features to benefit stormwater quality and quantity include Action 31 and 32.

Long Term Goal 6: Increase opportunities for passive and active recreational uses while at the same time protect water resources.

Objectives:

6-A: Identify key areas to protect and restore, and plan for recreational and interpretive opportunities adjacent to lake shores and riparian corridors.

Action 34: Develop water resource recreational plans or update current recreation plans with emphasis on appropriate water-based recreational opportunities. To help residents appreciate and value water resources, it is important to allow them to enjoy lakes and streams through recreational activities. However, these activities can be harmful to the resource unless proper care is taken to develop recreational programs with stewardship in mind. Therefore, recreation plans should be developed to provide access points for water-based recreational activities at lakes and streams that can tolerate such activities without being degraded. Particularly sensitive or rare water resources should be preserved for passive activities, such as viewing from a trail or wildlife/bird watching. Also, development of facilities for these activities should also be constructed to minimize impact on the resource.

6-B: Develop recreation plans for key natural areas that are consistent with this Watershed Management Plan.

Action 35: Update current Recreation Master Plans to include individual park plans that outline goals and strategies for protecting and managing key natural areas.

Other actions that will assist in creating recreation plans for key environmental areas include Action 29.

CHAPTER 7
WATERSHED ACTION MATRIX

7.0 Introduction

The Upper Clinton Subwatershed is made up of communities in different stages of development. Some parts of the subwatershed are relatively undeveloped, while other parts are substantially developed. This is the reason why the Best Management Practices chosen for this plan span a range of physical and managerial actions. Some of these actions are already being used by various communities, while others are in the planning stages. Some activities are not appropriate for specific communities, and will only be used by some of the watershed partners. The matrix lists all the actions previously described in Chapter 6, and shows how these actions will help meet the Plan's goals by relating them to the subwatershed's current condition. The matrix includes the following information:

1) **Recommended Action:** This lists the structural and managerial BMPs that are described in detail in the previous chapter.

2) **Goals & Objectives Addressed:** This column shows how the action will address the goals and objectives of the Subwatershed Plan.

3) **Pollutants Addressed:** The information in this column lists the pollutants that will be addressed by the recommended action.

4) **Sources and Causes Addressed:** These two columns describe the pollutant sources and causes that the action will address.

5) **Uses Addressed:** This lists the designated and desired uses that will be addressed by implementation of the action.

6) **Estimated Cost:** This provides a rough estimate of costs for implementing the action. This information is provided solely to give communities an idea of the potential costs of an action. They will not be used as a requirement to track costs for reporting purposes to MDEQ.

7) **Evaluation Methods:** This column describes different methods that could be used to evaluate the success of implementing the action.

Note that each subwatershed community outlines the time frame for the actions they have committed to in Table 7.2.

7.1 Evaluation Methods for Measuring Success

To ensure that the planned activities are meeting the goals of this Subwatershed Plan, methods need to be employed that can measure the relative success of each activity. The evaluation step is an important part of any watershed planning effort in that it provides feedback on the success (or not) of an activity. It also provides communities with important information about how to conduct future efforts, or how to change the approach to a specific problem to be more successful the next time. If activities are successful, this will gain more support for future activities amongst decision makers.

Qualitative and Quantitative Evaluation Techniques

Evaluation methods generally fall under two categories: qualitative and quantitative methods. The Action Matrix includes both types of evaluation techniques, based on the BMP or activity. Qualitative methods measure whether or not people have learned new facts, changed their attitudes, or changed their behaviors about their own or others' impact on water quality. Examples of these methods include pre- and post-event surveys and tracking the number of complaints received for illegal dumping or other harmful behaviors. Tracking participation in events is another qualitative method that includes tracking the number of events, number of participants, and amount of materials distributed. While these measurements are usually applied to the general public, land use decision-makers can also follow the same path to understanding the impacts of human activities on water quality. Measurements for this specific group include the number of inventories conducted (of both natural and human-made features), development and adoption of planning documents or ordinances, standards and/or guidelines, and development and implementation of land management programs.

In contrast, quantitative methods show how certain water quality parameters have changed over time, and are often the result of a physical change within the subwatershed. Examples of quantitative methods include water quality monitoring results, the number of complaints or problems (such as failing septic systems) addressed, and the outcome of stewardship projects, such as the amount of trash collected or the length of stream bank replanted or restored.

Recommended Action	Goals & Objectives Addressed	Pollutants Addressed	Sources Addressed	Causes Addressed	Uses Addressed	Estimated Cost	Evaluation Methods & Status
1. Implement waterfowl and pet waste management programs.	1-A	Bacteria	Waterfowl	Removal of vegetation	Fishery, aquatic life & wildlife, recreation	Brochure printing: $0.25 - $1 each. Riparian buffer plantings/restoration: $350/ac. Park/common area signage additional. *Source: Adapted from Middle One Rouge River Subwatershed Management Plan and the Mill Creek Subwatershed Management Plan.*	Number of individuals reached / personal observation; quantity of materials distributed; amount of buffer area planted/restored; pre-post event survey results; monitoring results.
2. Support County inspections and/or enforcement of Health Department regulations regarding on-site seweage disposal systems.	1-A	Bacteria	Failing and/or poorly maintained septic systems.	Improper septic construction/ maintenance	Fishery, aquatic life & wildlife, recreation	Costs vary depending on level of support and/or enforcement activities.	Number of OSDS cases addressed.
3. Promote and participate in existing annual watershed education and outreach events, such as River Day and the Clinton Clean-Up.	1-A, 1-B, 1-C, 2-B, 4-A, 4-B, 5-B, 5-C	All	All	All	All	Costs vary depending on the type of activity; material donations can often be obtained from local businesses for special events.	Number of events; number of participants; oucome of stewardship project (e.g. amount of trash collected, miles of stream cleaned.)
4. Promote and/or participate in the watershed education and outreach activities of local organizations as outlined in community Public Education Plans.	1-A, 1-B, 1-C, 1-D, 2-B, 4-A, 4-B, 5-B, 5-C	All	All	All	All	Costs vary depending on the type of activity.	Number of events; number of participants for workshops; pre-post surveys can be used to evaluate learning.
5. Promote and participate in the Clinton River Watershed Council's stormwater education program, as outlined in community Public Education Plans.	1-A, 1-B, 1-C, 1-D, 2-B, 4-A, 4-B, 5-B, 5-C	All	All	All	All	$10,000 - $11,000 per year for entire watershed; cost for each community is based on land area and population size. Additional in-kind services to be provided by the communities, such as newsletters, cable TV coverage, etc. *Source: CRWC.*	Number of events; number of participants; pre-post event survey results; monitoring results.
6. Promote, encourage, and/or participate in educational opportunities for land use decision-makers offered by the organizations listed in Action 4.	1-A, 1-B, 1-C, 2-B, 4-A, 4-B, 5-B, 5-C	All	All	All	All	Varies by activity. Costs may be offset by attendance fees.	Number of activities; number of participants; pre-post event survey results.
7. Develop comprehensive sanitary sewer infrastructure plans and/or maintenance programs.	1-A, 1-B	Bacteria	Failing and/or poorly maintained septic systems, illicit connections, CSO, SSO	Improper septic construction/ maintenance, CSOs, inadequate sanitary capacity.	Fishery, aquatic life & wildlife, recreation, drinking water	Review other local plans, draft and finalize plan, public meeting, council/board adoption. 80-120 hours to develop @ $100 - 150/hr. (consultant); 10 - 20 hours for legal review @ $200/hr. $500/public meeting. Costs are per community. *Source: Adapted from Anchor Bay Watershed Plan and Middle One Rouge River Subwatershed Management Plan.*	Community initiates development of the plan, creates a final draft through a series of input meetings, and adopts it.
8. Establish maintenance programs for stormwater management facilities.	1-A, 2-C, 5-B	All	CSO, SSO, stormwater runoff, flashy flows	CSO, inadequate sanitary capacity, poor stormwater management practices	All	Research and develop maintenance program. 80 hours to develop @ $100 - $150/hr. (consultant). 10 - 20 hours for legal review @ $200/hr. Costs are per community. *Source: Adapted from Anchor Bay Watershed Plan and Middle One Rouge River Subwatershed Management Plan.*	Community includes a section within the Stormwater Management Ordinance, Master Deed & Bylaws, or Engineering Standards that requires maintenance for stormwater management facilities both during construction and after the owner takes over long-term responsibility for the system; creates a final draft through a series of input meetings and adopts it.

Recommended Action	Goals & Objectives Addressed	Pollutants Addressed	Sources Addressed	Causes Addressed	Uses Addressed	Estimated Cost	Evaluation Methods & Status
9. Establish detention basin retrofit and enhancement programs in re-development projects.	1-A, 1-C, 2-C	Bacteria, hydrology, sediments	Waterfowl, stormwater runoff, flashy flows and stream bank erosion	Removal of vegetation, poor stormwater management practices, increased stormwater runoff	All	Varies based on project.	Number of re-development projects with improved stormwater systems.
10. Identify and eliminate illicit discharges.	1-A, 1-B	Bacteria	Illicit connections	Illicit connections	Fishery, aquatic life & wildlife, recreation	Approximately $1,000 per stream mile for investigation; correction varies dramatically depending upon nature of problem. Communities should coordinate efforts with County and/or may wish to contract with County. *Source: Stony Creek Subwatershed Management Plan.*	Community develops and implements an Illicit Discharge Elimination Plan.
11. Develop and implement a long-term monitoring strategy.	1-A, 1-B, 1-C, 5-B	All	All	All	All	Costs vary dramatically based on parameters tested. Physical & biological monitoring can be conducted by volunteers; chemical parameters can be tested by volunteers using low-cost kits. Bacteria monitoring should be conducted by the appropriate agency.	Tracking water quality monitoring activities and results.
12. Implement lawn care education programs for residents and businesses.	1-B, 2-B, 5-C	Bacteria, hydrology, phosphorus	Waterfowl, stormwater runoff, fertilizer use	Removal of vegetation, improper or excessive fertilizer application	All	Varies by type of education activity. Training: 40 - 80 hours at $100/hr. to prepare and coordinate workshop. Brochure printing: $0.25 - $1 each. *Source: Adapted from the Middle One Rouge River Subwatershed Management Plan.*	Number of activities; number of individuals reached; quantity of materials distributed; pre-post survey results; monitoring results.
13. Encourage golf course management programs that protect water quality.	1-B, 2-B	Phosphorus	Fertilizer use, stormwater runoff	Improper or excessive fertilizer application, removal of vegetation	All	Varies depending on activity (may include workshops, mailings, site visits, etc.)	Golf courses develop and implement management programs and/or activities.
14. Research and evaluate the effectiveness of a fertilizer ordinance.	1-B	Phosphorus	Fertilizer use	Improper or excessive fertilizer application	All	Research material, review ordinances, draft recommendations. 80-120 hours to develop @ $100 - $150/hr. (consultant). 10 - 20 hours for legal review @ $200/hr. $5,000 per year for coordination of program. Costs are per community. *Source: Adapted from Anchor Bay watershed Plan and MIddle One Rouge River Subwatershed Plan.*	Community to initiates research and determines effectiveness of fertilizer ordinance.

Recommended Action	Goals & Objectives Addressed	Pollutants Addressed	Sources Addressed	Causes Addressed	Uses Addressed	Estimated Cost	Evaluation Methods & Status
15. Review land use planning and management practices to promote Low Impact Development (LID).	1-B, 2-A, 2-B, 2-C, 5-C	All	Waterfowl, CSO, SSO, stormwater runoff, conveyance via road-side ditches, flashy flows and stream bank erosion	Removal of vegetation, CSO, inadequate sanitary capacity, increased impervious surface, poor stormwater management practices, inreased stormwater runoff	All	Research planning and management practices; review other local plans; draft and finalize recommendations. 80 - 120 hours @ $100 - $150/hr. (consultant). Costs are per community. *Source: Adapted from Anchor Bay watershed Plan and MIddle One Rouge River Subwatershed Plan.*	Community initiates development of regulations, guidelines or standards, creates a final draft through a series of input meetings, and adopts it.
16. Minimize directly connected impervious surfaces from new development through the implementation of Low Impact Development Plans.	1-B, 2-A, 2-C, 5-C	All	Waterfowl, stormwater runoff, conveyance via road-side ditches, flashy flows and stream bank erosion	Removal of vegetation, poor stormwater management practices, increased stormwater runoff	All	Review existing development regulations, guidelines, and standards; research other local plans; draft and finalize recommendations. 80 - 120 hours @ $100 - $150/hr. (consultant). Costs are per community. *Source: Adapted from Anchor Bay watershed Plan and MIddle One Rouge River Subwatershed Plan.*	Community initiates development of regulations, guidelines or standards, creates a final draft through a series of input meetings, and adopts it.
17. Develop and implement native vegetation guidelines.	1-B, 2-B, 2-C, 5-C	Hydrology, phosphorus, sediments	Stormwater runoff, fertilizer use, conveyance via road-side ditches, flashy flows and stream bank erosion	Removal of vegetation, poor stormwater management practices, improper or excessive fertilizer application, increased stormwater runoff	Fishery, aquatic life & wildlife, trails, education, aesthetics, function of water resources	Research and develop rules and/or technical guidelines for developers and property owners; draft and finalize recommendations. 80 - 120 hours @ $100 - $150/hr. (consultant). 10-20 hours @ $200/hr. for legal review. Costs are per community. *Source: Adapted from Anchor Bay watershed Plan and MIddle One Rouge River Subwatershed Plan.*	Community initiates development of regulations, guidelines or standards, creates a final draft through a series of input meetings, and adopts it.
18. Establish and/or support street sweeping programs.	1-B, 1-C, 5-B	Phosphorus, sediments	Fertilizer use, construction runoff	Improper or excessive fertilizer application, improper erosion and sedimentation controls	Fishery, aquatic life & wildlife, recreation, aesthetics	Approximately $100,000 per year based on a $55/hr. equipment cost, $30/hr. operator cost and operating an average of 150 days/year. Catch basin inserts cost $250-$1,000 each depending on size and type of filters; regular maintenance required. Costs are per community. *Source: Canton Community Public Works Department and CRWC.*	Community initiates development of street sweeping and/or catch basin cleaning program and implements it. Measure miles of streets sweeped and number of catch basins cleaned.

Recommended Action	Goals & Objectives Addressed	Pollutants Addressed	Sources Addressed	Causes Addressed	Uses Addressed	Estimated Cost	Evaluation Methods & Status
19. Educate municipal staff and/or contractors on "good housekeeping" practices, including proper fleet and service yard maintenance and landscaping activities.	1-B	All	All	All	All	Varies by activity. May include workshops, brochures, etc.	Number, type of programs, and materials distribututed. Documentation of changes in practices.
20. Implement soil erosion and sedimentation control (SESC) ordinances or standards.	1-C, 5-B	Phosphorus, sediments	Stormwater runoff, construction runoff	Poor stormwater management practices, improper erosion and sedimentation controls	Fishery, aquatic life & wildlife, aesthetics, function of water resources	Research and develop rules and/or standards; draft and finalize recommendations. 80 - 120 hours @ $100 - $150/hr. (consultant). 10-20 hours @ $200/hr. for legal review. Costs are per community. *Source: Adapted from Anchor Bay watershed Plan and MIddle One Rouge River Subwatershed Plan.*	Community initiates development of regulations, guidelines or standards, creates a final draft through a series of input meetings, and adopts it.
21. Implement soil erosion and sedimentation control education programs.	1-C, 5-B	Phosphorus, sediments	Stormwater runoff, construction runoff	Poor stormwater management practices, improper erosion and sedimentation controls	Fishery, aquatic life & wildlife, aesthetics, function of water resources	Varies by type of education activity. Training: 40 - 80 hours at $100/hr. to prepare and coordinate workshop. Brochure printing : $0.25 - $1 each. *Source: Adapted from the Middle One Rouge River Subwatershed Management Plan.*	Number of activities; number of individuals reached; quantity of materials distributed.
22. Improve soil erosion inspection and enforcement practices.	1-C, 5-B	Phosphorus, sediments	Stormwater runoff, construction runoff	Poor stormwater management practices, improper erosion and sedimentation controls	Fishery, aquatic life & wildlife, aesthetics, function of water resources	Increased staffing and enforcement would be approximately $45,000/yr. per insepctor. *Source: Community Average Cost for Entry Level Inspector/Engineer.*	Community/ County expands inspection and/or enforcement program. Track number of complaints/violations and enforcement actions.
23. Improve maintenance of unpaved roads, particularly at road-stream crossings.	1-C, 2-B, 5-B, 5-C	Sediments	Road-stream crossings, conveyance via road-side ditches	Poor road/bridge maintenance, removal of vegetation	Fishery, aquatic life & wildlife, afunction of water resources	Review practices and make recommendations. 80 - 120 hours @ $100 - $150/hr. (consultant). Costs could be shared by communities. *Source: MIddle One Rouge River Subwatershed Plan & Cost Estimating Guidelines Best Management Practices and Engineered Controls.*	Road commission reviews and revises maintenance practices. Sensitive areas are targeted for special treatment.
24. Develop or modify private road ordinances or standards to incorporate impervious surface minimization techniques.	1-C, 5-B	Hydrology, phosphorus	Stormwater runoff	Increased impervious surfaces, poor stormwater management practices	Fishery, aquatic life & wildlife, drinking water, function of water resources	Research and develop rules and/or standards; draft and finalize recommendations. 80 - 120 hours @ $100 - $150/hr. (consultant). 10-20 hours @ $200/hr. for legal review. Costs are per community. *Source: Adapted from Anchor Bay watershed Plan and MIddle One Rouge River Subwatershed Plan.*	Community initiates development of regulations, guidelines or standards, creates a final draft through a series of input meetings, and adopts it.

Recommended Action	Goals & Objectives Addressed	Pollutants Addressed	Sources Addressed	Causes Addressed	Uses Addressed	Estimated Cost	Evaluation Methods & Status
25. Cooperate with the County and other Clinton watershed groups and agencies on stream bank stabilization projects.	1-C, 2-B, 5-B, 5-C	Hydrology, sediments	Stormwater runoff, flashy flows and stream bank erosion	Increased impervious surfaces, poor stormwater management practices, increased stormwater runoff	Fishery, aquatic life & wildlife, trails, education, function of water resources	Survey streams @ $2,000/stream mile. Design/permit costs roughly 10 - 20% of construction costs. Bioengineering techniques range from $10 - $100 per lineal foot of stream. Labor/materials may be donated. Costs can be shared by communities. *Source: Middle One Rouge River Subwatershed Management Plan, ECT (Formerly Tilton & Associates, Inc.) and Cost Estimating Guidelines Best Management Practices and Engineered Controls.*	Geomorphology or other study is conducted to identify and prioritize sites; number of sites/length of stream bank stabilized; monitoring results.
26. Create and adopt local Impervious Surface Minimization/Mitigation provisions.	2-A	Hydrology, sediments	Stormwater runoff, flashy flows and stream bank erosion	Increased impervious surfaces, increased stormwater runoff	Fishery, aquatic life & wildlife, drinking water, function of water resources	Research and develop rules and/or standards; draft and finalize recommendations. 80 - 120 hours @ $100 - $150/hr. (consultant). 10-20 hours @ $200/hr. for legal review. Costs are per community. *Source: Adapted from Anchor Bay watershed Plan and MIddle One Rouge River Subwatershed Plan.*	Community initiates development of regulations, guidelines or standards, creates a final draft through a series of input meetings, and adopts it.
27. Create and adopt local regulations requiring a buffer along riparian corridors.	2-B, 5-C	Bacteria, hydrology, phosphorus	Waterfowl, stormwater runoff	Removal of vegetation	Fishery, aquatic life & wildlife, trails, function of water resources	Research and develop rules and/or standards; draft and finalize recommendations. 80 - 120 hours @ $100 - $150/hr. (consultant). 10-20 hours @ $200/hr. for legal review. Costs are per community. *Source: Adapted from Anchor Bay watershed Plan and MIddle One Rouge River Subwatershed Plan.*	Community initiates development of regulations, guidelines or standards, creates a final draft through a series of input meetings, and adopts it.
28. Develop and implement local stormwater management document(s), including stormwater management ordinances or standards, and/or maintenance programs.	2-C	Hydrology, phosphorus	Stormwater runoff	Poor stormwater management practices	Fishery, aquatic life & wildlife, recreation, drinking water, function of water resources	Research and develop rules and/or standards; draft and finalize recommendations. 80-120 hours to develop @ $100 - $150/hr. (consultant); 10-20 hours for legal review @ $200/hr. Costs are per community. *Source: Adapted from Anchor Bay Watershed Plan and Middle One Rouge River Subwatershed Management Plan*	Community initiates development of regulations, guidelines or standards, creates a final draft through a series of input meetings, and adopts it.
29. Inventory natural features (e.g. wetlands, floodplains, steep slopes, woodlands, unique ecosystems, etc.) and develop Natural Areas Resource Protection Plans.	3-A, 5-D, 6-B	Hydrology, phosphorus, sediments	Stormwater runoff, flashy flows and stream bank erosion	Removal of vegetation, increased stormwater runoff	All	Research existing GIS data coverages; general ground-truthing of features and qualities assessment; create GIS database of high-, medium-, and low-quality priorities Cost estimates: $5,000 - $10,000 for data gathering; $5,000 - $20,000/acre for field inspections. Costs for individual communities can be reduced if Michigan Natural Features Inventory (MNFI) information is used. *Source: Anchor Bay Watershed Plan.*	Community initiates inventory/assessments, creates a final draft, and adopts it.

Recommended Action	Goals & Objectives Addressed	Pollutants Addressed	Sources Addressed	Causes Addressed	Uses Addressed	Estimated Cost	Evaluation Methods & Status
30. Update community Master Plans to enhance natural feature preservation and create a basis for environmental protection ordinances.	3-B, 5-A	Hydrology, phosphorus, sediments	Stormwater runoff, flashy flows and stream bank erosion	Removal of vegetation, increased stormwater runoff	All	Review local plans and policies, draft and finalize plan modifications, public meeting, council/board adoption. 80-120 hours to develop @ $100 - $150/hr. (consultant). 10-20 hours for legal review @ $200/hr. $500/public meeting. Costs are per community. *Source: Adapted from Anchor Bay Watershed Plan and Middle One Rouge River Subwatershed Management Plan.*	Communitity initiates updates to the plan, creates a final draft through a series of input meetings, and adopts it.
31. Develop water resource and natural feature protection standards, ordinances, and/or programs.	3-C, 5-F	Hydrology, phosphorus, sediments	Stormwater runoff, flashy flows and stream bank erosion	Removal of vegetation, increased stormwater runoff	All	Review local ordinance, standards and/or guidelines; draft and finalize language; public meeting, countil/board adoption. 80-120 hours to develop @ $100 - $150/hr. (consultant); 10-20 hours for legal review @ $200/hr. $500/public meeting. Costs are per community. *Source: Adapted from Anchor Bay Watershed Plan and Middle One Rouge River Subwatershed Management Plan.*	Community initiates development of the ordinance, standards, and/or guidelines; creates a final draft through a series of input meetings, and adopts it.
32. Cooperate with the County, other Clinton River watershed groups, or agencies to identify, prioritize, and implement projects to construct, restore, and enhance wetlands.	3-C, 5-F	Hydrology	Stormwater runoff	Poor stormwater management practices	Fishery, aquatic life & wildlife, education, aesthetics, function of water resources	Work with other groups to prioritize wetlands for construction/ restoration; 160-320 hours @ $150/hr. Costs to construct wetland vary by type, size, extent of hydrological restoration needed, and extent of plantings; estimated at $75,000/acre. *Source: ECT (Formerly Tilton & Associates, Inc.).*	Wetland restoration maps are completed; projects are prioritized and implemented. Measure: acres of wetlands constructed/restored.
33. Cooperate with the County, other Clinton River watershed groups, and agencies to identify, prioritize, and implement projects to restore and enhance instream habitat.	5-A	Hydrology	Stormwater runoff	Poor stormwater management practices	Fishery, aquatic life & wildlife, education, aesthetics, function of water resources	Work with other groups to prioritize projects for instream habitat enhancement; costs vary depending on type and size of project. *Source: ECT (Formerly Tilton & Associates, Inc.) and Middle One Rouge River Subwatershed Management Plan.*	Sites are identified and prioritized; number of sites/amount of stream habitat restored; monitoring results.

Recommended Action	Goals & Objectives Addressed	Pollutants Addressed	Sources Addressed	Causes Addressed	Uses Addressed	Estimated Cost	Evaluation Methods & Status
34. Develop water resource recreational plans or update current Recreation Master Plans with emphasis on appropriate water-based recreational opportunities.	6-A	Bacteria, phosphorus	Waterfowl, failing and poorly maintained septic systems, illicit connections, CSO, SSO, fertilizer use, stormwater runoff	Removal of vegetation, improper septic construction/ maintenance, illicit connections, CSO, inadequate sanitary capacity, improper or excessive fertilizer application, increased impervious surfaces, poor stormwater management practices	Fishery, aquatic life & wildlife, recreation, trails, education	Review local plans and policies, draft and finalize plan modifications, public meeting, council/board adoption. 80-120 hours to develop @ $100 - $150/hr. (consultant). 10-20 hours for legal review @ $200/hr. $500/public meeting. Costs are per community. *Source: Adapted from Anchor Bay Watershed Plan and Middle One Rouge River Subwatershed Management Plan.*	Communitity initiates updates to the plan, creates a final draft through a series of input meetings, and adopts it.
35. Update current Recreation Master Plans to include individual park plans that outline goals and strategies for protecting and managing key natural areas.	6-B	Bacteria, phosphorus	Waterfowl, failing and poorly maintained septic systems, illicit connections, CSO, SSO, fertilizer use, stormwater runoff	Removal of vegetation, improper septic construction/ maintenance, illicit connections, CSO, inadequate sanitary capacity, improper or excessive fertilizer application, increased impervious surfaces, poor stormwater management practices	Fishery, aquatic life & wildlife, recreation, trails, education	Review local plans and policies, draft and finalize plan modifications, public meeting, council/board adoption. 80-120 hours to develop @ $100 - $150/hr. (consultant). 10-20 hours for legal review @ $200/hr. $500/public meeting. Costs are per community. *Source: Adapted from Anchor Bay Watershed Plan and Middle One Rouge River Subwatershed Management Plan.*	Communitity initiates updates to the plan, creates a final draft through a series of input meetings, and adopts it.

Table 7.1

Community Timeframes for Watershed Plan Actions										
Actions	Auburn Hills	Brandon Twp.	Clarkston	Independence Twp.	Lake Angelus	Orion Twp.	Pontiac	Springfield Twp.	Waterford Twp.	White Lake Twp.
1. Implement waterfowl and pet waste management programs.	C	L	C	C	C	C	C	C	C	L
2. Support County inspections and/or enforcement of Health Department regulations regarding on-site sewerage disposal systems.	N/A	C	N/A	C	N/A		S	C		C
3. Promote and participate in existing annual watershed education and outreach events, such as River Day and the Clinton Clean-Up.	C	C	C	C	C	C	C	C	C	C
4. Promote and participate in the watershed education and outreach activities of local organizations as outlined in community Public Education Plans.	C	C	C	C	C	C	C	C	C	C
5. Promote and participate in the Clinton River Watershed Council's stormwater education program, as outlined in community Public Education Plans.	N/A	C	C	C	C	C	C	C	C	N/A
6. Promote, encourage, and participate in educational opportunities for land use decision-makers offered by the organizations listed in Action 4.	C	C	C	C	C	C	C	C	C	S
7. Develop comprehensive sanitary sewer infrastructure plans.	C	W	C	C	N/A	W	C	N/A	C	C
8. Establish maintenance programs for stormwater management facilities.	C	L	S	C	N/A	C	C	C	C	S
9. Establish detention basin retrofit and enhancement programs.	N/A	W	N/A	C	N/A	C	S	C	C	S
10. Identify and eliminate illicit discharges.	C	C	C	C	C	C	C	C	C	C
11. Develop and implement a long-term monitoring strategy.	N/A	W	C	C	C	C	C	C	C	L

Actions	Auburn Hills	Brandon Twp.	Clarkston	Independence Twp.	Lake Angelus	Orion Twp.	Pontiac	Springfield Twp.	Waterford Twp.	White Lake Twp.
12. Implement lawn care education programs for residents and businesses.	N/A	C	C	C	C	C	C	C	C	C
13. Encourage golf course management programs that protect water quality.	N/A	N/A	N/A	W	N/A	W	S	C	W	S
14. Research and evaluate effectiveness of fertilizer ordinance.	N/A	N/A	W	W	C	W	W	C	W	L
15. Review land use planning and management practices to promote Low Impact Development (LID).	N/A	C	N/A	C	N/A	C	W	C	C	L
16. Minimize directly connected impervious surfaces from new development through the implementation of Low Impact Development Plans.	N/A	S	N/A	C	N/A	C	W	C	S	L
17. Develop and implement native vegetation guidelines.	N/A	W	W	W	W	W	W	C	W	S
18. Establish and/or support street sweeping programs.	C	N/A	C	N/A	N/A	N/A	C	N/A	N/A	N/A
19. Educate municipal staff and/or contractors on "good housekeeping" practices, including proper fleet and service yard maintenance and landscaping activities.	C	C	S	S	C	S	C	S	S	S
20. Implement soil erosion and sedimentation control (SESC) ordinances or standards.	N/A	N/A	N/A	S	N/A	C	C	S	N/A	C
21. Implement soil erosion and sedimentation control education programs.	N/A	C	C	S	C	C	C	C	C	S
22. Improve soil erosion inspection and enforcement practices.	N/A	C	C	C	C	C	C	C	C	L
23. Improve maintenance of unpaved roads, particularly at road-stream crossings.	N/A	C	N/A	C	C	C	C	C	C	C

Actions	Auburn Hills	Brandon Twp.	Clarkston	Independence Twp.	Lake Angelus	Orion Twp.	Pontiac	Springfield Twp.	Waterford Twp.	White Lake Twp.
24. Develop or modify private road ordinances or standards to incorporate impervious surface minimization techniques.	N/A	C	N/A	S	W	C	W	C	C	S
25. Cooperate with the County and other Clinton watershed groups and agencies on stream bank stabilization projects.	N/A	W	W	W	N/A	W	C	N/A	W	S
26. Create and adopt local Impervious Surface Minimization/Mitigation provisions.	C	C	W	C	W	C	W	C	C	L
27. Create and adopt local regulations requiring a buffer along riparian corridors.	C	W	W	C	W	C	W	C	C	W
28. Develop and implement local stormwater management document(s), including stormwater management ordinances or standards, and/or maintenance programs.	N/A	C	S	C	W	C	S	C	C	S
29. Inventory natural features (e.g. wetlands, floodplains, steep slopes, woodlands, unique ecosystems, etc.) and develop Natural Areas Resource Protection Plans.	N/A	W	W	C	C	C	W	C	W	S
30. Update community Master Plans to enhance natural feature preservation and create a basis for environmental protection ordinances.	N/A	C	S	C	W	C	W	C	C	S
31. Develop water resource and natural feature protection standards, ordinances, and/or programs.	C	C	C	C	C	C	W	C	C	S
32. Cooperate with the County, other Clinton River watershed groups, or agencies to identify, prioritize, and implement projects to construct, restore, and enhance wetlands.	N/A	W	W	W	N/A	W	W	W	W	L
33. Cooperate with the County, other Clinton River watershed groups, and agencies to identify, prioritize, and implement projects to restore and enhance instream habitat.	N/A	W	W	W	N/A	W	W	W	W	W

Actions	Auburn Hills	Brandon Twp.	Clarkston	Independence Twp.	Lake Angelus	Orion Twp.	Pontiac	Springfield Twp.	Waterford Twp.	White Lake Twp.
34. Develop water resource recreational plans or update current Recreation Master Plans with emphasis on appropriate water-based recreational opportunities.	N/A	N/A	N/A	C	C	L	C	N/A	L	S
35. Update current Recreation Master Plans to include individual park plans that outline goals and strategies for protecting and managing key natural areas.	N/A	L	N/A	C	N/A	L	W	S	L	S

C= Currently planning/implementing
S= Will implement in the short-term (5 years or less)
L= Will implement in the long-term (More than 5 years)
W= On Wish List - Want to consider or do in the future
N/A = Not applicable to that community

CHAPTER 8
APPENDIX

8.0 February 1, 2005 Public Meeting Results by Group

Group #1

1. Education of residents regarding fertilizers, alternative landscape uses, and pesticides
2. Update local ordinances/planning tools to allow for preservation of natural areas to reduce stormwater problems
3. Change public attitudes of what is aesthetically pleasing
4. Education of developers
5. Locate old drains to determine where they go and how they may be contributing to the problem
6. Educate residents of effects of "household products" and proper disposal
7. Retro-fit existing developments to be stormwater friendly
8. Use existing natural areas/nature centers as focal points for education
9. Education of commercial fertilizing companies/distributors
10. Encourage organic gardening
11. Include stormwater management practices in master deeds of new developments
12. Develop a marketing scheme to educate consumers
13. Reduce the goose population
14. Monitor existing septic systems

Group #2

1. Long range plans for storm drains
2. Reduce waterfowl/seagull problems (hunting?, round ups are costly)
3. Promote use of less damaging fertilizers
4. Improved water management on/along roads
5. Protect river corridors in townships (100ft buffers, include wetlands)
6. Test septic systems
7. Strong ed component – public, developers, govt.
8. Impervious surfaces – creative ways to reduce, creative roadway design to reduce destruction (i.e. 66 ft. from road vs. protect trees; change County right-of-way clearing regulations; less right-of-way width esp. in subdivisions)
9. Not allowing permits that will result in significant erosion/water problems (i.e. house on steep hill with steep roads)
10. Promote alternative landscaping (natives, less grass)
11. Identify storm drain problems/locations & changes
12. Drain commission minimizes neg. impacts
13. Get money for projects (repairs, bmp's)
14. Improved golf course management
15. Ordinances require BMP's (retention/detention)
16. Require better topsoil on new developments

Group #3

1. Stormwater runoff (containment)
2. Consistent monitoring & testing of lakes & streams
3. Regional agency for lake boards for coordinated efforts
4. Review design standards in communities in watershed for consistency
5. Phosphorus (reduction on residential properties, public education, buffer zones for natural filters)
6. Monitoring wetlands condition & loss
7. Areas of concern (fuel tanks, old dumps, farm contamination)
8. Public education re: development limiting impervious surface

Group #4

1. Educate developers and municipal officials on sustainable stormwater management practices: BMP's
2. Increase lake area/riparian residents' awareness & involvement: geese, fertilizer, landscaping
3. Preserve/keep intact as many high quality wetlands as possible.
4. Educate residents on septic maintenance
5. Provide incentives to residents, developers, and others for good practices (landscaping awards, etc.
6. Promote economic benefits of good stormwater management practices and low impact developments.
7. Provide residents, developers etc. with specific alternatives to bad/current practices
8. Create interactive public demonstration site
9. Enact ordinances that protect water quality and natural resources
10. Create/host public awareness/involvement events (Creek fest, River day)
11. Have State/County show up
12. Develop Master Plan that recognizes and has goal of protecting water quality
13. Educate residents on proper use/disposal of household hazardous waste
14. Continued research on environmental impacts in subwatershed
15. Identify potential corridor linkages in subwatersheds
16. Initiate outreach/involvement programs targeted to young school-age children
17. Assure proper RV disposal practices, car washing practices
18. Identify "time bombs"
19. Clean water for human consumption and recreation
20. Protect enhance wildlife habitat

21. Protect human health

22. Educate/train landscapers on sustainable practices

23. Educate residents on sustainable landscaping practices (buffers, natives)

Group #5

1. Updated ordinances (Land Use Planning)
2. Fertilizer – reduced phosphorus (high phosphorus)
3. School projects (public awareness)
4. Engineered Topography (land use planning)
5. Maintain habitat (fishery)
6. Lake Associations (public awareness)
7. Birds, geese (high phosphorus)

Goal: Land Use Planning

1. Increase buffers
2. BMP's ($)
3. Cluster developments
4. Indigenous species
5. Mitigation
6. Decrease impervious areas

Goal: Fishery

1. Control pollutants
2. Address invasive species
3. Identify species
4. Identify species location
5. Water temp. control

Goal: Public Awareness

1. Work shops
2. Media coverage
3. Publish Data
4. Organizations

Goal: Recreational Access

1. Evaluate lake access
2. Lake reclamation
3. Remove pollutants
4. Geese control
5. Timely septic maintenance

Goal: High Phosphorus

1. Septic Maintenance

Group #6

1. Increase regulation of phosphorus
2. Promote use of native vegetation
3. Promote natural boundaries and buffers within developments
4. Increase youth education
5. Promote 'natural appearance' turf
6. Increase involvement of lawn care companies
7. Promote monitoring/enforcement of septic fields & self contained sewer systems.
8. Increase developer involvement
9. Encourage cluster developments/deter clear cut development
10. Enforce/strengthen zoning laws
11. Increase the public's understanding of their role in protecting streams & lakes.
12. Promote soil testing to assess needs
13. Pursue periodic/sale of residence testing of septic fields
14. Promote recycling of HazMat and awareness of recycling locations/times

8.1 Upper Clinton Subwatershed Existing and Potential Future Impervious Cover Analysis

Overview of Impervious Cover

Impervious Cover (IC) derives from human development and has a variety of damaging effects on streams. The Center for Watershed Protection has developed an "IC Model" (ICM) that can serve as a framework for watershed managers to use in evaluating the existing and potential future extent of stream degradation due to IC in the watershed.

What is Impervious Cover?

The following definition (Schueler, 1994) succinctly characterizes IC:

> *"Impervious Cover represents the imprint of land development on the landscape. It is composed of two primary components: the rooftops under which we live, work and shop, and the transport system (roads, driveways, and parking lots) that we use to get from one roof to another."*

How Does Impervious Cover Impact Stream Ecosystems?

A preponderance of evidence has shown that the amount of IC in a watershed has a direct influence on the integrity of the hydrology, physical structure, water quality, and biology of the streams and rivers in that watershed (Center for Watershed Protection, 2003). IC impacts stream ecosystems by increasing the volume of stormwater runoff discharged from the watershed to the stream. ***Hydrologic impacts*** including disruption of natural water balance, increased flood peaks**,** increased stormwater runoff**,** more frequent flooding, increased bank full flows, and lower dry weather flow. **Structural habitat impacts** include stream widening & erosion, reduced fish passage, degradation of habitat structure, decreased channel stability, loss of pool-riffle structure, fragmentation of riparian tree canopy, and decreased substrate quality. **Water quality impacts** include increased stream temperature, pollutants, and risk of beach closure.

The Impervious Cover Model (ICM)

The IC Model (ICM) creates a framework that classifies the quality of streams and rivers based on the percentage of IC in their watersheds (Schueler, 1994). The framework classifies streams as sensitive (0-11% IC), impacted (11-25% IC), and non-supporting (>25%) (Figure 1). Each of these classifications represents a gradient tending toward increasing levels of degradation as more IC is added to the watershed. Specific signs of degradation are offered for each IC category (
Table 1).

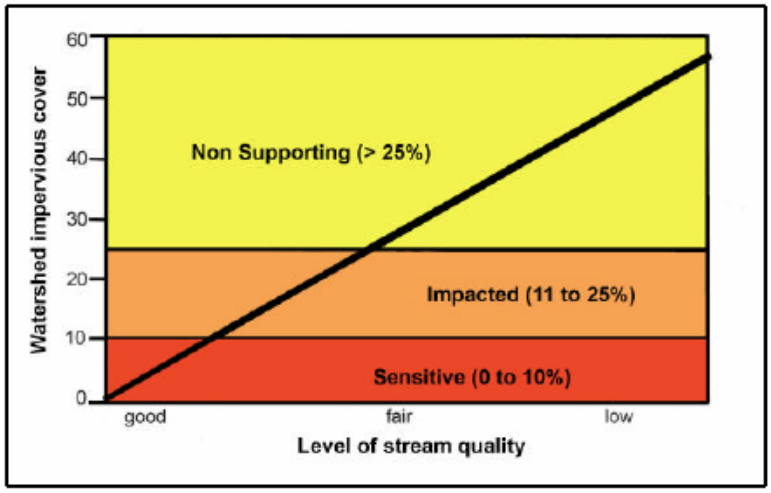


Figure 1. The IC Model (Schueler, 1994)

Table 1. Stream attributes according to the IC Model (Schueler, 1994)

Sensitive Stream	Impacted Stream	Non-Supporting Stream
0-10%	**11-25%**	**>25%**
High quality, stable flow regime	Signs of degradation, flow regime destabilizes	Low quality; stream is essentially a conduit for conveying stormwater
Stable channels are in stable equilibrium	Altered stream geometry	Severely eroded and incised stream channel
Excellent habitat structure	Degraded physical habitat in the stream	Structure needed to sustain fish is diminished or eliminated
Excellent water quality	Water quality degraded; contact recreation becomes an issue	Water contact recreation is no longer possible
Diverse communities of both fish and aquatic insects	Many sensitive fish and aquatic insects disappearing from the stream	Stream cannot support any but the most tolerant of life forms
Do not experience frequent flooding	Flooding becomes a more serious problem	Flooding becomes a serious problem requiring drastic engineering solutions

Tasks of Analysis

This analysis was conducted as a part of the development of a subwatershed management plan for the Upper Clinton, a tributary to the Clinton River in Oakland County. The purpose of the analysis was to evaluate the existing and potential future IC in the subwatershed in order to understand existing conditions and potential future conditions as a basis for goal-setting.

Four tasks were undertaken:

1. Delineate catchments within the Upper Clinton Subwatershed.

2. Estimate IC for the watershed using year 2000 Color-Infrared photography.

3. Estimate potential future IC using community master plans.

4. Estimate the extent of potential reductions in IC that may be afforded by implementation of "Better Site Design" measures (Center for Watershed Protection, 1998).

Methods

Combinations of automated and manual GIS functions were used to delineate catchments and to develop the estimates of existing and future IC.

Catchment Delineation

In order to report IC conditions with a level of detail useful for watershed planning, a sub-drainage area delineation was undertaken using ESRI ArcHydro tools (Maidment, 2002) and a 20-foot resolution topography model. This delineation resulted in the identification of 22 sub-drainage areas, or catchments, within the Upper Clinton subwatershed (Figure 2). A detailed technical instruction of the methodology utilized to create the delineation is available on the CD-ROM accompanying the *Arc Hydro: GIS for Water Resources* manual.

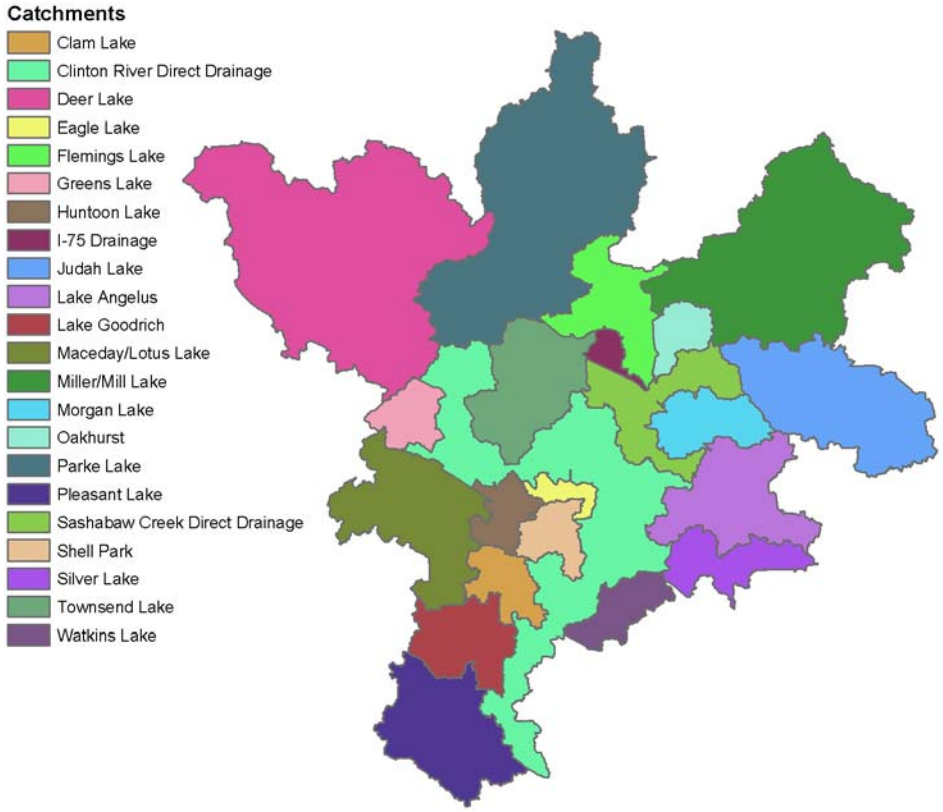


Figure 2. Catchments in the Upper Clinton Subwatershed

Existing Impervious Cover

Existing IC was estimated using a semi-automated analysis of 2000 color-infrared photography. An algorithm was developed using ERDAS software to classify the photography into 4 categories: vegetative cover, nonvegetative cover, wetlands, and water. Wetlands and water were derived directly from stereo-compiled Oakland County GIS coverages. In addition, buffered Oakland county road centerlines were used to "burn in" all roads. The nonvegetative class was then manually interpreted to segregate IC from bare soil. Bare soil classes consisted of development sites, cultivated lands, and gravel pits. IC areas

consisted of paved areas and rooftops. Gravel roads were included in the IC class. Pixel class summaries were generated for each catchment, and total acres of IC as well as percent of IC were generated.

Potential Future Impervious Cover

In order to generate estimates of IC percentages for Oakland County's parcel-based land use model, pixel summaries for each land use classification over the entire geographic area were calculated. These numbers were then used to calculate potential IC (Table 2).

Table 2. 2001 Oakland County land use classes and associated % IC values

Land Use Classification	Estimated % IC
Water	0
Agricultural	1.1
Vacant	2
Recreation and Conservation	2.9
Single Family, 10 acres or greater	3
Single Family, 5 to 9.9 acres	5.4
Single Family, 2.5 to 4.9 acres	7.9
Extractive	9.6
Transportation, Utility, and Communication	10.7
Single Family, 1 to 2.4 acres	12.5
Single Family, 14,000 to 43,559 sq. ft	23.6
Public/Institutional	28
Railroad ROW	30
Single Family Units w/ one parent parcel	31.8
Industrial	32.5
Single Family, 8,000 to 13,999 sq. ft.	35
Single Family, Less than 8,000 sq. ft.	41.6
Multiple Family	42.8
Mobile Home	46.1
Road ROW	47.8
Commercial/Office	52.2

Potential future land use was estimated by combining several datasets into one: Oakland County 2001 Land Use, Oakland County Composite Master Plan, and Oakland County Hydrography. Each polygon in this combined dataset contained the following attributes:

- Existing Land Use (based on 2001 land use)
- Future Land Use (the planned land use based on the most recent Community Master Plan)
- Area (in square feet)
- Buildable (a state denoting whether the land represented by the polygon can be built on

The "Buildable" field contained the following possible values:

1. **Buildable** – A*reas that are not any of the below; developable areas*
2. **Water** – *Land area classified as water by the OC Hydrography*
3. **Wetland** – *Land area classified as "swamp/marsh" by the OC Hydrography*

4. **Committed Land Use** – *Land areas in a use other than Single Family or Vacant, Agricultural, or Extractive**
5. **Built-out** – *Single family parcels that are developed to their fullest potential***

* Land areas that were in any use other than single family or vacant were assumed to remain in that use.

** The "Built-out" areas were determined by manually selecting parcels by comparing the planned and existing parcel-size and by visually identifying parcels that almost certainly will not be split.

To estimate total potential future IC, the future additional IC acres and the year 2000 IC acres were totaled for each catchment and the watershed. Potential reductions in IC were estimated by using reduction factors. These factors can be achieved through the use of "Better Site Design" techniques (Better Site Design Handbook (1998). The following reduction factors were used (Huron River Watershed Council, 1999):

- Reduction of 20% for utilizing residential *open-space development* (attributed to reduced road length)
- Reduction of 14% for utilizing *road width reduction* in residential development
- Reduction of 20% for *reduced parking* in commercial and industrial development

Results

Year 2000 Land Cover

The total Subwatershed estimated IC for 2000 was 17%, which placed the Upper Clinton Creek Subwatershed within the "Impacted" category of the ICM. Individual catchment land cover estimates were also made (Table 3, Figure 5). Each catchment is denoted with it's classification in the ICM.

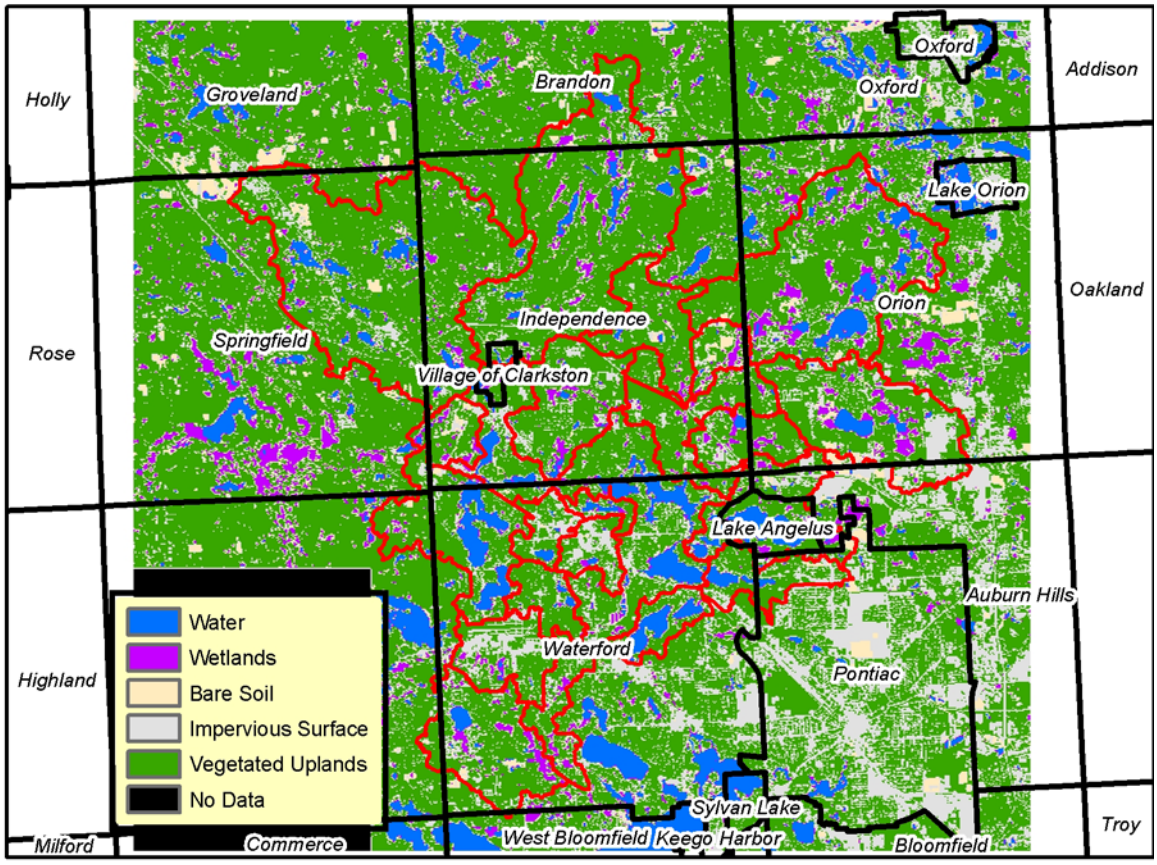
Table 3. Year 2000 Landcover Estimates for Upper Clinton Subwatershed Catchments

Catchment	% Impervious	% Vegetated Upland	% Wetland	% Surface Water	% Bare Soil
Oakhurst (Sensitive)	7	60	17	3	7
Miller/Mill Lake (Sensitive)	10	67	10	11	10
Parke Lake (Sensitive)	10	77	6	6	10
Deer Lake (Impacted)	11	77	3	6	11
Flemings Lake (Impacted)	11	81	3	3	11
Greens Lake (Impacted)	14	62	13	5	14
Morgan Lake (Impacted)	14	72	10	4	14
Maceday/Lotus Lake (Impacted)	15	62	2	21	15
Sashabaw Creek Direct Drainage (Impacted)	15	77	6	1	15
Lake Angelus (Impacted)	16	52	5	24	16
Pleasant Lake (Impacted)	17	67	10	5	17
Watkins Lake (Impacted)	18	43	1	38	18
I-75 Drainage (Impacted)	19	77	3	1	19
Townsend Lake (Impacted)	21	69	7	3	21
Clam Lake (Impacted)	24	70	1	5	24
Clinton River Direct Drainage (Impacted)	24	55	4	16	24
Judah Lake (Non-Supporting)	25	57	10	6	25
Silver Lake (Non-Supporting)	28	57	0	12	28
Eagle Lake (Non-Supporting)	29	51	3	17	29
Lake Goodrich (Non-Supporting)	38	55	5	2	38
Huntoon Lake (Non-Supporting)	41	51	0	6	41
Shell Park (Non-Supporting)	43	51	3	2	43

Catchment IC ranged from 7% to 43%. Of the 22 catchments, 3 were classified as "Sensitive", 13 as "Impacted", and 6 as "Non-Supporting". Impervious surfaces are largely concentrated along commercial corridors, including M-59, Dixie Highway, and Baldwin Road. Other areas with significant imperviousness include the I-75 corridor and residential lakefront areas (

Figure 3).

Figure 3. % Land Cover Year 2000 in the Upper Clinton Subwatershed



Potential Future Development

Based on the existing development status of land and community master plans, the location and type of potential future development was mapped and summarized for each catchment and for the entire subwatershed (Figure 4, Table 4, Table 5). The largest category of planned land use was single family residential, totaling 9,768 planned acres. Approximately 75% of this is large lot residential, between 1 and 5 acres. Significant quantities of land are planned for commercial/office (589 acres) and industrial (397 acres). A total of 485 acres are planned for recreation and conservation.

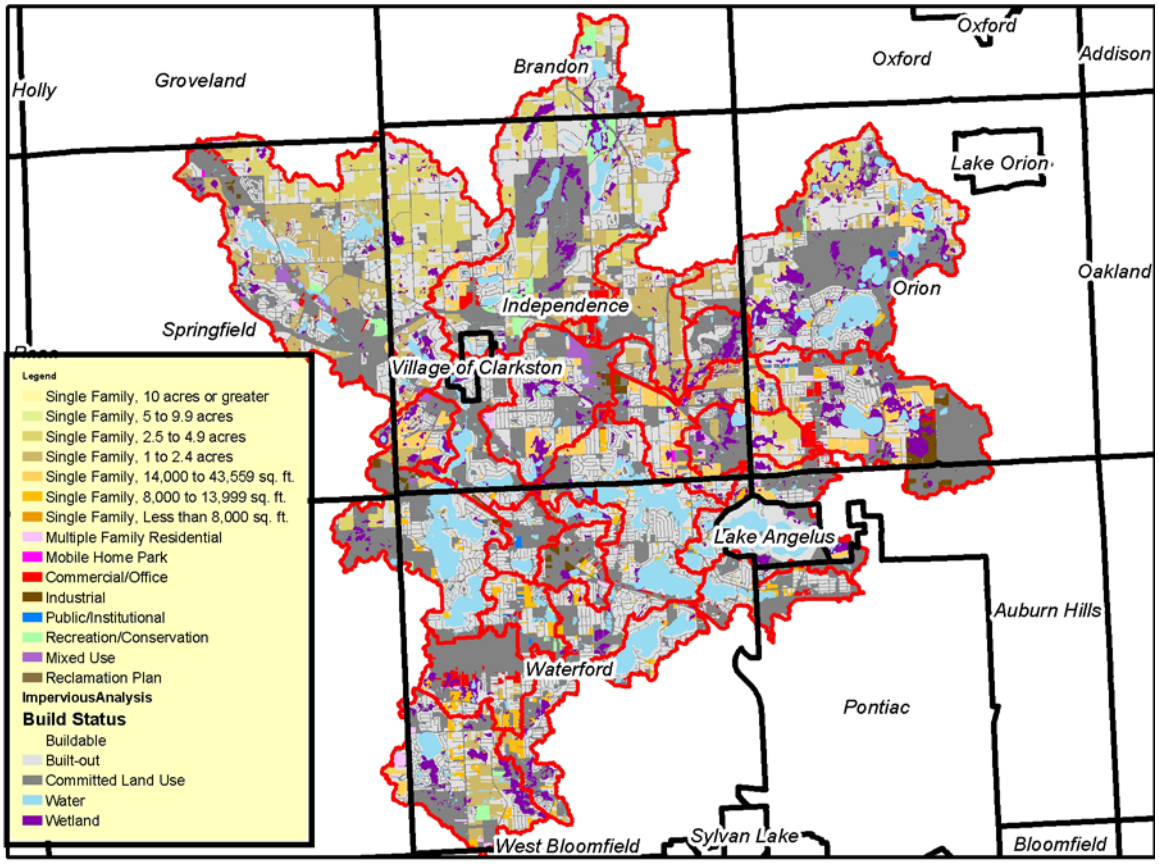


Figure 4. Development Status and Planned Future Land Uses n the Upper Clinton Subwatershed

Table 4. Planned Future Land Uses in the Upper Clinton Subwatershed

Planned Future Land Use	Acres	Category % of Developable Land
Single Family, 1 to 2.4 acres	4128	35.7%
Single Family, 2.5 to 4.9 acres	3239	28.0%
Single Family, 14,000 to 43,559 sq. ft	1480	12.8%
Single Family, 8,000 to 13,999 sq. ft.	911	7.9%
Commercial/Office	589	5.1%
Recreation and Conservation	485	4.2%
Industrial	397	3.4%
Multiple Family	239	2.1%
Public/Institutional	52	0.5%
Mobile Home	16	0.1%
Single Family, Less than 8,000 sq. ft.	14	0.1%
Grand Total	**11549**	
% Subwatershed Developed	**80%**	

Overall, the subwatershed is approximately 80% developed, with most of the undeveloped land in the northern portion of the subwatershed, in Springfield, Independence, and Orion Townships. The most highly developed areas are in Waterford Township, the City of Lake Angelus and the City of Pontiac. Catchments with significant amounts of undeveloped land (below 75% developed) include Deer Lake (63%), Flemings Lake (58%), Greens Lake (66%), Morgan Lake (70%), and Sashabaw Creek Direct Drainage (67%). The four most highly developed catchments include Watkins Lake (95%), Huntoon Lake (95%), Eagle Lake (93%) and Clinton River Direct Drainage (93%). Over half of the planned recreation /conservation land areas are in the Parke Lake catchment (253 acres).

Table 5. Planned Future Land Uses for Catchments of the Upper Clinton Subwatershed

CATCHMENT	ACRES	PLANNED COMMERCIAL (ACRES)	PLANNED INDUSTRIAL (ACRES)	PLANNED MOBILE HOME (ACRES)	PLANNED MULTIPLE FAMILY (ACRES)	PLANNED PUBLIC INSTITUTIONAL (ACRES)	PLANNED RECREATION (ACRES)	PLANNED SF- 8000 SQFT OR LESS (ACRES)	PLANNED SF- 8000-13999 SQ FT (ACRES)	PLANNED SF- 140000-43560 (ACRES)	PLANNED SF- 1-2.49 ACRES (ACRES)	PLANNED SF- 2.5-4.9 ACRES (ACRES)	% CATCHMENT DEVELOPED (BASED ON MASTER PLAN)
Clam Lake	843	15			2	10	25			83			84%
Clinton River Direct Drainage	6567	64	11		22		26	91		191	68		93%
Deer Lake	9317	72	15	4	48		68	66	1535	12	1593		63%
Eagle Lake	342	2								18	5		93%
Flemings Lake	1730	50					5	1	92		584		58%
Greens Lake	778							176			87		66%
Huntoon Lake	709	6	5		6	15				2			95%
I-75 Drainage	286				5			1			65		75%
Judah Lake	3682	95	189		7	9		256	61	59	47		80%
Lake Angelus	2439	21	9		28		7	84	22	40		8	91%
Lake Goodrich	1482	82			5					119	32		84%
Maceday/Lotus Lake	2974		62			5	17	26	96	55	23		90%
Miller/Mill Lake	6375	9				11	13	111	387	69	357		85%
Morgan Lake	1218	23			22			91	179	10	38		70%
Oakhurst	655								7		70		88%
Parke Lake	7634	106					253	129	824		611		75%
Pleasant Lake	2619	1			54		52	62		116	306		77%
Sashabaw Creek Direct Drainage	1785		39	12	2	1	9	216	36	43	223		67%
Shell Park	729	7	43		9		3			20			89%
Silver Lake	1197	19					1			49		6	94%
Townsend Lake	2325	6	22		28	1	5	170			21		89%
Watkins Lake	862	11	3		2					24			95%

Potential Future Impervious Cover & Impact of Better Site Design

The potential future IC was estimated using existing land use plans. Both conventional and "Better Site Design" scenarios were considered (Figure 6, Figure 7). The future IC of the Upper Clinton Subwatershed is projected to increase five percentage points from year 2000 estimates, from 17% to 23%, based on existing land use plans. Deer Lake catchment in Springfield and Independence Townships has the greatest potential to add IC acres within the watershed, potentially adding 2, 227 additional acres of IC under conventional development schemes and bringing the catchment area from 11% IC (at the "Sensitive" to "Impacted" threshold) to 24% IC (at the "Impacted" to "Non-supporting" threshold). Other large potential percent increases include Flemings Lake (increase of 8%), Townsend Lake (increase of 12%), and Greens Lake (increase of 13%).

Estimated potential reductions in IC using "Better Site Design" methods were substantial in Deer Lake (8%), Greens Lake (6%) and Townsend Lake (9%). Five catchments were classified "Non-supporting" in the year 2000. Future development is projected to increase this number to ten. "Better Site Design" measures may be able to prevent 2 catchments (Townsend Lake and Greens Lake) from progressing to the non-supporting category.

Eleven catchments are classified as "Impacted" in 2000. Future development is projected to increase this number to 21. "Better Site Design" measures will not prevent any of these catchments from moving into the "Impacted" category". Oakhurst catchment is the only catchment which will remain in the ""Sensitive" category under current development policy.

Table 6. Year 2000 and Potential Future IC Estimates of Communities in the Stony Creek Watershed

Catchment	Acres	Year 2000 Acres Imperviousness	Potential Additional Impervious Acres (Conventional Site Design)	Potential Additional Impervious Acres (Better Site Design)	% Impervious (2000)	% Future Impervious (Conventional)	% Future Impervious (Better Site Design)	BSD Savings
Clam Lake	843	202	251	242	24	30	29	1
Clinton River Direct Drainage	6567	1576	1749	1716	24	27	26	1
Deer Lake	9317	1025	2227	1453	11	24	16	8
Eagle Lake	342	99	109	107	29	32	31	1
Flemings Lake	1730	190	327	302	11	19	17	2
Greens Lake	778	109	209	166	14	27	21	6
Huntoon Lake	709	291	303	300	41	43	42	1
I-75 Drainage	286	54	68	65	19	24	23	1
Judah Lake	3682	921	1197	1111	25	33	30	3
Lake Angelus	2439	390	477	452	16	20	19	1
Lake Goodrich	1482	563	667	647	38	45	44	1
Maceday/Lotus Lake	2974	446	525	502	15	18	17	1
Miller/Mill Lake	6375	638	813	781	10	13	12	1
Morgan Lake	1218	171	250	235	14	20	19	1
Oakhurst	655	46	59	56	7	9	9	0
Parke Lake	7634	763	1056	1001	10	14	13	1
Pleasant Lake	2619	445	594	566	17	23	22	1
Sashabaw Creek Direct Drainage	1785	268	415	387	15	23	22	1
Shell Park	729	313	343	338	43	47	46	1
Silver Lake	1197	335	370	364	28	31	30	1
Townsend Lake	2325	488	759	552	21	33	24	9
Watkins Lake	862	155	173	170	18	20	20	0

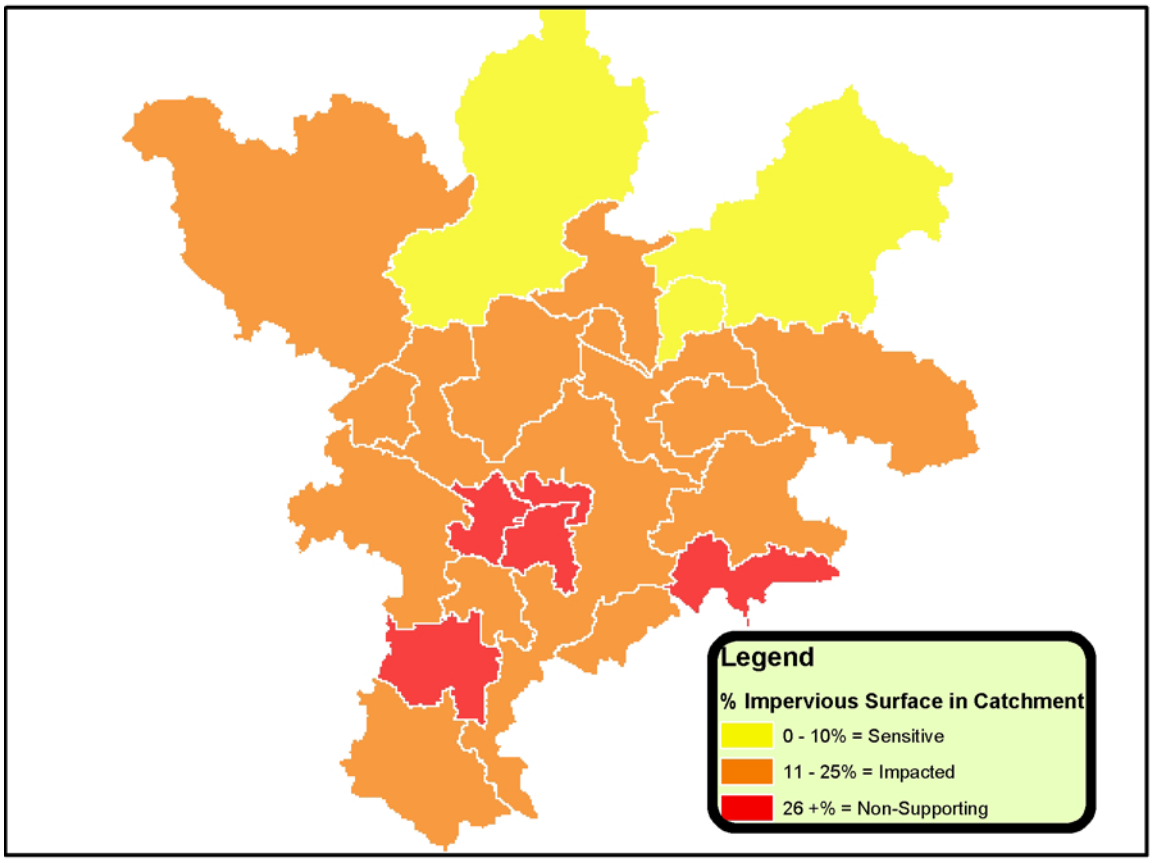


Figure 5. Year 2000 Impervious Surfaces in the Upper Clinton Subwatershed

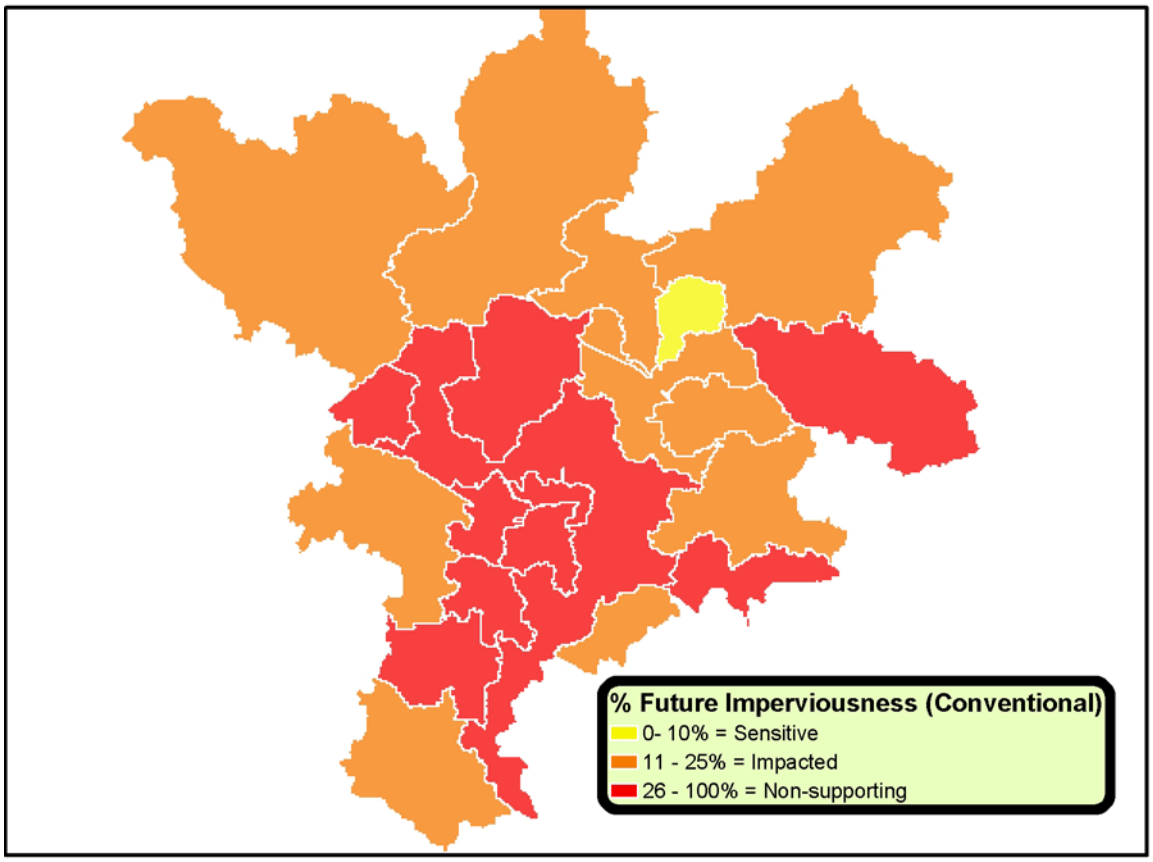


Figure 6. Future Impervious Surfaces in the Upper Clinton Subwatershed Utilizing Conventional Development

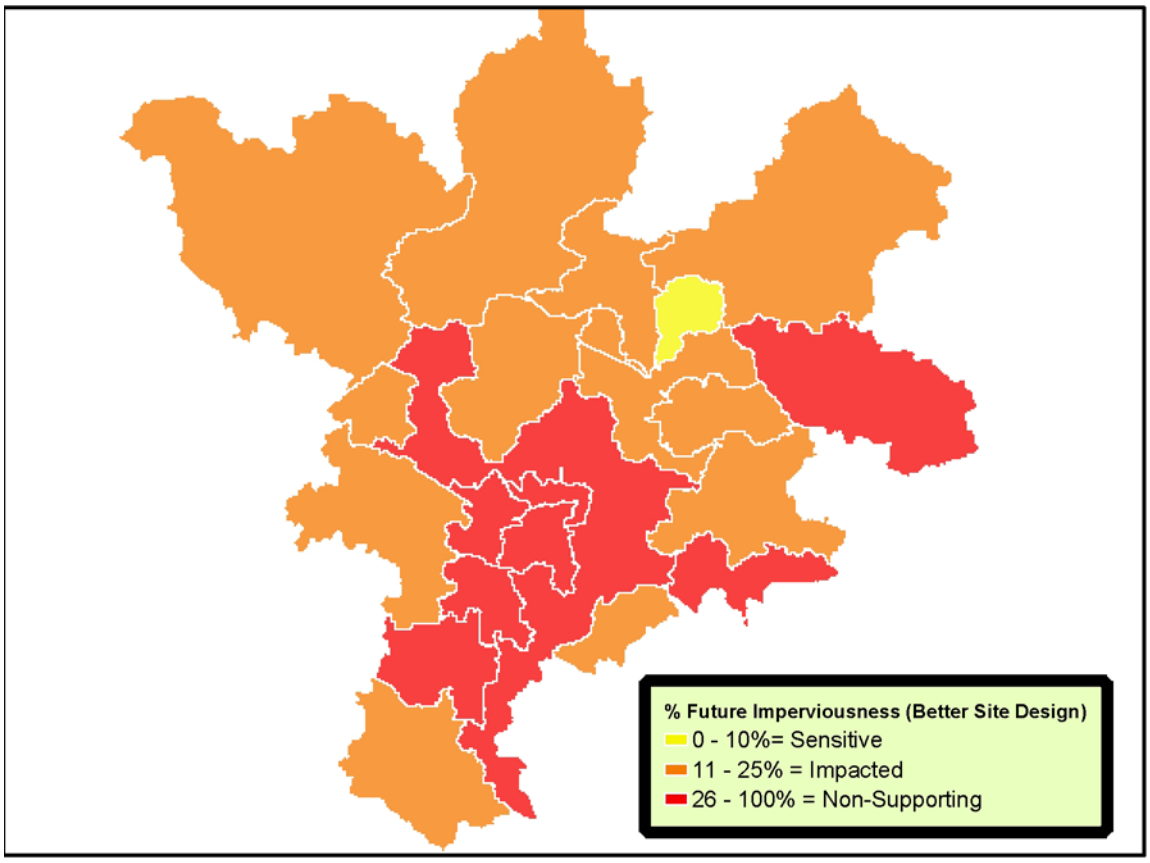


Figure 7. Future Impervious Surfaces in the Upper Clinton Subwatershed Utilizing Better Site Design

Potential Errors in the Analysis

The accuracy of the future IC estimates depends upon two factors; the accuracy of the IC estimates for each land class (discussed in the next section) and the accuracy of the methodology in estimating potential development areas.

Potential Development Methodology

Community master plan data was combined with wetlands and water features to remove "unbuildable" land areas. The remaining land was then evaluated to determine if the land was in a "committed use" using GIS data sources. Committed uses were generally parks and schools. Finally, the remaining land was evaluated to determine whether it was "built-out" to its fullest potential, thereby not likely to be developed. Any error in the databases or manual or automated processing could affect the outcome of the analysis. Redevelopment was not considered in the analysis.

Error in Estimating IC for Land Use Classes

Because the master plan data was parcel specific, IC estimates were generated for each land use classification by generating average pixel summaries of imperviousness for each parcel in Oakland County's parcel-specific 2001 land use data. The actual percentage of IC on any particular parcel within a land use classification may vary widely from the average value. This variation likely introduced error into the potential IC analysis; therefore the future imperviousness values represent average imperviousness conditions and should only b*e* used as a general guide for projecting future conditions. **This analysis does not purport to make a highly accurate forecast of future conditions, but rather provides an indication of future trends.**

Conclusions

Based on the results of the analysis, the following conclusions can be made:

1. Overall, the Upper Clinton Subwatershed is currently an "Impacted" stream system based on the ICM (17% IC).

2. Because of the uneven development pattern across the Subwatershed, some areas are "Sensitive" while others are "Impacted" or "Non-supporting".

3. Potential Future IC (around 20-23%) will result in increased IC but overall the subwatershed will remain in the "Impacted" category.

4. Five catchments are classified as "Non-supporting" in 2000. Future development is projected to increase this number to 10, based on existing land use plans. "Better Site Design" measures may be able to prevent 2 catchments (Townsend Lake and Greens Lake) from progressing to the non-supporting category.

5. Eleven catchments are classified as "Impacted" in 2000. Future development is projected to increase this number to twenty-one, based on existing land use plans. "Better Site Design" measures will not prevent any of these catchments from moving into the "Impacted Category". Oakhurst catchment is the only catchment which will remain in the ""Sensitive" category.

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8.3 Completed Community Planning Checklists