Sturgeon Creek Watershed Management Plan

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Prepared for

Midland Conservation District

by

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MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY

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STURGEON CREEK

WATERSHED MANAGEMENT PLAN

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EXECUTIVE SUMMARY

The Sturgeon Creek Watershed Management Plan (WMP) is the result of a nonpoint source pollution grant under the U. S. Environmental Protection Agency's (EPA) Clean Water Act Section 319 initiative, in coordination with the Michigan Department of Environmental Quality (MDEQ). The Watershed exhibits unique hydrologic problems in addition to water quality, habitat, and soil erosion issues. The primary goal of this WMP is to improve cooperation between local residents and local and state agencies in efforts to protect, restore, and enhance the natural resources of the Watershed and the Saginaw Bay.

The Sturgeon Creek Watershed (Watershed) encompasses areas of agricultural land, the Au Sable State Forest, and a portion of the City of Midland (City). The Sturgeon Creek flows into the Tittabawassee River, situated in the Northern Coastal Basin of the Saginaw Bay Watershed.

The Watershed has many unique land features, the most notable being a protected wetland in the center portion of the Watershed, which is part of the Au Sable State Forest. Encroaching development from urban areas is threatening the water quality and habitat for wildlife of this large wetland system and the rest of the Watershed. The area has experienced severe floods in the past decade. Changes in the land use, most notably the increased urbanizing areas surrounding the City, have raised concerns of additional flooding problems. In an effort to address these threats, the preservation of wetlands and the riparian corridor were expressed as high priority concerns for the Watershed. Three principle land use initiatives were recommended to address these priority concerns: Promotion of low impact development to address urban growth concerns; wetland mitigation/restoration within the watershed to address concerns related to hydrologic stability; and promotion of a greenways initiative and conservation easements to address concerns centered around the riparian corridor.

A lack of water quality information left residents and other concerned entities wondering about the health of the Sturgeon Creek, and its contribution of pollutants to the Tittabawassee River and Saginaw Bay. A detailed watershed inventory was conducted to identify the sources and causes of nonpoint source pollution in the Watershed. Initial findings of the inventory and water sampling indicate impaired water quality at levels high enough to classify sediment and nutrients, and possibly *E. coli* and pesticides, as high priority concerns for the Watershed prioritization process. The sources of sediment were found to be streambank erosion, rill and gully erosion, and unstable tile outlets. The possible sources of nutrients include manure runoff, fertilizer runoff, and failing septic systems. A concerted effort to begin a sampling regime in the Watershed was initiated through this project and will continue through the efforts of Saginaw Valley State University and local high schools.

As part of the Watershed Management Plan, a Policy Review Document (PRD) was prepared for the City of Midland to evaluate the effectiveness of their land use policies related to environmental protection. The Policy Review Document revealed that although the City is above average in their efforts of watershed protection compared to other communities in Michigan, areas for ~~of~~ improvement do exist and were identified. Examples of model ordinances that could be used as guidelines for changes and modifications to the existing rules and ordinances were included in the PRD.

The results of the investigation completed for the plan, taken together with the hydrologic analysis and historical information, lead to the following general recommendations about water quality, wetlands restoration, land use policies, and hydrology issues in the Watershed:

RECOMMENDATIONS PERTAINING TO WATER QUALITY

- Reduce total suspended solids (TSS), in areas identified in MDEQ water quality monitoring studies and volunteer monitoring programs, by preventing soil erosion and reducing sedimentation.

- Reduce phosphorus loading to meet EPA guidance level of 0.1 mg/l P for flowing water and possibly set standard of 50 micrograms/l P for lakes as a bench mark in setting criteria for wetlands.

- Monitor and reduce nitrogen levels where necessary to meet water quality standards.

- Preserve or restore wetlands and create buffers to filter out excess nutrients before they enter rivers and streams.

- Prevent *E. coli* from entering surface waters and meet Michigan Water Quality Standards of 1,000 count/100 mg for partial body contact recreation and 300 count/100 mg for total body contact recreation.

- Meet warmwater minimum for dissolved oxygen of 4 to 5 mg/l by maintaining cool temperatures and limiting nutrient loading.

- Monitor pesticide usage and impacts, and limit contamination from improper use and storage of pesticides and chemicals.

- Investigate levels of heavy metals in Watershed using volunteer monitoring programs.

- Develop strategies to reduce inputs to meet Michigan Water Quality Standards.

RECOMMENDATIONS PERTAINING TO WETLANDS PRESERVATION AND RESTORATION

- Locate areas for potential wetlands restoration to increase storage capacity in rapidly developing subcatchments, based on GIS information.

- Restore wetlands in other areas of the Watershed to improve water quality, increase groundwater recharges, and provide habitat based on GIS information.

- Mitigate wetland loss in the Watershed by replacing wetland functions that are unavoidably lost due to development, such as flood storage, water quality protection, fish and wildlife habitat, and groundwater recharge, within the Watershed.

RECOMMENDATION PERTAINING TO LAND USE POLICIES

- Add development standards to local zoning ordinances to ensure that adequate consideration is given to sensitive environmental features.

- Promote low impact development concepts by encouraging the placement of development in less sensitive areas while preserving forested land, wetlands, and other ecologically valuable landscape features.

- Revise Planned Unit Development (PUD) requirements to allow open space to be condensed into one area.

- Adopt a buffer ordinance.

- Promote a greenways initiative to protect and/or enhance the riparian corridor.

- Review Soil Erosion and Sedimentation Control (SESC) inspection and enforcement and adopt an ordinance.

- Adopt open space ordinances.

- Create tax incentives for conservation easements.

- Adopt native landscaping ordinances.
- Adopt wetland protection ordinances.
- Adopt planning ordinances that limit impervious surfaces.
- Implement storm water management practices.
- Adopt ordinances that require detention of parking lot runoff and harvesting of cattails in detention basins to remove heavy metals.
- Minimize fragmentation of habitats.
- Minimize spread of invasive and exotic species.
- Minimize downstream channelization.
- Protect recharge areas by reducing or preventing increases in impervious surfaces.
- Reduce oil and grease inputs.

RECOMMENDATIONS PERTAINING TO HYDROLOGY

- Preserve and increase canopy on waterways and maintain vegetation on the south and east sides of county drains.
- Increase ratio of groundwater recharge to surface water runoff by protecting recharge areas and reducing impervious surfaces.
- Increase storm water storage though the restoration of wetlands.
- Perform a hydraulic analysis to evaluate the capacity of Sturgeon Creek.
- Design detention storage for the 25-year, 24-hour storm.
- Create uniform standards of 0.13 cfs/acre release rate for developing areas in the Watershed.
- Conduct further investigation in watershed for areas of “no detention” zones.

All of these recommendations will work toward meeting the goals of the WMP, which are to restore the designated uses of the Watershed as a warmwater fishery, providing habitats for other indigenous aquatic life and wildlife, and for partial and total body contact recreation.

The Oversight Committee for the Watershed provided continued support and direction for the development of the WMP. Several subcommittees were formed during the planning process, namely the Information and Education Team, the Technical Subcommittee, the Prioritization Subcommittee, and the Water Quality Subcommittee.

The WMP is an investigation into the water quality and water quantity concerns of the Watershed and presents recommendations to address those concerns. The recommendations are organized according to structural and vegetative Best Management Practices (BMPs), policy and management, and information and education. The specific objectives of the recommendations are quantified to estimate the cost of reducing nonpoint source pollution in the Watershed and, ultimately, Saginaw Bay.

NOTE: Geographic Information System (GIS) data used in Land Use interpretation was obtained from the Michigan Center for Geographic Information before it was made publicly available on the geographic database library website. The land use data in the WMP is referenced as the MDEQ Land Use 2000; however, this data is based on aerial photography completed in 1992. After the WMP was submitted for review, the land use/land cover data was posted on the state website as 1992 National Land Cover Dataset.

CHAPTER 1 - DESCRIPTION OF WATERSHED

1.1 OVERVIEW

LOCATION AND SIZE

The Watershed encompasses 64 square miles (40,862 acres) of Midland County in the east central part of the Lower Peninsula of Michigan (Figure 1). The upper reaches of Sturgeon Creek begin in predominantly agricultural land, in Hope and Mills Townships. The Creek then slowly makes its way south through the forested wetlands of the Au Sable State Forest, which lies mostly in northeast Lincoln Township and northwest of Larkin Township (Figure 2). Tributaries from the central portion of Larkin Township contribute water westward to the Creek. Tributaries from southern Lincoln Township traverse the northeastern corner of Homer Township and join Sturgeon Creek in the City of Midland. Sturgeon Creek flows through the City to its final destination, the Tittabawassee River.

SPECIAL CONDITIONS IN THE WATERSHED

The Watershed is a subwatershed of the Saginaw Bay Watershed. The International Joint Commission, a group representing Canadian and United States interests in the Great Lakes, designated the Saginaw Bay Watershed as an Area of Concern (AOC) in 1978. Cleanup activities over the last 20 years, such as the separation of combined sewers, the enforcement of industrial discharge permits, and the improvements in agricultural practices have dramatically improved water quality.

The Tittabawassee River is on MDEQ's 303(d) non-attainment list for not meeting designated uses. Measures should be taken to ensure that the Sturgeon Creek is not contributing to the pollution.

PHYSIOGRAPHY AND TOPOGRAPHY

The dominant parent materials of the soils in the Watershed were deposited by glaciers and the melt water from the glaciers. Outwash and lacustrine materials, alluvium, glacial till, and organic material are distributed in various amounts throughout the Watershed and determine the limits of the chemical and mineralogical composition of the present day soils (SCS, 1979).

The majority of the Watershed is flat, with little relief to influence drainage and erosion. Very few steep escarpments exist in the entire county. The elevation in the Watershed varies between 700 feet (212 meters)above sea level at the upper reaches of the Watershed to 610 feet (185 meters) above sea level where Sturgeon Creek joins the Tittabawassee River (Figure 3). The Au Sable State Forest, in the

western central portion of the Watershed, is between 675 and 640 feet (205 and 194 meters) above sea level. The eastern portion of the Watershed is approximately 680 feet (206 meters) above sea level, facilitating the southwesterly flow in this portion toward Sturgeon Creek. As a reference, the Saginaw Bay, which is the receiving water body of the Tittabawassee River, is 580 feet above sea level according to the International Great Lakes Datum 1985.

CLIMATE

The Watershed is in a temperate climate, with average temperatures of 25.1^{o}F in the winter and 69.5^{o}F in the summer. The average daily minimum temperature in the winter is 17.9^{o}F and the average daily maximum temperature in the summer is 80.8^{o}F (SCS, 1979).

A growing degree day is a unit of heat available for plant growth. Growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50°F) during the month. For example, if the minimum temperature during a day is 46°F and the maximum is 78°F, the average would be 62°F, which is 12°F higher than the base temperature of 50°F. The growing degree days for that day would therefore be 12°F. The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in the spring and the first freeze in the fall. The average number of growing degree days ranges from zero in the months of December, January, and February to 672 in July (SCS, 1979). The total average number of growing degree days in a year in Midland County is 2,716.

Average rainfall in the Watershed is shown in Table 1.1 as inches per month, averaged over 30 years. Average annual rainfall is 29.3 inches, 58% of which falls between April and September. Thunderstorms occur on about 33 days out of each year, mostly between June and August. Snow falls at an average of 38.2 inches each winter. At least 1 inch of snow lies on the ground for an annual average of 81 days, but varies greatly from winter to winter. Average humidity at midday is 62%, higher at night, and around 80% at dawn. Wind averages 12.1 miles per hour in March, the breeziest month, and prevails from the southwest (SCS, 1979).

Table 1.1 - Rainfall in the Sturgeon Creek Watershed (SCS, 1979)

Month	Minimum (inches*)	Maximum (inches*)	Average (inches)
January	0.9	2.3	1.6
February	0.7	2.2	1.5
March	1.3	2.9	2.1
April	1.8	3.7	2.8
May	1.5	3.7	2.6
June	1.7	4.2	3.0
July	1.3	3.9	2.7
August	1.4	4.5	3.1
September	1.7	3.8	2.8
October	1.0	3.7	2.5
November	1.6	2.9	2.3
December	1.1	3.2	2.2
	Minimum (in)	**Maximum (in)**	**Average (in)**
Year Total	**25.6**	**32.9**	**29.3**

* Recurrence of two years in ten

1.2 SOILS

The Watershed lies predominantly in the Kingsville-Pipestone-Covert soil association. While the upper reaches of the Sturgeon Creek are in this association, with a short journey through Ingersoll-Pella, the majority of the tributaries gain ground in the Lenawee-Bowers-Wixom association. A large area of the lower portion of the Watershed and State Drain subwatershed, around the border of the City, is predominantly Belleville-Wixom soils. The descriptions of these series from the USGS Soil Survey are as follows:

- Kingsville-Pipestone-Covert: Nearly level and gently sloping, poorly drained to moderately well drained soils that have a sandy subsoil or upper substratum; formed in outwash or glacial lake deposits.

- Ingersoll-Pella: Nearly level and gently sloping, poorly drained and somewhat poorly drained soils that have a loamy subsoil; formed in glaciolacustrine and glaciofluvial deposits.

- Lenawee-Bowers-Wixom: Nearly level and gently sloping, very poorly drained to somewhat poorly drained soils that have a loamy and clayey subsoil or a sandy and loamy subsoil; formed in glaciolacustrine and till deposits.

- Belleville-Wixom: Nearly level and gently sloping, very poorly drained to somewhat poorly drained soils that have a sandy and loamy subsoil or a sandy upper substratum; formed in glaciofluvial material over till or glacial lake deposits.

Much of the Watershed is in poorly drained soils that are remnants of glacial activity. Infiltration is slow and slopes are very slight. Although some of the substratum is sandy, water tends to pond and form wetlands. Runoff and risk of nonpoint source pollution may be higher in these areas than where soils allow infiltration.

Figure 4 shows the hydrologic soil groups, which classifies the runoff producing characteristics of each soil type. The grouping is based on the inherent capacity of the soil, without vegetation, to permit infiltration. Group A soils have rapid infiltration and low runoff potential. Group D soils have very slow drainage and high runoff potential, similar to impervious areas. When soils have two classifications (e.g., A/D), the second letter represents the natural state of the soil. If the soil is artificially drained, thus altering its natural state, the fist letter is its resulting hydrologic soil group.

- **Group A Soils:** High infiltration rate, low runoff potential. Well drained to excessively drained sands or gravelly sands. High rate of water transmission.

- **Group B Soils:** Moderate infiltration rate. Moderately well to well drained. Moderately fine to medium coarse texture. Moderate rate of water transmission.

- **Group C Soils:** Slow infiltration rate. Has layer that impedes downward movement of water. Moderately fine to fine texture. Slow rate of water transmission.

- **Group D Soils:** Very slow infiltration rate, high runoff potential. Clays with high shrink/swell potential. Permanent high water table. Claypan or clay layer at or near surface. Shallow over nearly impervious material. Very slow rate of water transmission.

Table 1.2 presents the total acres and percent of area represented for each hydrologic soil group in the Watershed. Group B soils are predominant in the Watershed, especially in the upland agricultural areas, which were once Hemlock and White Pine forests. Much of the Watershed is artificially drained to improve agricultural production, thus increasing the potential rate of runoff. Group A soils are common in the state forest areas, perhaps a result of glacial recession or alluvial deposition. These gravelly soils are in high water table areas creating the marshy wetland conditions in the state forest.

Table 1.2 - Hydrologic Soil Group Areas of the Sturgeon Creek Watershed

Hydrologic Soil Group	Infiltration	Runoff	Acres	% of Watershed
A	High	Low	5,368	13.13
A/D	High	High	7,422	18.16
B	High	High	15,177	37.13
B/D	High	High	10,858	26.56
C	High	High	1,614	3.95
D	High	High	341	0.83
Other	Low	High	99	0.24

1.3 LAND USE

The MDEQ Land Use 2000 land cover data was used to calculate the land use acreages in the Watershed. Three land uses, agriculture, forest, and urban are dominant in distinct areas of the Watershed, as illustrated in Figure 5. Agriculture, which compromises 37% of the land use in the Watershed combined with rangeland, at 4% of the use in the Watershed are predominant in the upper portion. Approximately 33% of the Watershed is classified as forest, mostly in the central western portion of the Watershed, where the Au Sable State Forest is located. The lower portion, where the Sturgeon Creek enters the Tittabawassee River in the City, includes the majority of the 3% of urban and built up land in the Watershed.

The Michigan Department of Natural Resources (MDNR) researched survey notes from when townships and sections were established in Michigan in the early 1800s. Maps of pre-settlement vegetation were created from descriptions of the habitats and ecosystems. Figure 6 illustrates the findings in the Watershed. Upland Hemlock-White-Pine forests dominated the majority of the Watershed. Mixed conifer and mixed hardwood swamps were dominant in the area that is now the Au Sable State Forest. Table 1.3 describes the acreage and percent of the Watershed that each land use represents and compares the pre-settlement land cover with current land use.

Table 1.3 - Land Use in the Sturgeon Creek Watershed

Change in Land Cover	2000 Land Use		1800 Land Cover	
	Acres	% Watershed	Acres	% Watershed
Agricultural Land	13,410	32.8%	0	0.0%
Forest Land	13,604	33.3%	32,168	78.7%
Forested Wetlands	10,570	25.9%	8,592	21.0%
Wetlands	423	1.0%	118	0.3%
Rangeland	1,597	3.9%	0	0.0%
Urban and BuiltUp	1,206	3.0%	0	0.0%
Open Water	59	0.1%	Unknown	

The Au Sable State Forest accounts for much of the forested area in the Watershed. Forested buffers exist along the Upper Sturgeon and Boyle Drain. Pre-settlement vegetation was mainly coniferous forests of Hemlock and White Pine covering the upland areas with the remaining land in swamps and wetlands. The draining of the swamp and wetlands and clearing of land for agricultural use resulted in a significant loss of these natural ecosystems.

Most of the current development in the Watershed is occurring in Larkin Township, especially in the Jacobs Drain subbasin. The City has identified a Municipal Urban Growth Area (MUGA), in which utilities will be extended only if those areas are annexed to the City. This boundary is an attempt to curb urban sprawl by limiting services to a specified distance from the City.

Figure 7 shows the subcatchments which compromise the Watershed. Table 1.4 describes the acreages and percentages of land use within each subcatchment. The southern subcatchments of Jacobs, Hahn, and State have higher percentages of urban areas, while the northern subcatchments of Harris-McCoy-Weaver, Upper Sturgeon, Newell, and Grass are predominately agricultural and forested. The Dittmar and other central subcatchments in the Au Sable State Forest have a large amount of forested wetlands.

Larkin Township recognized the importance of understanding existing land uses to plan for the future uses in the development of its Master Plan, drafted in 1992. Existing land use tables and figures serve as a ready reference when considering everyday problems in land use management and public improvement proposals.

Table 1.4 - Subcatchment Land Use

	Dittmar		Grass		Hahn		Harris		Jacobs		Newell		State		Upper Sturgeon	
Land Use	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Commercial/Industrial/Transportation					14.4	1.7%	2.3	0.0%	121.7	4.9%	12.2	0.2%	99.1	1.9%		
Deciduous Forest	1162.3	36.5%	2920.2	41.2%	311.1	37.6%	943.2	18.0%	369.5	14.8%	2028.9	27.0%	1847.2	34.9%	1401.7	35.1%
Emergent Herbacious Wetland	29.7	0.9%	30.6	0.4%	28.6	3.5%	19.4	0.4%	164.7	6.6%	32.5	0.4%	102.4	1.9%	24.0	0.6%
Evergreen Forest	23.2	0.7%	78.1	1.1%	2.5	0.3%	54.7	1.0%	12.3	0.5%	331.7	4.4%	59.1	1.1%	52.3	1.3%
High Density Residential			1.0	0.0%	13.9	1.7%	0.1	0.0%	59.0	2.4%	6.7	0.1%	33.7	0.6%	0.5	0.0%
Low Density Residential	1.3	0.0%	25.2	0.4%	59.5	7.2%	2.5	0.0%	16.9	0.7%	56.2	0.7%	74.9	1.4%	1.7	0.0%
Mixed Forest	2.0	0.1%	11.6	0.2%			9.5	0.2%	0.7	0.0%	40.9	0.5%	15.6	0.3%	6.5	0.2%
Open Water	2.2	0.1%	9.8	0.1%			0.5	0.0%	169.9	6.8%	6.3	0.1%	3.0	0.1%	19.1	0.5%
Pasture/Hay	48.3	1.5%	227.4	3.2%	41.4	5.0%	118.6	2.3%	1116.1	44.8%	619.4	8.2%	156.5	3.0%	71.8	1.8%
Row Crops	202.5	6.4%	2696.7	38.0%	176.3	21.3%	2954.2	56.5%	13.3	0.5%	3399.1	45.2%	1655.8	31.3%	925.8	23.2%
Urban/Recreational Grasses													9.7	0.2%		
Wooded Wetland	1708.5	53.7%	1087.9	15.3%	179.5	21.7%	1127.8	21.6%	447.5	18.0%	988.1	13.1%	1232.1	23.3%	1493.9	37.4%
Total Acres	**3180.2**		**7088.5**		**827.2**		**5232.9**		**2491.6**		**7522.0**		**5288.9**		**3997.2**	

1.4 HYDROLOGY

Hydrology explains the distribution and movement of water both above and below the ground surface. The general flow of water tends to be southwesterly in the upper reaches, then turns southeast before entering the Tittabawassee River.

STREAMS

The main channel in the Watershed is Sturgeon Creek, which begins in Hope Township of Midland County, then flows through Lincoln and Larkin Townships on its way to the City, where it joins the Tittabawassee River (Figure 2). The Sturgeon Creek is 17.7 miles long and normally flows less than 6 feet in depth in the downstream end and less than 3 feet in depth upstream of Sugnet Road. There are 143 total stream miles in the Watershed when all the tributaries are included.

Drains in the upper reaches, within the Harris-McCoy-Weaver subcatchment, are channelized to drain the agricultural land (Figure 7). Much of the area in the Upper Sturgeon and Grass subcatchments remains forested, which provides high quality buffers for the streams. Grass Creek is also know as Boyle Drain. Throughout this document, the waterway will be referred to as Boyle Drain and the subcatchment will be referred to as the Grass subcatchment.

Sturgeon Creek winds through the middle of the heavily forested Dittmar subcatchment, where it begins to meander and spread across the floodplains. This area is managed by the MDNR, and though it is a public area, access is limited to a few small logging roads. This portion of the Sturgeon Creek is very remote with little human disruption.

The Newell subcatchment is mainly agricultural, with some rural residential and forested areas. More artificial drainage occurs in this subcatchment than the northernmost subcatchments. The main tributary in the subcatchment is Newell Drain, which joins the Sturgeon Creek north of Barstow Airport, just north of the City limits.

The Sturgeon Creek picks up momentum further downstream, when urban runoff is added to the drainage system. The Jacobs subcatchment is experiencing rapid growth which has degraded Jacobs Drain with excessive sedimentation and nutrients. The most urban subcatchment contains the Hahn Drain which flows through the residential area of the City. The Inman Drain empties into the State Drain near the built-up area adjacent to US-10, then flows through the City where runoff is often flashy and flows may peak quickly from the rushing of water over parking lots, rooftops, and through storm sewers.

COUNTY DRAINS

The majority of the waterways in the Watershed are under the jurisdiction of the Midland County Drain Commissioner (MCDC). Table 1.5 lists the county drains and some of their characteristics.

Table 1.5 - County Drains in the Sturgeon Creek Watershed

Drain Name	Location/Subcatchment	Miles	Date of Establishment	Date of Most Recent Improvements
Dittmar	Dittmar	6.640	1905	1915
Boyle	Grass	17.010	1899	1998
Clark	Grass	2.750	1899	1985
Kelly	Grass	2.630	1899	1994
Morris	Grass	2.750	1905	1996
Schoolhouse	Grass	1.890	1913	1985
Hahn	Hahn	3.280	1902	1986
Harris	Harris-McCoy-Weaver	7.450	1906	1988
McCoy	Harris-McCoy-Weaver	3.220	1908	1990
Weaver	Harris-McCoy-Weaver	5.330	1959	1986
Jacobs	Jacobs	9.625	1906	1992
Kohtz Drain	Jacobs	0.790	1990	1990
Woodland	Jacobs	0.370	1979	1979
Balcirak	Newell	0.625	1918	1962
Dempski	Newell	3.790	1908	1991
Lathrope	Newell	0.67	1998	1998
Miller	Newell	5.520	1901	1959
Neill-Bridges	Newell	2.49	1906	1987
Newell	Newell	24.690	1895	1992
Pluss	Newell	2.170	1898	1989
Venner	Newell	3.020	1904	1962
Visgar	Newell	8.240	1898	1985
Beck	State	4.530	1903	1996
Bensch	State	12.840	1900	1997
Inman	State	9.860	1896	1990
State	State	6.690	1902	1948
Stems	State	7.400	1894	1978

The MDEQ, Land and Water Management Division, estimated the flooding frequency discharges of Sturgeon Creek at three locations: downstream of the confluence with State Drain, at Perrine Road, and downstream of the confluence with Boyle Drain. Table 1.6 presents those estimates.

Table 1.6 - Discharge Frequencies of Three Locations in the Sturgeon Creek Watershed

Chance Peak Flows	Flow Rate at State Drain	Flow Rate at Perrine Road	Flow Rate at Boyle Drain
10 years (10%)	1000 cfs	630 cfs	500 cfs
50 years (2%)	1600 cfs	980 cfs	800 cfs
100 years (1%)	1800 cfs	1100 cfs	900 cfs
200 years (.5%)	2100 cfs	1300 cfs	1100 cfs
500 years (.2%)	2500 cfs	1500 cfs	1200 cfs

IMPOUNDMENTS

Beaver dams have been the most significant impoundments in the Watershed, located mainly in the Au Sable State Forest. A few man made impoundments exist in the Watershed, mainly as settling ponds near the mall. Landowners have dammed, diverted, or otherwise altered the course of water for aesthetic reasons or personal use. Small ponds in residential areas have been noted, but these do not have a significant effect on overall flows.

GROUNDWATER

Water flowing under the surface of the land between the spaces of particles that make up the soils and the deposits of clay, sand, and gravel is groundwater. The movement of groundwater often flows toward surface water, and recharges rivers, lakes, and streams with the cold, filtered water on which they often depend to maintain flow. The Watershed has a relatively high water table, helping to keep wetlands and surface water flows stable. Much of the Watershed is in a sandstone Pennsylvanian aquifer with sandstone base.

1.5 WETLANDS

The Watershed is mottled with wetlands. Water is slow to move through the majority of the Watershed. Hydric soils are abundant, especially in the western region. Many wetlands have been drained, revealing organic rich soil for agriculture, a mainstay of the local economy. The Au Sable State Forest still holds a large percentage of wetland areas in the watershed. For a more comprehensive description of the Watershed see Chapter 4 - Implementation.

Table 1.7 shows the distribution of wetlands in the Watershed by subcatchment. Total acres of the subcatchment, and the percentage of the total Watershed area that the subbasin occupies is displayed. The acreage of wetlands by subcatchment, the percentage of that subcatchment that is wetlands (Wetland Concentration), and the percentage of the wetlands in the total Watershed that is within each subcatchment (Wetland Distribution) are also displayed. Wetlands represent 4.84% of the Watershed. The disbursement of the wetlands is mostly in the Dittmar subbasin, in and around the Au Sable State Forest. The State, Newell, and Grass subbasins each have over 10% of the wetlands in the total Watershed.

Table 1.7 - Wetlands

Subbasin	Acreage of Subbasin (ac)	% of Area of Watershed	Wetlands in Subbasin (ac)	Wetland Concentration in Subbasin	Wetland Distribution Across Watershed
Dittmar	4,178.71	10.41%	593.42	14.20%	30.53%
Grass	8,473.72	21.11%	229.74	2.71%	11.82%
Hahn	1,625.47	4.05%	110.48	6.80%	5.68%
Harris	5,255.51	13.09%	127.55	2.43%	6.56%
Jacobs	2,738.55	6.82%	30.84	1.13%	1.59%
Newell	8,056.45	20.07%	321.80	3.99%	16.56%
State	5,498.15	13.70%	368.04	6.69%	18.94%
Upper Sturgeon	4,316.69	10.75%	161.59	3.74%	8.31%
TOTAL	40,143.41		1,943.45	4.84%	

Pre-settlement vegetation maps identify 8,711 acres that were wetlands at the time of the surveys in the 1800s (Figure 6). The extensive farming in this area resulted from draining much of the wetlands to expose the rich organic soils. This change in land use included the loss of 6,767.5 acres (78%) of the pre-settlement wetlands.

1.6 NATURAL RESOURCES

The Watershed includes large tracts of forested wetlands, part of which are in the Au Sable State Forest and part are owned privately. The Division of Fire Management and Forestry and the Division of Wildlife, within the MDNR, co-manage the Au Sable State Forest as multiuse for timber and recreation, mainly hunting and fishing. The Sturgeon Creek is a designated warmwater fishery, however, no fish stocking is occurring at this time.

Beaver dams are abundant in the State Forest, making it a prime area for duck hunting. Open beaver trapping season is from November 1 to mid-April, and trappers often take advantage of this resource. The current policy of the MDNR is to leave beaver dams intact in almost all cases. Permits for dam removal on state land will only be issued if it causes flooding or rising of the water table on private land.

The floodplain forests, which are prolific throughout the Watershed, provide a unique and very diverse habitat. The hydric soils have an organic rich chemistry that allows distinctive species of plants to prosper. Vernal pools provide spring reproduction sites for amphibians, whose population changes are often thought of as good indicators of changes in environment and climate. The subtle variations in habitat between permanently flooded, seasonally flooded, and upland forest that occur in floodplain forest areas allow for very rich biodiversity and strong biological integrity.

Midland County is home to many threatened and special concern species listed by the State of Michigan, as well as two endangered species; the Snuffbox Mussel (*Eipioblasma triguetra*) and the American Burying Beetle (*Nicrophorus americenus*). The mature, large tracts of forested wetland in the Watershed provide habitat for the red-shouldered hawk, a threatened species in the State.

The City owns several parcels of land along Sturgeon Creek, most of which are undeveloped. However, there are City maintained parks within the Watershed for recreation, picnicking, and outdoor enjoyment. At the mouth of the Sturgeon Creek is Emerson Park and the Pere Marquette Rail-to-Trail Linear Park. An old railroad trestle passes over the mouth of the Sturgeon Creek as it empties into the Tittabawassee River.

In the early 1990s, the MDNR forester held discussions with various landowners adjoining state land that sits between Perrine Road on the east and Stark Road on the west. Clear cutting was a common practice in the state lands at that time. The argument was that by prescribing clear cutting, mixed soft and hardwood forests could be converted into stands of poplar, which some people claimed was fast growing and good for wildlife. Opponents explained that oaks are also important for wildlife by providing acorns and shelter. A study conducted in the area discussed the soil types in the region and calculated site index data for various species of trees. The site index for oak trees on the ridges in this piece of state land were rated at 80, which indicated that the oaks were as fast growing as poplar.

Given the public's distaste for clear cutting, the MDNR forester decided to recommend a series of experiments for the future where the MDNR would manage the various compartments by several different prescriptions so they could gather real data on what actually worked best across the variety of soil types, drainage, and other ecological factors. The forester agreed to leave a buffer strip of no less than 300 feet between the point where they would prescribe the various management practices and Sturgeon Creek and also the various privately held lands. The size of any clear cut area was limited so as not to become an eyesore. In response to landowner desires, the compartments where many oaks and other hardwoods were present would be managed by either shelterwood or selective harvest prescriptions. When oak stands are clear cut, they tend to grow back in a "bush" rather than a single tree trunk. Poplar regenerates by new shoots that come from roots spread throughout the area where they already are located, but if the new shoots do not receive enough sunlight, they will not thrive. When a compartment of oak and mixed hardwoods is appropriately thinned by either shelterwood or selective harvest methods, the oak and hardwood stand can be maintained and strengthened.

CHAPTER 2 - POLITICAL LANDSCAPE

2.1 DEMOGRAPHICS

Approximately 13,239 people live in the Watershed as projected by the proportion of residents by percent area of the township or city in the Watershed. The major population center is the City of Midland, population 41,685, and there are no other established cities in the Watershed. Table 2.1 depicts the population variations by governmental unit within the Watershed. The 1990-2000 percent population change in Larkin Township and Lincoln Township were significantly higher at 25.81% and 26.01%, respectively than the national change (13.1%) and the change in Michigan (6.9%). The 2000 population projection of 3,800, that was under estimated for Larkin Township in 1992, was off by 19%, over 700 people (U.S. Census Bureau 2000).

The majority of the Watershed is in Larkin Township and Lincoln Township, each containing about 30% of the area of the Watershed. Hope Township contains 21.6% of the Watershed, while Mills Township contains 11% of the area of the Watershed. The City contains 10.2% of the Watershed at the mouth of the Sturgeon Creek. The remaining 0.2% of the Watershed is in Homer Township.

The population density of the United States is 79.6 people per square mile. Michigan's population density is 175 people per square mile. Midland County, home of the Watershed, falls in the middle at 159.1 people per square mile. The population density proportion in the Watershed is high in the City, but relatively low in the surrounding townships. Mills and Hope Townships, in the northernmost reaches of the Watershed, have population densities of just 52 and 55 people per square mile, respectively. The middle townships, Lincoln and Larkin Townships, have populations of 97.1 and 138.8 per square mile, respectively.

Table 2.1 - Demographics

Governmental Unit	Total Acres	Acres in Watershed	Govt. Unit % of Watershed	Population 1980 Census[a]	1980 Population per Square Mile	Population 1990 Census[b]	1990 Population per Square Mile	Population 2000 Census	Watershed % of Govt. Unit	Estimated 2000 Watershed Population[C]	2000 Population per Square Mile	% Population Change 1980 - 2000	% Population Change 1990 - 2000
Homer Township	13,773	73	0.2%	4,477	208.0	4,235	196.8	3,924	0.53%	21	182.3	-12.35%	-7.34%
Hope Township	14,973	8,842	21.6%	1,249	53.4	1,220	52.1	1,286	59.05%	759	55.0	2.96%	5.41%
Larkin Township	20,820	11,418	27.9%	3,303	101.5	3,588	110.3	4,514	54.84%	2,476	138.8	36.66%	25.81%
Lincoln Township	15,015	11,890	29.1%	1,643	70.0	1,807	77.0	2,277	79.19%	1,803	97.1	38.59%	26.01%
Mills Township	23,044	4,481	11.0%	1,461	40.6	1,635	45.4	1,871	19.45%	364	52.0	28.06%	14.43%
City of Midland	22,175	4,158	10.2%	37,016	1,068.3	38,053	1,098.3	41,685	18.75%	7,816	1,203.1	12.61%	9.54%
TOTAL	**109,800**	**40,862**	**100.0%**	**49,149**		**50,538**		**55,557**		**13,239**		**13.04%**	**9.93%**
Midland County[d]	333,440	40,862	100.0%	73,578	141.2	75,651	145.2	82,874	12.25%		159.1	12.63%	9.55%

a) Data from 1980 U.S. Census of Population, *Number of inhabitants*
b) Data from 1990 U.S. Census, *Selected Population and Housing Characteristics*
c) Populations are projected based on percentage area of township and city in Watershed.
d) Midland County Directory, 2001-2001

Table 2.2 - Diversity

Governmental Unit	Total Population[a]	Watershed % of Govt. Unit	Watershed Population[b]	Male[b]	Female[b]	White[b]	Black/African American[b]	Amer. Indian / Alaska Native[b]	Asian[b]	Native Hawaiian / other Pacific Islander[b]	Hispanic / Latino[b]	Other Race[b]*	One Race[b]	Two or More Races[b]
Homer Township	3,924	0.5%	21	10	11	20	0	0	0	0	0	0	21	0
Hope Township	1,286	59.1%	759	392	367	740	8	2	1	1	5	2	754	6
Larkin Township	4,514	54.8%	2,476	1,260	1,215	2400	18	4	21	0	27	5	2,449	27
Lincoln Township	2,277	79.2%	1,803	913	890	1,775	4	0	10	0	16	2	1,790	13
Mills Township	1,871	19.4%	364	184	180	356	1	3	0	0	7	1	361	2
City of Midland	41,685	18.8%	7,816	3,746	4,071	7,299	143	23	211	5	150	44	7,723	93
TOTAL	**55,557**	**37.2%**	**13,239**	**6,504**	**6,735**	**12,591**	**173**	**32**	**242**	**5**	**206**	**52**	**13,098**	**141**
% of Watershed Population				49.13%	50.87%	95.11%	1.31%	0.24%	1.83%	0.04%	1.55%	0.41%	98.94%	1.06%
Midland County	82,874			40,646	42,228	79,148	868	335	1,233	28		361	81,973	901

[a] 2000 Census
[b] Populations are projected based on 2000 Census and percentage area of township and city in Watershed.

2.2 COMMUNITY PROFILES

One of the stakeholders in the Sturgeon Creek Watershed Steering Committee (Steering Committee) is the Mid-Michigan Medical Center. It is located on the downstream banks of the Sturgeon Creek. In 1986, the hospital experienced flooding and has serious concerns about a recurrence of this event.

The north side of the City, which falls within the Watershed contains a variety of activity. An airport catering to small aircraft and major shopping centers including a large mall are among the commercial and recreational destinations. The county fair is held every August in this area, and the fairgrounds are open for a variety of events from spring through fall.

Table 2.2 shows the amount of diversity in the Watershed, where 95% of the population is white. The largest minorities are Asian with approximately 242 residents, Hispanic or Latino with approximately 206 residents, and Black or African American with approximately 173 residents throughout the Watershed. Less than half of a percent each is American Indian or Alaska Native, Hawaii Native, or other Pacific Islander, or other race. One percent of the population responded as being of mixed race. The population is nearly evenly split between males and females, with slightly more females, especially in the more densely populated areas.

The Midland and Meridan school districts are represented in the Watershed. The Midland Public School District has been a partner in the Watershed planning process and is actively taking a role in protecting water quality by having students involved in water quality sampling on the Sturgeon Creek. The students will participate in sampling, analyze the results, display the results on the internet, and make a presentation of their findings. Saginaw Valley State University is a partner of the school district in the water quality monitoring effort.

The Municipal Urban Growth Area (MUGA) bounds the expansion of the City services and annexation in the Sturgeon Creek Watershed in Larkin Township. Water and sewer services will not be provided by Larkin Township to the properties that lie within the MUGA, but must be annexed by the City to have these services supplied. According to the annexation agreement between the City and Larkin Township, a landowner may petition to be annexed if the parcel is contiguous to the City and within the MUGA. If the petition is not contested, the parcel will be annexed.

The largest employers in the Watershed are the Dow Chemical Company and the Dow Corning Corporation. The headquarters of these large international companies are located in Midland. The former is the largest chemical company in the U.S., manufacturing a wide range of products. The latter is a world leader in silicone chemistry. There is a significant population of scientists and engineers in the Watershed, many with environmental and health experience. Other large employers in the Midland area are the Mid-Michigan Medical Center, Midland Public Schools, and the Midland Mall.

2.3 OFFICIALS

Watershed management involves local stakeholders and decision-makers. Communication with these stakeholders is essential to achieve the goals and objectives of the plan. Table 2.3 lists all of the federal, state, county, township, and city officials that have a vested interest in the Watershed. This should be updated every few years.

2.4 STEERING COMMITTEE

The formation of the Steering Committee was one of the first tasks completed in the planning project. The Steering Committee consisted of a variety of members including landowners, organizations, and groups interested in the restoration and preservation of the Watershed.

Table 2.4 lists the representatives of groups that have participated in the Watershed management planning process and the committees on which they have served. Their input has been invaluable in the formation of this plan.

Meetings were held monthly during the first year of the project, then quarterly for the second year of the project. The other committees met as necessary to complete their tasks.

Table 2.3 - Officials Representing the Sturgeon Creek Watershed as of January 1, 2003

Name	Position	Contact Number
Federal and State Offices		
Mr. Dave Camp	US Congressional District #4	202-225-3561
Mr. Tony Stamas	State Senate District #36	517-373-7946
Mr. John Moolenaar	State Representative District #98	517-373-1791
Ms. Sandy Caul	State Representative District #99	517-373-1791
County Offices		
Mr. David D. Benda	Administrator/Controller	989-832-6797
Judge Thomas L. Ludington	42nd Circuit Court	989-832-6825
Judge Paul J. Clulo	42nd Circuit Court	989-832-6830
Judge Phillip VanDom	75th District Court	989-832-6700
Judge John Henry Hart	75th District Court	989-832-6700
Judge Dorene Allen	Probate Court	989-832-6880
Mr. Norman W. Donker	County Prosecutor	989-832-6772
Mr. John S. Reder	Sheriff	989-839-4600
Ms. Karen A. Holcomb	Clerk	989-823-6739
Mr. Scott I. Haines	Register of Deeds	989-832-6820
Mr. Douglas Enos	Drain Commissioner	989-832-6770
Ms. Mary Cornell	Equalization	989-832-6844
Mr. Roger Garner	Emergency Services	989-832-6750
Ms. Bridgette Gransden	Finance	989-832-6782
Mr. Michael Krecek	Health Departments	989-832-6380
Mr. Kevin Beeson	Facilities Manager	989-832-6790
Mr. Tom R. Wilmot	Mosquito Control	989-32-5044
Mr. Thomas A. Plachta	Information Systems	989-832-6653
Mr. Paul Pounders	Parks and Recreation	989-832-6870
Mr. Deepak Gupta	Road Commission	989-687-9060
Ms. Cindy Winland	Planning Department	989-832-6879
Mr. Jerry L. Jones	Surveyor	989-836-9611
Mr. Wynne D. Downing	Treasurer	989-832-6850
Ms. Esther Seaver	Volunteers for Recycling	989-631-1668
Ms. Elizabeth Szymanski	County Extension	989-832-6640
Board of Commissioners		
Mr. Ted O'Neil	2nd District County Commissioner	989-832-6382
Ms. Otis Wilson	5th District County Commissioner	989-832-6387
Mr. James T. Bradley	6th District County Commissioner	989-832-6388

Table 2.3 - Officials Representing the Sturgeon Creek Watershed as of January 1, 2003

Name	Position	Contact Number
Township Offices		
Ms. Barbara Radosa	Homer Township Supervisor	989-835-5671
Ms. Anita Sanger, Chairperson	Homer Township Planning Commission	989-835-1297
Mr. Theodore M . Wendt	Hope Township Supervisor	989-689-3600
Mr. Mike Kressler	Hope Planning Commission	989-689-5500
Mr. Leonard Servinski	Larkin Superintendent	989-631-2796
Mr. Jerry Steger, Chairperson	Larkin Planning	989-835-3795
Mr. Gregory Hermans	Larkin Zoning Board of Appeals	989-832-0631
Mr. Gerald Nightlinger	Lincoln Superintendent	989-687-5644
Mr. Joseph Leigeb	Lincoln Planning/Zoning Board Appeals	989-687-5068
Mr. Daniel Bloom	Mills Superintendent	989-832-2293
Ms. Rosemary Urban, Chairperson	Mills Planning	989-835-2783
Ms. Jean Pitch, Chairperson	Mills Zoning	989-689-3430
City Offices (837-3300)		
Mr. Drummond Black	Mayor	989-837-3300
Mr. Karl Tomion	City Manager	989-837-3301
Mr. John Duso	Assistant City Manager	989-837-3301
Mr. Jon Lynch	Planning Director	989-837-3379
Mr. Mark Ostgarden	City Planner	989-837-3374
Mr. Rod Wieland, Chairman	Planning Commission	989-837-3374
Mr. Brian McManus	Engineer	989-837-3348
Mr. Bradd Maki	Assistant City Engineer	989-837-3351
Ms. Selina Crosby Tisdale	Community Relations Coordinator	989-837-3301
Ms. Gussie Peterson	Health & Safety Coordinator	989-837-3502
Mr. Steve Young	Wastewater Superintendent	989-837-3341
Mr. Hank Holthof, Chairman	Zoning Board of Appeals	989-837-3374
Mr. Daniel Hargarten	Fire Chief	989-837-3410
Mr. Martin McGuire	Director of Public Services	989-835-2531
Mr. Robert Fisher	Director of Fiscal Services	989-837-3322
Mr. Noel Bush	Utilities Director	989-837-3341

Table 2.4 - Watershed Management Planning Participants

Stakeholder Name	Affiliated Organization	Steering Committee	I&E Sub-Committee	Technical Committee	Prioritization Sub-Committee	Water Monitoring
Ms. Nancy Atwood	County Health Department			X		X
Mr. Lou Badour	Board Member, Midland Conservation District	X		X		
Mr. Charlie Bauer	MDEQ - Surface Water Quality	X		X	X	
Ms. Deb Bloom	Mills Township	X	X			
Mr. Bruce Campbell	Citizen		X			
Mr. Dave Claerhout	Farm Services Agency	X		X		
Dr. Stacy Daniels	Crystal Lake Watershed Fund, Inc & Riparian Owner	X		X		X
Mr. Gary Deshano	Developer - Midland Homebuilders Association	X		X		
Mr. Ted Doan	Citizen (Dow Foundation)	X				
Mr. Doug Enos	Midland County Drain Commissioner	X		X	X	
Mr. Joe Hass	MDEQ - Permitting			X	X	X
Mr. Jim Hergot	USDA RC&D			X		
Ms. Dorothy Horan	H.H. Dow High School					X
Ms. Diane Hornbrook	Fishbeck, Thompson, Carr & Huber, Inc.	X		X	X	
Mr. John Kneibel	Ducks Unlimited - Zone Chairman			X		
Mr. Doug Koop	The Little Forks Conservancy, Director	X				
Mr. Norm Lake	Larkin Township - Citizen	X		X		
Mr. Robert Lehmann	Saginaw Valley State University	X		X		X
Mr. Elan Lipschitz	The Little Forks Conservancy, LPS			X	X	X
Mr. Bradd Maki	Assistant City Engineer - City of Midland			X		
Mr. Doug Morse	MDEQ	X		X		X
Ms. E. Wendy Ogilvie	Fishbeck, Thompson, Carr & Huber, Inc.	X		X	X	
Mr. Ted O'Neal	County Board of Commissioner	X		X		
Mr. Bill Page	Citizen, Midland Conservation District		X			
Mr. John Rapanos	Private Developer	X				
Ms. Sara Schaefer	MDNR Habitat Biologist			X		X

Table 2.4 - Watershed Management Planning Participants

Stakeholder Name	Affiliated Organization	Steering Committee	I&E Sub-Committee	Technical Committee	Prioritization Sub-Committee	Water Monitoring
Mr. Paul Schroll	Midland High School					X
Mr. Will Sears	USDA - NRCS			X	X	
Mr. Mike Stein	Midland Board of Realtors	X				
Mr. Denis Varner	Midland Conservation District			X		
Mr. Phil Varner	Board Member, Midland Conservation District	X		X		
Mr. Charles Wakeman	Mid-Michigan Medical Center	X		X		
Mr. Steve Young	City of Midland Waste Water Plant	X		X		X
Mr. Robert Zbiciak	MDEQ - Land and Water Management	X		X		

CHAPTER 3 - WATER QUALITY

3.1 PREVIOUS STUDIES

Limited information is available for water quality conditions in the Watershed. The MDNR completed a biological survey of Sturgeon Creek in 1992. The objective of the study was to qualitatively evaluate the impact that land use practices have had on the aquatic macroinvertebrate and fish communities, physical habitat, and chemical water quality of Sturgeon Creek. Fish and benthic sampling were completed at three locations in the Watershed. The MDNR also evaluated habitats and collected water samples for water quality analysis at these three locations. An additional water sample was collected from a fourth location for water quality analysis.

The survey rated the Sturgeon Creek water quality as good (slightly impaired) at Station 1, the downstream end of the State Forest and the most upstream sampling location; fair (moderately impaired) at Station 2; and poor (severely impaired) at Station 3, the most downstream location. Stream quality impairment was attributed, in part, to improper land use practices (MDNR, 1992).

The *Midland County River Corridor Protection Plan* (1984) describes the major watercourses and their surrounding land uses and practices in Midland County, Michigan. These include Chippewa River, Pine River, Salt River, and Tittabawassee River. Sturgeon Creek is not directly assessed**,** but many of the observations, such as concerns of sediment and nutrients, apply to this water body.

3.2 CURRENT STUDIES

NONPOINT SOURCE SURVEY

Accurate assessment of the condition of the watershed is best done by first-hand observation. A field inventory, which primarily consisted of walking the length of Sturgeon Creek and its tributaries, was conducted by Midland Conservation District (MCD) staff between the summer of 2001 and the spring of 2002.

METHODOLOGY

The inventory was completed by walking on the streambank or in the water, usually upstream, so that silt would not disturb the view of the stream bottom. A data sheet was completed at each site where there was evidence of nonpoint source pollution (Appendix 1). Seven categories were observed and recorded: debris and trash, construction sites, stream crossings, rill and gully erosion, tile outlets, streambank erosion, and others (including algal blooms). At all observation points, basic information was recorded about the size of the stream, surrounding land use, buffers, and other information. Each major category contained descriptive subcategories that could later be used to group and prioritize these sites.

The observation locations were recorded geographically with a Global Positioning System (GPS) unit, when available, or drawn on a map. A photograph was taken at each site to document a "before" condition of the site as part of the evaluation process.

The sites were numbered using a code that consisted of four parts. The first part of the identification number was based on the EPA's Reach File Version 3.0 numbering system. Streams that had not been numbered in this system were given a number based on the major tributary it fed into, plus an extension number. For example, an unnumbered stream that spilled into reach number 867 could be numbered 8671. Unnumbered streams were given extension numbers in a consecutive manner heading upstream. The drain names and the locations of the reaches by number are listed in Table 3.1.

The second part of the site number was the first three letters of the township. The third portion was the two-digit section number. The final part of the site number was a two-digit site number. Site numbering began at the point where the tributary entered Sturgeon Creek, and increased as the surveyor headed upstream. In each section, the numbering started at 01 and increased consecutively until the tributary entered another section.

The data collected during the stream survey was checked for inconsistencies. It was then converted to a DBF (IV) file and entered as a point file into ArcView 3.2 GIS system. Photographs were then linked to the points. The data was sorted by category in a spreadsheet. The categories identified included debris and trash, construction sites, stream crossings, rill and gully erosion, tile outlets, streambank erosion, and others. Using the subcategories within each category, the sites were prioritized by severity and extent of the pollution. The data is tabulated in Appendix 2.

FINDINGS

The sites of nonpoint source pollution identified in the Watershed during the inventory are displayed in Figure 8. The most common source of pollution in the Watershed was streambank erosion. Erosion was noted at 52 sites, the majority of which had mostly bare banks.

Many sites had debris and trash, rill and gully erosion, or tile outlet erosion concerns. Much of the debris accumulation was due to log jams that blocked flow or diverted water. The rill and gully erosion occurred predominantly in agricultural areas. Some erosion was the result of improperly functioning culverts or tiles. Two major types of problems were associated with tile outlets: erosion and discharge. A tile outlet may cause erosion if the placement is too high and water falls a great enough distance to gouge the stream bottom. Additionally, if water rises, causing eddy currents around the outlet, the area around the outlet erodes. Some outlets also discharged black or milky water indicating an illicit connection to the system.

The southern portion of the Watershed, outside the City, is quickly developing. Two construction sites were observed in the watershed that had deficient soil erosion and sedimentation control measures. Road stream crossings were occasionally found to have erosion problems, predominantly on the shoulders. Many algal blooms occurred where flow was blocked in residential areas and were occasionally observed in agricultural areas.

INVENTORY OF ROAD/STREAM CROSSINGS

A road/stream crossing inventory is being conducted by the MCD in conjunction with the MDEQ. A representative sample of crossings will be inventoried according to the MDEQ specifications. At each site, a data sheet (Appendix 3) will be completed and digital photographs taken. This information will be submitted to the MDEQ as a public record. A summary of the results will be included in the updated version of this plan.

THE CITY OF MIDLAND STORM SEWER OUTFALL EVALUATION

The purpose of a storm sewer is to quickly remove water from the streets after rainstorms or spring snow melt to ensure road safety and property protection. Storm water discharges into streams or other surface water bodies, such as drains, to maintain rapid water drainage. Without treatment, this direct pipeline to the waterways has the potential to be the source of many types of pollution. Chemicals and trash can enter the system through this avenue. Improperly installed or poorly maintained storm water outfalls can be a point of erosion in a stream system.

The storm sewer outfalls within the city limits of Midland have been evaluated to determine whether they are contributing to the input of nonpoint source pollution into the Sturgeon Creek. The following information was gathered on each outflow found: location, size, composition and condition of the pipe, as well as flow characteristics such as blockage, color, and odor.

Proportionately, very few were found to have suspicious discharges indicating that illegal dumping is not a large problem in the storm sewer systems. The outfalls were, however, found to be a significant source of erosion. In many cases this erosion is extensive and compromises the integrity of the streambank. The City has an agreement with the MCDC to maintain the drains within the City limits. The storm sewer outfalls leading into the drains contained within the City limits are also included in this study. These results will be delivered to the City of Midland and the MCDC. Information will be shared with the City's Utilities, Engineering and Building Departments, the City Manager's office, and City Council, who will determine which outfalls are of the highest priority and the estimated cost of each repair. When funding becomes available, cost-share dollars may be sought to assist the City in preventing further erosion at these sites.

Table 3.1 - Reach Numbers and Locations in the Sturgeon Creek Watershed

Reach Number	Name	Township Location
4	Sturgeon Creek	Hope, Lincoln, Larkin, Midland
60	Newell	Larkin, Mills
601	Newell Branch 1	Larkin
602	Newell Branch 2	Larkin
603	Newell Branch 3	Larkin
604	Newell Branch 4	Larkin
6041	Newell Branch 4, Branch 1	Larkin
605	Newell Branch 5	Larkin
6051	Newell Branch 5, Branch 1	Larkin
134	No Name	Larkin
135	No Name	Midland
434	No Name	Larkin, Lincoln
435	No Name	Larkin, Lincoln
436	No Name	Larkin, Lincoln
437	No Name	Lincoln
438	No Name	Lincoln
439	No Name	Lincoln
440	No Name	Lincoln
441	Dittmar	Lincoln
442	Hahn	Larkin, Lincoln, Midland
887	Jacobs	Larkin, Midland
8871	Jacobs Branch 1	Larkin
8872	Jacobs Branch 2	Larkin
8873	Jacobs-Woodland 2	Larkin
8874	Jacobs-Woodland North Branch	Larkin
8875	P. Gwyn. Sub.	Larkin
888	Pluss	Larkin
889	Pluss Branch 2	Larkin
890	Miller	Larkin
891	Visgar	Larkin
8911	Visgar Branch 1	Larkin
892	Boyle	Larkin, Hope
893	Whitmer	Larkin, Lincoln, Mills
894	No Name	Mills
895	Morris	Hope, Mills
896	Schoolhouse	Hope, Lincoln
897	Kelly	Hope, Lincoln
898	No Name	Hope
899	No Name	Hope
900	No Name	Hope
901	Weaver	Hope
9011	Weaver Branch 1	Hope
9012	Weaver Branch 2	Hope

Table 3.1 - Reach Numbers and Locations in the Sturgeon Creek Watershed

Reach Number	Name	Township Location
902	McCoy	Hope
903	Harris	Hope
9031	Harris Branch 1	Hope
904	Dittmar	Lincoln
905	No Name	Lincoln
906	State	Lincoln, Midland
907	Bensch	Larkin, Midland
908	Beck	Lincoln, Midland
9081	Beck Branch 1	Midland
909	Inman	Lincoln, Midland
916	Sterns	Lincoln
No Number	Waldo	Larkin
No Number	Waldo Branch 7	Larkin
No Number	Venner	Larkin
No Number	Kruse	Larkin
No Number	Schneider Court	Larkin
No Number	Dempski	Larkin
No Number	McPhillips	Lincoln
No Number	Clark	Lincoln

3.3 STREAM MONITORING

WATER QUALITY MONITORING

Educational and nonprofit groups are pooling their time, manpower, and resources to monitor chemical, physical, and biological parameters in the Watershed. The MCD is coordinating these groups and has purchased a Hydrolab. Saginaw Valley State University (SVSU) is using the Hydrolab for in-stream monitoring of pH, dissolved oxygen, turbidity, temperature, and conductivity. SVSU will also analyze water samples for heavy metals.

The Midland Public Schools is testing for nitrate and ammonia using ion selective electrodes. They are also identifying major organisms in the water. Their activities are conducted through an after-school environmental club, which began sampling during September 2002.

Midland's Waste Water Treatment Plant is analyzing water samples for phosphate and bacterial contamination. Other tests (i.e., biological oxygen demand) have been discussed and may also be performed. The sampling sites are shown in Figure 9.

The information obtained in the water quality monitoring will be used by the MCD as one of many techniques to evaluate the progress of the implementation of the WMP. The comparison of sites in the Watershed on the same date, as well as comparisons of the same site over time, can yield qualitative trends to be analyzed. These trends could show which areas of the watershed are being most affected by water quality improvement BMPs or by land use changes in the Watershed.

3.4 HYDROLOGIC ANALYSIS

INTRODUCTION

A hydrologic analysis was performed for Sturgeon Creek to provide quantitative information in regard to flood discharges. The primary goal of this analysis was to determine the flows associated with flooding events and assist the Steering Committee with policy and BMP decision making. The hydrologic model used in the analysis was able to predict the impact of future development on flood frequency discharges and volumes. The results of the future condition analysis in the downstream urbanizing areas of the watershed, located in Lincoln, Larkin, and Homer Townships and the City, may be used to establish storm water design criteria for new development that will not significantly increase the flow rates and velocities in the Sturgeon Creek system.

HYDROLOGIC ANALYSIS

The goal of the hydrologic analysis was to develop a computational model for flows in the Watershed. The software used for the hydrologic model was the U.S. Army Corp of Engineers program HEC-HMS. This program computed sub-basin hydrographs (a relationship between flow rate and time for a particular rainfall event) and then routed these hydrographs through the river system using the Muskingum Cunge routing method. The result was a tool that can be used to predict how the Watershed will respond to various frequency rainfall events. The analysis was completed based on 1978 land use conditions in the watershed, which were the most recent conditions available in the format necessary to conduct the analysis.

MODEL DEVELOPMENT

The Watershed was sub-divided into 13 sub-basins as illustrated in Figure 7. The Watershed boundary was based on the MDEQ delineation, while the sub-basin delineations were based on county drainage district maps.

HYDROLOGIC PARAMETERS

The HEC-HMS model used Soil Conservation Service (SCS) loss computations and Clark unit hydrographs. The rainfall distribution was a SCS Type II with rainfall depths from *Bulletin 71 - Rainfall Frequency Atlas of the Midwest* (Illinois State Water Survey, 1992). An aerial adjustment factor of 0.953 was used for the 64-square-mile watershed.

CURVE NUMBER

Curve numbers (CN) were based on available soils and land cover data (Figures 4 and 5). The Midland County soils data was taken from the State Soil Geographic (STATSGO) database and the land cover was taken from the 1978 Michigan Resource Information System (MIRIS) database. ArcView 3.2 was used to create a database file providing areas for all combinations of hydrologic soil groups and land use for each sub-basin. The curve number was then averaged for the area using an excel spreadsheet. Two CN estimates were produced for each sub-basin. A high value and a low value were computed based on drained and undrained soil conditions with dual soil group designations. The more conservative, higher value was used in the model.

TIME OF CONCENTRATION

The time of concentration for each sub-basin was computed using the method outlined in *Computing Flood Discharges for Small Ungaged Watersheds* (Sorrel, 2001). A number of flow paths were identified in each sub-basin. The distance and elevation drops were determined using Map Tech USGS mapping software. A spreadsheet was used to compute the time of concentration from the map information. The storage coefficient for the Clark unit hydrograph was set equal to the time of concentration.

ADJUSTMENTS FOR PERCENT PONDING

Adjustments were made in the time of concentration to account for ponding in the sub-basins. These adjustments were based on Equation 9.1 in *Computing Flood Discharges for Small Ungaged Watersheds.* The new time of concentration was one that reproduces the reduced peak discharges utilizing Equation 9.1 directly. To determine the percentage of ponding in each sub-basin, the GIS database was used to generate a file of wetland areas. The percentage of ponding was then computed using a spreadsheet.

TIME OF CONCENTRATION FOR SUB-BASINS ALONG THE CREEK

Sub-basins No. 1 through No. 5 drain by lateral runoff. The times of concentration for these sub-basins were based on overland and waterway flow to Sturgeon Creek.

RESULTS

EXISTING CONDITIONS

The Watershed generally has flat slopes and significant wetland ponding, especially in the upper sub-basins. The initial program runs were made for existing land use conditions. The input parameters, times of concentration, and the computed peak flows from each of the sub-basins for the 100-year, 24-hour rainfall event are given in Table 3.2.

Chart 3.1 compares computed hydrographs from four sub-basins; Grass Creek, Dittmar Drain, State Drain, and Jacobs Drain to highlight the differences among the Sturgeon Creek sub-basins. The Grass Creek sub-basin is the second largest of the 13 sub-basins. It releases a large volume of water. The Dittmar sub-basin contains part of the Au Sable State Forest and includes mostly wetlands. Wetlands have great storage capacities, and tend to release storm water over longer periods of time. The peak flows, therefore, occur later in the Dittmar sub-basin and the time of concentration is longer and peak flows are lower than for the Grass Creek, State Drain, and Jacobs Drain sub-basins.

Most of the peak flow rates occur between 20 and 48 hours after the end of the rainfall. The earlier peak flow rates at sub-basins Nos. 4 and 5 are a result of runoff from a much smaller land area (0.4 and 1.9 square miles).

FUTURE LAND USE - DEVELOPED CONDITIONS

The hydrologic model was also used to predict flow rates under future land use conditions. The existing storm water criteria for the MCDC requires detention equivalent to the 10-year storm with an allowable release rate of 0.33 cfs/acre. The future land use scenario was completed to evaluate detention basin release rate policies for the 25-year, 24-hour rainfall event.

The Technical Committee suggested the maximum amounts of development in various sub-basins for the next 50 years of development. The hypothetical development included the addition of high density (1/4 acre lot size) residential land use to replace approximately 40% of the existing farmland in the Newell, Jacobs, and State sub-basins. The development affected both the SCS curve number and the time of concentration. As more land is developed, a larger portion of the rainfall runs off (higher curve number) and less time is required to reach the outlet of the sub-basin. A weighted curve number was calculated using the same procedure as that for the existing land uses. The time of concentration was reduced using the following method. An equivalent impervious fraction was computed from the 1978 land use (existing curve numbers) and future curve numbers. If CN_1 is the existing curve number and CN_2 is the future curve number then this impervious fraction, *f*, is as follows:

$$f = \frac{CN_2 - CN_1}{100 - CN_1}$$

It is then assumed that the time for flows over that impervious fraction is reduced by 50%. If t_{C1} is the current time of concentration then the future value, t_{C2}, is computed as follows:

$$t_{c2} = t_{c1} (1 - f/2)$$

Table 3.3 compares peak flow rates and runoff volumes for the 25-year, 24-hour storm for both existing and future developed land use conditions.

Assuming that all developments in the Watershed are required to provide detention, the Sturgeon Creek Technical Committee suggested that an analysis be run to determine the allowable release rate from detention basins during future developed conditions, where the developed peak flow rates from the sub-basins match the existing conditions peak flow rates. Four model applications were performed. They modeled the impacts of release rate restrictions of 0.33 cfs/acre (existing Midland County Standards) 0.13 cfs/acre, 0.10 cfs/acre and 0.04 cfs/acre for three developing sub-basins. The hydrologic parameters used for the existing and developed conditions are as follows:

	Existing Conditions		Developed Conditions	
Sub-basin	Curve Number	Time of Concentration (hr)	Curve Number	Time of Concentration (hr)
Newell	69	22.3	72	21.3
Jacobs	69	8.9	70	8.76
State	75	18.4	77	17.7

Table 3.4 shows the results of the four model applications.

FUTURE LAND USE - ADDITIONAL WETLANDS

The Technical Committee suggested that 80% of hydric soils that are currently not wetlands could potentially be converted to wetlands in the following sub-basins: Harris/McCoy/Weaver, Upper Sturgeon, Grass Creek, northern Newell, and middle/northern state. The majority of hydric soils that were not currently wetlands were assumed to be in agricultural use. The change of farmland to wetlands affects both the SCS CN and the time of concentration.

A weighted CN was calculated using the same procedure as that for the existing land uses. New ponding factors for each sub-basin were calculated based on the hydric soils. The time of concentration was increased using the method outlined in *Computing Flood Discharges for Small Ungaged Watersheds* (Sorrel, 2001). A spreadsheet was used to compute the time of concentration using the new ponding factors.

Table 3.5 compares peak flow rates for the 25-year, 24-hour storm for both existing and additional wetland conditions.

CONCLUSIONS

Almost half of the drainage area to the Sturgeon Creek is forested. The upper and middle portions of the Watershed are characterized by forestland and agricultural uses. The lower portion of the Sturgeon Creek is characterized by forestland, agricultural uses, and residential areas with increasing urban development. This development will have some impact on the amount of runoff entering the Sturgeon Creek.

Comparisons of existing and future flow rates in the Newell, Jacobs, and State sub-basins, without detention, show the potential impact of development in the lower part of the Watershed. In the lower sub-basins, the peak flow rates entering the Sturgeon Creek from a 25-year storm event are shown to increase by an average of 15% and the runoff volumes by 11%. The peak flow rates in the Sturgeon Creek near the confluence with the State Drain increase by an average of 4% and the runoff volumes also increase by an average of 4%. The increased flow rates could increase flood elevations. Increased runoff volumes, due to more impervious cover, may decrease baseflow to the river.

The most significant finding from the storm water detention basin release rate evaluation during the 25-year, 24-hour storm is that providing storm water detention, with the goal of maintaining sub-basin peak discharges to existing rates may result in peak flow rates at the Sturgeon Creek outlet that are higher than those for existing conditions. The evaluation found that storm water detention delays the peak discharge enough to have it coincide with the peak flows from further upstream. The first three scenarios use storm water detention basin release rates of 0.33 cfs/acre, 0.13 cfs/acre, and 0.10 cfs/acre. The evaluation found that to maintain the peak discharges at the Sturgeon Creek outlet to existing levels after development, a storm water detention basin release rate on the order of 0.04 cfs/acre or less is required.

Storm water detention with release rates of 0.10, 0.13, or 0.33 cfs/acre also showed an increase in peak discharges for the 25-year, 24-hour event as shown in Table 3.4. This is due to similar conditions as in the overall Watershed where development near the outlet of the sub-basin delays the release of the storm water runoff until it coincides with upstream flow.

The appropriate design criteria for storm water detention in those sub-basins should be based on the conveyance capacity of the drainage system. Further detailed study may determine that it is appropriate to establish “no detention” zones in the lower portion of the developing sub-basins.

A detention basin release rate of 0.13 cfs/acre has typically been found to provide the most effective and feasible design criteria to control flooding from new development for more extreme rainfall events (25-year and higher frequencies). This release rate does not effectively control the potential for more frequent bankfull, channel-forming flows which tend to increase the rate of erosion in natural channels. Conventional detention systems also do not effectively mitigate the increase in the volume of runoff from the additional impervious surfaces associated with development.

Comparisons of existing conditions and additional wetlands within the Watershed (Harris/McCoy/Weaver, Upper Sturgeon, Grass Creek, Newell, and State sub-basins) show the potential impact of wetland restoration. In the upper sub-basins, the peak flow rates entering the Sturgeon Creek from a 25-year storm event would potentially decrease by as much as 48% with wetlands restored. Peak flow rates in the upper Sturgeon Creek near the confluence of Grass Creek would also potentially decrease by up to 48%. In the Lower Sturgeon Creek, the peak flow rates from a 25-year storm event would potentially decrease by up to 36% with wetlands restored.

Several recommendations are made as a result of this study.

- The hydrologic modeling demonstrated the potential benefits of increased storm water storage through the restoration of wetlands. Wetlands restoration should be evaluated and encouraged.

- A hydraulic analysis to evaluate the capacity of the Sturgeon Creek should be conducted using results of the HEC-HMS hydrologic model. This analysis would evaluate the hydraulic capacity of the channel and all crossings along the creek.

- Based on their research, the Kent County Storm Water Task Force recommended a discharge rate of 0.05 cfs/acre for storms up to the 2-year storm, and 0.13 cfs/acre for larger runoff volumes. The total detention storage should be designed to hold the runoff volume from the 25-year design storm, which is considered adequate for protecting the natural environment and structures from the effect of peak flows coming from an urbanizing area. For the Watershed, the study indicated that storm water detention basin release rates greater than 0.04 cfs/acre may cause increased peak flows at the creek outlet and at the outlet of several sub-basins. A uniform standard, using 0.13 cfs/acre release rate as a bench mark, could be developed. Local planners need to utilize smart growth techniques and wetlands restoration to alleviate the burden of just the developer to achieve these rates.

- Further study should be completed to determine where it is appropriate to create “no detention” zones in the lower portion of the Newell and State sub-basins. Extended detention with a very low release rate (0.04 cfs/acre) could also be considered to control flooding and provide water quality benefits.

Table 3.2 - Hydrologic Model Parameters and Results (100-Year, 24-Hour) - Existing Conditions

Sub-basin Name	Effective Drainage Area (mi^2)	Curve Number	Time of Concentration (hr)	Peak Flow (cfs)	Time to Peak (hr)
Harris/McCoy/Weaver	8.2	76	20	455	31.3
Upper Sturgeon	6.3	70	15	361	26.7
Sub-basin 1	2.7	66	11.5	164	23.3
Grass Creek	11.1	69	14.5	751	26.3
Sub-basin 2	1.7	60	18.7	54	30.5
Dittmar	5.0	67	38.6	109	48.7
Sub-basin 3	1.5	64	10.6	86	22.4
Newell	11.7	69	19.7	516	31.2
Sub-basin 4	0.4	67	1.8	101	13.6
Jacobs	3.9	69	8.6	334	20.3
Hahn	1.3	73	15.7	157	27.3
State	8.3	75	17.4	503	28.5
Sub-basin 5	1.9	74	3.2	441	14.9

Table 3.3 - Peak Flow Rates and Runoff Volumes for Future Developed Conditions (25-Year, 24-Hour)

	Existing Conditions		Future Developed Conditions		Change	
Sub-basin Name	Peak Flow Rate (cfs)	Runoff Volume (ac-ft)	Peak Flow Rate (cfs)	Runoff Volume (ac-ft)	PFR (cfs)	RV (ac-ft)
Newell	257	774	309	893	+52	+119
Jacobs	177	257	200	270	+23	+13
State	284	720	320	784	+36	+64

PFR = Peak Flow Rate
RV = Runoff Volume

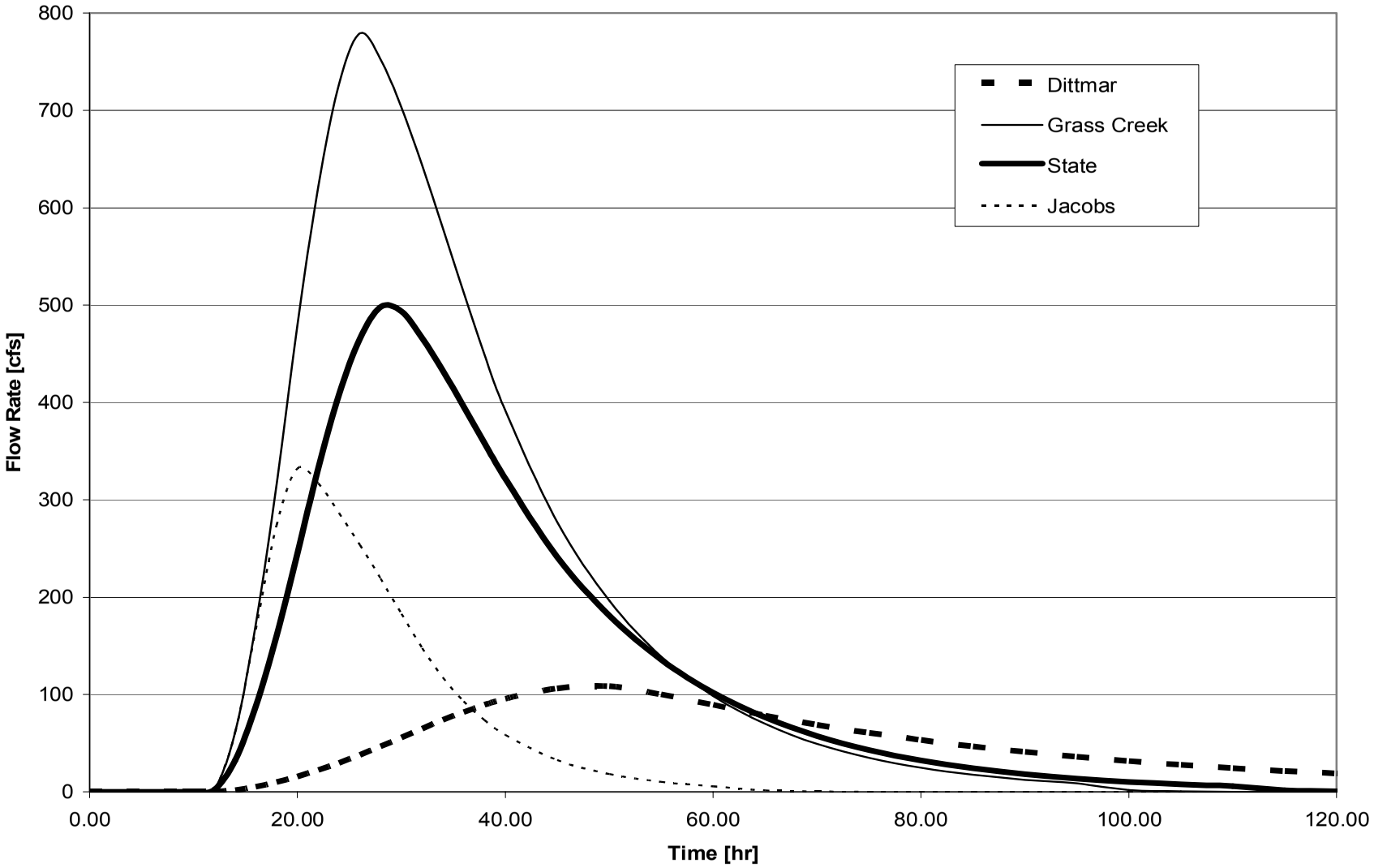
Table 3.4 - Peak Flow Rates and Detention Basin Release Rates (25-Year, 24-Hour)

Condition	Peak Discharge (cfs)			
	Newell Sub-basin	Jacobs Sub-basin	State Sub-basin	Sturgeon Outlet
Existing	257	177	284	1,176
Developed (no storm water detention)	309	200	320	1,230
Developed (0.33 cfs/acre release rate)	315	191	338	1,295
Developed (0.13 cfs/acre release rate)	302	165	316	1,316
Developed (0.10 cfs/acre release rate)	290	156	302	1,302
Developed (0.04 cfs/acre release rate)	223	123	255	1,191

Table 3.5 - Peak Flow Rates for Additional Wetland Conditions (25-Year, 24-Hour)

Sub-basin Name	Peak Flow Rates (cfs)		
	Existing Conditions	Additional Wetlands	Changes
Harris/McCoy/Weaver	248	114	-134
Upper Sturgeon	194	108	-86
Grass Creek	317	174	-143
Newell	257	210	-47
State	284	153	-131

Chart 3.1 - Hydrographs of Existing Conditions (100-Year, 24-Hour)



3.5 DESIGNATED USES OF THE STURGEON CREEK WATERSHED

The Technical Committee created a Prioritization Subcommittee to evaluate how impairments to the watershed have affected its designated uses. The following members were assigned to this committee:

- Mr. Scott Marsh, Midland Conservation District
- Mr. Charlie Bauer, MDEQ
- Mr. Elan Lipschitz, Little Forks Conservancy
- Mr. Joe Haas, MDEQ
- Mr. Doug Morse, MDEQ
- Mr. Tom Nelson, Isabella County Conservation District
- Mr. Will Sears, Midland County Natural Resource Conservation Service
- Ms. E. Wendy Ogilvie, FTC&H
- Ms. Diane Hornbrook, FTC&H

The committee held its first meeting on February 27, 2002, at the MCD offices. The committee's first task was to identify the designated uses of the surface water within the Watershed. The following designated uses have been assigned by the State of Michigan for all "waters of the state." They provide a starting point for discussion about the goals of the watershed project.

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

3.6 PRIORITIZATION OF DESIGNATED USES

The Committee's next order of business was to prioritize the identified designated uses based on the degree of impairment. The impairments had previously been selected through examination of field inventory results, existing studies, including the 1992 MDEQ Biological Survey, and local knowledge. The prevalence and impact of each pollutant was discussed in relationship to each of the designated uses. The subcommittee determined that the highest priority designated use in the Watershed is warmwater fisheries which is impaired primarily by sediment.

The main questions that were posed to aid in prioritization were the following:

- How are the designated uses impaired in this watershed?
- What are the ways in which the designated uses are part of the community?
- What is the feasibility of restoring the uses?
- Which restoration efforts will have the greatest cost benefit?
- What BMPs in other watersheds have had the greatest positive and negative effects, and what can be learned from other studies?
- Which BMPs are most appropriate for the Watershed?

The amount of activity for each designated use and the amount of impairment from the pollutants were the weighted determining factors. Consensus was reached in the Prioritization Committee after thorough discussion, yielding the following results:

WARMWATER FISHERY

Providing a warmwater fishery requires maintaining fish populations of bass, pike, walleye, or pan fish in the Watershed's streams. Not only is water quality a concern, but appropriate temperature and habitat must also be maintained. Dissolved oxygen should not fall below 5 mg/l for rivers and streams. Fish populations must be sustainable, thus the needs for all stages of the fish's life cycles must be considered. Warmwater fishery was determined to be the most impacted designated use. Sediment has damaged the quality of fisheries. Silt and sand has covered the streambed, not only reducing the spawning grounds, but also destroying the habitat of their macroinvertebrate food sources. Fishing is a popular activity in the Watershed, but is impaired by the degraded fish population according to the MDEQ Biological Survey.

OTHER INDIGENOUS AQUATIC LIFE AND WILDLIFE

The use of the Watershed's surface water by other indigenous aquatic life and wildlife requires maintaining water quality. Maintaining large contiguous areas of forest, wetlands, and upland meadow is also important for many species. Land development and fragmentation threatens indigenous populations by cutting natural areas into smaller, non-contiguous areas. Indigenous aquatic life and wildlife are also greatly impacted by the sediment and nutrients that enter the water. Algal blooms are common in parts of the Watershed, often downstream of residential areas. The MDEQ Biological Survey indicated that macroinvertebrate communities and habitats were slightly impaired in the upstream site, moderately impaired in the mid-section site, and severely impaired in the downstream site. The stream impairment was attributed to poor flow stability, embeddedness and siltation, and bottom deposition which may be the result of logging, land clearing, agriculture, and other development. These factors resulted in reduced available habitat for aquatic macroinvertebrate species.

The Sturgeon Creek flows through a portion of the Au Sable State Forest, which is home to many indigenous, non-game and game species. This area is managed by the MDNR and has many protections. However, surrounding areas are not afforded such protections and destruction of wetland and floodplain forest communities is occurring. The fragmentation of habits that could occur by not protecting the surrounding areas of the forest is damaging to the wildlife populations.

PARTIAL AND TOTAL BODY CONTACT RECREATION

Partial body contact recreation includes activities where some skin contact is made with the water, but the body is not submerged. Fishing and boating are examples of partial body contact recreation. Water quality must meet minimum standards for health and safety reasons. For example, *E.coli* must be below 1,000 count per 100 ml. Although recreational boating, fishing, and, to a lesser extent, swimming are important uses in the watershed, they are less impacted by surface water impairment than the fisheries and wildlife habitats. Algal blooms downstream of residential areas indicate excess nutrient inputs, possibly from septic system failures or lawn fertilizers entering the stream. Excessive nutrients encourage algal growth and eutrophication, and may create health hazards.

Total body contact recreation includes activities in which total submersion occurs, such as swimming, and the possibility of ingesting the water exists. The season of concern is May 1 to October 31. Water quality issues include pathogens and toxic substances, but most toxic substances have not been studied in the Sturgeon Creek Watershed thus far.

AGRICULTURE

Potential agricultural uses of the creek and its tributaries includes irrigation and livestock watering. Surface water of the Watershed is rarely used for irrigation or watering livestock. Most of the agricultural areas are in the upstream reaches. The potential exists for bacteria-laden manure runoff to reach the streams causing livestock to become ill from water contaminated with bacteria. Sediment has not degraded the quality of irrigation water nor the potential for drawing irrigation water. The Prioritization Subcommittee determined that the use of the Watershed for agriculture was not impaired.

PUBLIC WATER SUPPLY

Public water supply is defined as surface water treated for use as the community's drinking water. At this time, the surface waters in the Sturgeon Creek Watershed are not used as a public water supply. Public water facilities are currently designed for groundwater extraction for individual wells outside of the City. Public water supply for the City is from Lake Huron. Use of the Sturgeon Creek as a public water supply is not warranted nor economically feasible.

INDUSTRIAL WATER SUPPLY

Industrial water supply concerns are temperature, clarity, salinity, and water quality, such as dissolved oxygen. Industries located in the Watershed do not currently use surface waters as a water source. A new industrial venture could possibly choose to use surface water as its water supply, but would more likely prefer using a groundwater supply or Lake Huron.

NAVIGATION

Navigation of recreational small craft such as canoes and kayaks in certain stretches of the Creek occurs occasionally and is not impaired by surface water degradation. Commercial navigation has not occurred in the Watershed, with the possible exception of shallow draft vessels in the late 1800s.

3.7 IMPAIRMENTS TO THE DESIGNATED USES

The following pollutants and impairments have caused the greatest impairment to the designated uses in the watershed. The linkages between the designated uses, impairments, sources, and causes are summarized in Table 3.6.

SEDIMENT

Sediment in the streams originates from streambank and upland erosion, as well as some gouging of the streambed. Streambank erosion was found in the Watershed where livestock and human access have reduced the integrity of the bank. Unstable flows force eroding energy at the streambanks and stream bottom. Some tile outlets have been installed haphazardly or erosion has caused the bank to change, resulting in erosion around the outlet pipe or at the impact point of the discharge. Upland activity, such as certain agricultural or construction practices, have caused soil erosion and sediment-laden runoff to enter the streams. Erosion also often occurs at road/stream crossings. Culverts may be poorly designed, resulting in eddy erosion near the structures. Road embankments may be steep and poorly vegetated, and therefore are susceptible to erosion. Due to the expansive wooded wetlands and soil types in the Watershed, silt and organic detritus tend to compose much of the sediment in central regions of the Watershed.

Various studies, such as the MDEQ Biological Inventory, have shown sediment to be the pollutant of greatest concern in the Watershed. Total suspended solids affect turbidity, light penetration, and habitat.

Sediment has covered riffles and ruined spawning sites, as well as destroying macroinvertebrate and other aquatic life habitat.

EXCESSIVE NUTRIENTS AND ALGAE

In the Watershed, algal blooms, an indicator of excessive nutrients, were observed downstream of residential areas. The nutrients of concern are nitrogen and phosphorus because increases in the levels of these nutrients may have drastic effects on the ecosystem. The presence of algal blooms may indicate that septic systems are malfunctioning or leaking, or storm water is washing lawn fertilizers, pet waste, and other accumulated nutrients into the stream. It may also indicate manure runoff, since the watershed contains agricultural land.

Elevated nutrients, mainly phosphorus, in surface waters result in overpopulation of select aquatic plant species, such as those that are best able to quickly absorb the nutrients, grow, and adapt to changing conditions. These species dominate and crowd out other species, which can have dramatic effects on fish and other wildlife populations. Algal blooms are unsightly and cause areas to be unfit for recreation.

DISSOLVED OXYGEN AND PH LEVELS

The Watershed has little elevation change. As a result, the Creek and its tributaries flow very slowly, and are stagnant at certain times of the year and in certain locations. When the Creek is stagnant, it functions more like a lake than a creek. As algae dies, the algal material settles to the Creek bottom and is broken down by microbial activity. As the microbial metabolic activity increases, oxygen is consumed, and the pH drops from the production of carbonic acid. The oxygen depletion is exacerbated when warm summer temperatures reduce the amount of dissolved oxygen in the system. The combination of these factors can result in anaerobic conditions in the stream, especially near the bottom of these stagnant areas. Reduction of the oxygen levels in the stream can result in fish kills and the decline of populations of other aquatic species.

HYDROLOGY

Changes in flow patterns, especially increased peak flows and decreased attenuation, have caused multiple problems in the lower reaches of the watershed. Development and wetland destruction increase the amount of imperviousness in the watershed. As a result, storm water runoff reaches the streams faster and with greater volume and force than if it were allowed to seep into the ground. A greater amount of water with greater energy enters the stream, eroding the banks and causing flooding. Water rushes

through the system, rather than slowly seeping through the ground to recharge the stream. Water surface elevations are extremely high immediately after rain events and may be very low after a relatively short period of time.

These fluctuations in water level and velocity damage fish and wildlife habitats in many ways. The physical effects make the streams unfit for some species. Erosion quickly destroys habitat and increases sedimentation. The fluctuations also affect recreation, such as fishing, boating, and swimming, occasionally making conditions treacherous or unmanageable.

OTHER POLLUTANTS AND NONPOINT POLLUTION CONCERNS

TEMPERATURE

Storm water that passes over heated urban land, such as parking lots and driveways, can increase the temperature of a stream. Most aquatic species prefer temperatures to be maintained within certain optimal ranges, and increased temperatures can be a disturbance to the ecosystem.

PESTICIDES

Pesticides intended to eradicate insects on lawns or crops are often captured in rainwater and wash into the streams, affecting native aquatic insect and macroinvertebrate populations. A reduction in these populations causes a decline in fish populations.

OIL AND GREASE

Runoff from parking lots and roadways often contains oil, grease, and other vehicle fluids which are harmful to aquatic species.

METALS AND OTHER TOXIC SUBSTANCES

Urban storm water runoff, especially from roads with heavy traffic, often contain heavy metals. Airborne mercury from coal-fired power production is dissolved in rain water. PCBs enter the surface water system through a variety of sources. Household and commercial waste such as paints, florescent lights, and capacitators contain PCBs and dioxins. These pollutants can become airborne or be washed out of their containers and into streams when not disposed of properly. These compounds become bound to sediment and are absorbed by macroinvertebrates and other aquatic organisms. The metals may have

toxic effects throughout the food chain, especially in industrialized areas. Mercury bioaccumulates in tissue and fish may contain such high levels of mercury that they become toxic to predators or are unfit for human consumption.

E. COLI BACTERIA

E. coli is an indicator of other pathogens in the water. Warm blooded animals carry the bacteria and it is often found in manure and septic systems. The presence of *E. coli* in stream water may indicate that there is a source of human or animal waste in the area.

Table 3.6 - Prioritized Designated Uses and Pollutants in the Sturgeon Creek Watershed

Designated Use	Pollutants/Impairments	Sources	Causes
#1 - Warmwater fishery	**#1** Excessive sediment[2] (Total suspended solids and total dissolved solids at Jacobs Drain)	Streambank erosion[1]	Livestock access[1]
			Human access[1]
			Unstable flows[3]
		Rill and gully erosion[1]	Road/stream crossings[1]
			Farm practices[1]
			Development (s)
		Tile outlets[1]	Improper installation[1]
	#2 Excessive nutrients[2] (T. phosphorus at Cook Road)	Manure (s)	Livestock in stream[1]
			Manure runoff (s)
			Improper application (s)
		Fertilizer runoff (s)	Improper application (s)
			Spills (s)
		Septic system failures (s)	Improper maintenance (s)
	#3 Pesticides (s)	Urban runoff (s)	Improper application (s)
			Spills (s)
		Agricultural runoff (s)	Improper application (s)
			Spills (s)
	#4 Dissolved oxygen and pH levels (s)	Manure (s)	Improper application/storage (s)
		Excessive algae[1]	Failing septic systems (s)
	#5 Temperature (s)	Lack of shading[1]	Removal of streamside vegetation[1]
		Impervious surfaces (s)	Development (s)
	#6 Oil & grease (s)	Urban runoff (s)	Residual from gas stations/parking lots/roads (s)

Table 3.6 - Prioritized Designated Uses and Pollutants in the Sturgeon Creek Watershed

Designated Use	Pollutants/Impairments	Sources	Causes
	#7 Metals (s)	Urban runoff (s)	Residual from gas stations/parking lots/roads (s)
	#8 Hydrology[3]	Impervious surfaces (s)	Development (s)
			Decreased roughness of banks
		Channelization (s)	Destruction of meanders
		Loss of wetlands[4]	Drainage for agriculture and development
#2 - Other indigenous aquatic life and wildlife	**#1** Excessive sediment[2]	Same as above	Same as above
	#2 Excessive nutrients[2]	Same as above	Same as above
	#3 Pesticides (s)	Same as above	Same as above
	#4 Dissolved oxygen and pH levels (s)	Same as above	Same as above
	#5 Temperature (s)	Same as above	Same as above
	#6 Oil & grease (s)	Same as above	Same as above
	#7 Metals (s)	Same as above	Same as above
	#8 Hydrology[3]	Same as above	Same as above
#3 - Partial/total body contact recreation	**#1** *E. coli* bacteria (s)	Manure (s)	Livestock in stream[1]
			Manure runoff (s)
			Improper applications (s)
		Septic system failures (s)	Improper maintenance (s)
	#2 Excessive nutrients[2] and algae[1]	Same as above	Same as above
Agriculture	Not an impaired use		
Public water supply	Not a use		
Industrial water supply	Not a use		
Navigation	Not a use		

s = Suspected

1) Watershed inventory conducted September 2001 - January 2002

2) Morse, Douglas. 1992. A Biological Survey of Sturgeon Creek, Midland County, July 8, 1991. MI/DNR/SWQ-92/107.

3) Saginaw Bay Watershed Prioritization Process.

4) Hydrologic Study, FTC&H, 2002.

5) Wetland Map, FTC&H, 2002.

3.8 PRIORITIZATION OF POLLUTANTS

The final step in the identification and prioritization of designated uses was to rank the pollutants within each designated use by the amount of degradation the pollutants were causing on surface waters in the watershed. The prevalence of each pollutant was considered, and its weighted effects based on its toxicity were evaluated. Known pollutants were often ranked higher than suspected pollutants, unless the effects of the suspected pollutant had the potential to cause devastating disturbances. The ranked results are displayed in Table 3.6.

3.9 DESIRED USES OF THE STURGEON CREEK WATERSHED

The designated uses discussed in Section 3.5 have been assigned by the State of Michigan to address water quality concerns. The Steering Committee has determined that other uses, not necessarily related to water quality, are also desirable for the Watershed. These are not goals of the WMP, but merely suggestions for the future use of the Watershed. All comments listed were received from the public at public meetings or the Steering Committee meetings. The suggestions must be considered as to how they integrate with other recommendations in the WMP before being implemented.

WILDLIFE HABITAT

- Maintain wildlife corridors along Sturgeon Creek and create creature highways for safe passage of wildlife between open spaces.

- Study deer and beaver management techniques to determine the most beneficial methods of controlling populations and impacts on the Watershed.

RECREATION

- Develop a Sturgeon Creek Greenway throughout the Watershed working with the Saginaw Bay Greenways Collaborative.

- Create more accessibility to the Au Sable State Forest with educational information provided about the Forest ecosystem.

- Improve recreational navigation in the lower reaches by installing access sites and removing log jams and other obstructions.

DEMONSTRATION FOR INNOVATIVE SITE DESIGNS AND PRESERVATION

- Increase use of innovative landscaping and bioretention areas in urban portions of the Watershed in storm water management.

- Create an open space development demonstration area within the watershed to illustrate the concept.

- Protect landscapes to allow functioning of natural systems in Watershed. Include healthy buffers on streams through the acquisition of property or conservation easements.

- Encourage increased future land use planning. The Larkin Township Master Plan was adopted in 1993 and lists goals and objectives for many types of development. It includes residential, commercial, and industrial development, as well as community facilities, transportation, recreation, and open space. Future land use planning is identified as important to the development of Larkin Township.

GIS DEPARTMENT

- Establish County GIS Department to incorporate information and develop coordinated base maps and information systems.

SUSTAINABILITY

- Form Midland County Watershed council to continue mission of the Steering Committee.

- Continue water quality monitoring through university and local school participation and the MDEQ biological surveys.

3.10 WETLAND RESTORATION AND PROTECTION

One of the most notable attributes of the Watershed is its extensive forests, a substantial percentage of which are also wetlands. The Steering Committee desires to not only preserve the wetlands that exist in the Watershed, but to also restore and create more wetlands in appropriate locations. Funding through the Wetlands Reserve Program is available, making wetland restoration economically feasible. Awareness of and participation in this program should be encouraged.

Figure 10 shows potential wetland restoration areas based on soil type. The areas in yellow have hydric (or wetland) soils. The areas in green contain existing wetlands, according to the combined results of the MDEQ 2000 Land Use Data and early 1980s National Wetlands Inventory maps. The blacked out areas are those areas already developed. Wetland restoration in these areas would be unlikely, though there is the potential for constructing storm water detention basins in the developed areas. The yellow areas would be most conducive to wetland restoration, because they formerly contained wetlands and wetland functions should develop quickly in these soils.

The recommendations from the hydrologic study should be applied to Figure 10 to determine the prime wetland restoration sites. Each individual site will have to be visited to determine its condition and the cost-benefit of restoring wetland functionality. Mr. Robert Zbiciak, Wetland Specialist, of the MDEQ has established criteria for evaluating or prioritizing wetland restoration sites. He identified the following factors to consider when determining which sites to restore. They are listed in decreasing level of priority:

- Sites located within “critical areas” where the majority of pollutants originate.
- Sites where the restored wetland would be the most effective in addressing an identified source or cause of impairment.
- Proximity to a water course; closer is preferred.
- Willingness of the landowner to restore the wetland.
- The MDEQ permit requirements and the likelihood of obtaining a permit (if one is required).
- Current use of the restorable area. Open space or agricultural land is generally preferred.
- Size of the restorable area. Establish a minimum size for restoration projects.
- Adjacent land use. Adjacent areas of natural habitat are preferred from a wildlife perspective. However, from a water quality perspective, it may be better to have the restoration area adjacent to a source or cause of an impairment.
- Soil types within the restoration area. Muck and peat might be preferred over mineral hydric soils.
- Number of landowners that would need to consent to allow the wetland to be restored. Generally, the more landowners that are involved, the more difficult it is to accomplish the project.

- Cost of restoration. Projects that can be done inexpensively, such as tile breaks and ditch plugs, should be favored over expensive projects that involve extensive construction of dikes or significant earth moving.

Before restoring a wetland site, the resulting effects on neighboring property must also be considered, to avoid unwanted flooding.

3.11 GOALS AND OBJECTIVES

The Steering Committee developed goals and objectives for the Watershed based on the known impairments to the designated uses, as described in Table 3.7.

The goals for the designated use of warmwater fishery are to improve the habitat for a warmwater fishery and to provide high quality waters for the fisheries habitat. Sediment, nutrients, and hydrology are known impairments to this use in the Watershed. Suspected impairments include temperature, low dissolved oxygen levels, hydrocarbons, pesticides and chemicals, and heavy metals. Continued water quality monitoring will identify areas in which BMPs need to be applied to reduce sediment and nutrient loading. Increased enforcement of soil erosion and sedimentation control measures will further reduce sedimentation and attached nutrients. The recommendations of the hydrologic model address the impairments from the altered hydrology of the system and identify locations for potential wetlands restoration.

The designated use of indigenous aquatic life and wildlife focuses on the ecosystems of the Watershed. The goal for this use is to protect areas to continue to function as natural systems in the Watershed. Sediment, nutrients, hydrology, and the fragmentation of habitat are known impairments to this use. Suspected impairments include temperature, low dissolved oxygen levels, invasive and exotic species, hydrocarbons, pesticides and chemicals, and heavy metals. Sediment and nutrients will be reduced by installing buffers along the waterways in the Watershed to filter runoff and provide habitat. The recommendations of the hydrologic model address the impairments from the altered hydrology of the system and identify locations for potential wetlands restoration. Land preservation and conservation programs can assist in the protection of large tracts of land to minimize the fragmentation of habitats.

Partial and total body contact recreation are popular uses in the Watershed, but are suspected to be impaired by fecal coliform bacteria, specifically, *E. coli.* The goal for these uses in the Watershed is to keep waters safe for boating, fishing, and swimming in designated areas in the Watershed. Preventing *E. coli* from entering the surface waters will work toward meeting Michigan Water Quality Standards.

Identified sources will be eliminated and other preventive BMPs will be implemented to reduce inputs from unknown sources.

Suspected pollutants will be addressed through educational efforts and the reduction of storm water runoff. The establishment of a volunteer monitoring program will increase awareness and stewardship in the Watershed.

Table 3.7 - Water Quality Goals and Objectives for the Sturgeon Creek Watershed

Designated Use	Goal	Pollutants/Impairments/Threats	Objectives
Warmwater fishery	Improve habitat for warmwater fishery and provide high quality waters for fisheries.	Excessive sediment (Total suspended solids (TSS) and total dissolved solids (TDS) at Jacobs Drain)	Reduce TSS in areas identified in the MDEQ water quality monitoring studies and volunteer monitoring programs by preventing soil erosion and reducing sedimentation.
		Excessive nutrients (Total phosphorus at West Main Street)	Reduce phosphorus loading to meet EPA guidance level of 0.1 mg/l P for flowing water and possibly set standards of 50 micrograms/l P for lakes in setting criteria for wetlands.
			Monitor and reduce nitrogen levels where necessary to meet water quality standards.
			Preserve or restore wetlands and create buffers to filter excess use of nutrients before they flow into rivers and streams.
		Temperature (s)	Preserve and increase canopy on waterways and maintain vegetation on the south and east sides of county drains.
			Increase ratio of groundwater recharge to surface runoff by protecting recharge areas and reducing impervious surfaces.
		Low dissolved oxygen level(s)	Meet warmwater minimum for dissolved oxygen of 4 to 5 mg/l by maintaining cool temperatures and limiting nutrient loading.
			Monitor pH levels for extremes.

Table 3.7 - Water Quality Goals and Objectives for the Sturgeon Creek Watershed

Designated Use	Goal	Pollutants/Impairments/Threats	Objectives
		Hydrology	Follow recommendations of hydrologic model and mapping. Locate areas for potential wetlands restoration to increase storage capacity. Minimize channelization. Protect recharge areas by reducing or preventing increases in impervious surfaces.
		Hydrocarbons (s)	Reduce oil and grease inputs.
		Pesticides and chemicals (s)	Monitor pesticide usage and impact with information from previous MDEQ study on pesticides in the Saginaw Bay Watershed.
			Limit contamination due to improper use and storage of pesticides and chemicals.
		Heavy metals (s)	Investigate levels of heavy metals in Watershed using ICP and the Volunteer Monitoring program.
			Develop strategies to reduce inputs to meet Michigan Water Quality Standards.
Other indigenous aquatic life and wildlife	Protect areas to function as natural systems in the Watershed.	Excessive sediment (Total suspended solids and total dissolved solids at Jacobs Drain)	Encourage natural buffers along streams to filter sediment and create habitat using native species.
			Protect natural systems and increase conservation areas.

Table 3.7 - Water Quality Goals and Objectives for the Sturgeon Creek Watershed

Designated Use	Goal	Pollutants/Impairments/Threats	Objectives
		Excessive nutrients (Total phosphorus at Cook Road)	Reduce phosphorus loading to meet EPA guidance level of 0.1 mg/L P for flowing water and possibly set standards of 50 micrograms/l P for lakes in setting criteria for wetlands.
			Monitor and reduce nitrogen levels where necessary to meet water quality standards.
			Restore wetlands to promote natural uptake of phosphorus while creating habitat.
		Fragmentation of habitat	Minimize fragmentation of habitat.
		Temperature (s)	Preserve and increase canopy on waterways and maintain vegetation on the south and west sides of county drains.
			Increase ratio of groundwater recharge to surface runoff by protecting recharge areas and reducing impervious surfaces.
		Low dissolved oxygen level(s)	Meet warmwater minimum for dissolved oxygen of 4 to 5 mg/l by maintaining cool temperatures and limiting nutrient loading.
			Monitor pH levels for extremes.
		Invasive and exotic species (s)	Minimize spread of invasive and exotic species.

Table 3.7 - Water Quality Goals and Objectives for the Sturgeon Creek Watershed

Designated Use	Goal	Pollutants/Impairments/Threats	Objectives
		Hydrology	Follow recommendations of hydrologic model and mapping. Locate areas for potential wetlands restoration to increase storage capacity. Minimize downstream channelization. Protect recharge areas by reducing or preventing increases in impervious surfaces.
		Hydrocarbons (s)	Reduce oil and grease inputs.
		Pesticides and chemicals (s)	Monitor pesticide usage and impact with information from previous MDEQ study on pesticides in the Saginaw Bay Watershed.
			Limit contamination due to improper use and storage of pesticides and chemicals.
		Heavy metals (s)	Investigate levels of heavy metals in Watershed using ICP and the Volunteer Monitoring program.
			Develop strategies to reduce inputs to meet Michigan Water Quality Standards.
Partial/total body contact recreation	Keep waters safe for boating, fishing, and swimming in designated areas.	Fecal coliform bacteria (s) (*E. coli*)	Prevent *E. coli* from entering surface waters and meet Michigan Water Quality Standards of 1,000 count/100 mg for partial body contact recreation and 300 count/100 mg for total body contact recreation.

3.12 WATER QUALITY SUMMARY

The Watershed encompasses 40,862 acres, which can be separated into eight major subbasins. Sturgeon Creek is 17.7 miles long. The total length of the Creek and all of its tributaries is 143 miles. The Watershed has a large amount of forest land and forested wetlands, which flood seasonally. The upper reaches are in agricultural use, the middle section passes through state managed forest land, and the lower reaches flow to the Tittabawassee River through residential and urban land, including the City.

The designated uses of surface water in the Sturgeon Creek watershed that have the highest priority are warmwater fishery, other indigenous aquatic life and wildlife, and partial/total body contact recreation. Little information is available on water quality in the Watershed, but sedimentation has been documented as degrading the streambeds and excessive nutrients are impacting water quality.

The known sources of sediment and nutrients are scattered throughout the Watershed. A survey of the Creek and its tributaries was completed in summer 2001 and spring 2002. The following indications of nonpoint source pollution were observed during the survey:

- 31 sites with debris and trash
- 2 construction sites with soil erosion
- 9 eroded stream crossing sites
- 30 rill and gully erosion sites
- 23 tile outlet erosion or discharge sites
- 52 streambank erosion sites
- 13 occurrences of algal blooms
- 31 miscellaneous nonpoint source pollution sites
- 1 filled sediment lagoon

The overall goals for the designated use of warmwater fishery were to improve riparian habitat and water quality by mitigating sources of sediment and excessive nutrients. Protecting the designated use of indigenous aquatic life and other wildlife will have an ancillary benefit for the warmwater fishery since it will require the restoration and protection of riparian corridors. Another goal for the watershed is the enhancement of partial and total body contact recreation. A summary of the impairments facing the Sturgeon Creek watershed follows:

Impairment: **Sediment**

Description: Excess sediment covers riffles, destroys spawning habitat, and causes turbidity.

Sources: Sediment comes from both upland and in-stream sources. Cropland, construction sites, gullies, and stream crossings were identified as sources.

Causes: Conventional tillage practices that leave soil exposed to water and wind erosion cause erosion. Exposed soil erodes from construction sites where proper soil erosion and sedimentation control practices are not installed or maintained. Active gully erosion on fields without filter strips or stabilized outlets adds sediment to the stream. Unrestricted livestock and vehicle access to the stream causes streambank erosion.

Goals: Improve habitat for warmwater fishery and provide high quality waters for fisheries.
Protect areas to function as natural systems in Watershed.

Objectives: Reduce TSS in areas identified in the MDEQ water quality monitoring studies and volunteer monitoring programs by preventing soil erosion and reducing sedimentation.

Encourage natural buffers along streams to filter sediment and create habitat using native species.

Protect natural systems and increase conservation areas

Impairment: **Nutrients**

Description: Excess nutrients, such as phosphorus and nitrogen, cause eutrophication, a cycle which depletes oxygen and increases plant growth to an extent where many fish species can not survive. Algae grows at a rapid rate due to the excess nutrients; mainly phosphorus. The algae settles on slow moving stream bottoms as it dies and forms a thick layer of organic matter. The decomposition process depletes oxygen, causing anoxic conditions which creates methane. The process destroys the balance of water chemistry and food webs.

Sources: Nutrients in fertilizers used in agricultural applications, residential applications, and landscaping enter the river and streams in storm water runoff. Nutrients concentrated in human and animal wastes are introduced into surface waters through leaking manure storage areas, failing septic systems, and direct discharges from livestock access or runoff. Yard waste, especially leaves and grass clippings, dumped in the waterways decompose quickly into available nitrogen and organic matter, adding to the nutrient levels.

Causes: Improper fertilizer and manure application and storage allow nutrients to enter surface water and groundwater. Septic system failures and direct discharges are a speculated contributor. Yard wastes piled on the banks of streams may blow directly into the water adding nutrients or yard waste can enter during a flooding event. Lack of buffer strips in agricultural and residential areas.

Goal: Improve habitat for warmwater fishery and provide high quality waters for fisheries. Protect areas to function as natural systems in Watershed.

Objectives: Reduce phosphorus loading to meet EPA guidance level of 0.1 mg/l P for flowing water and possibly set standards of 50 micrograms/l P for lakes in setting criteria for wetlands.

Monitor and reduce nitrogen levels where necessary to meet water quality standards.

Preserve or restore wetlands and create buffers to filter and use excess nutrients before they flow into rivers and streams.

Restore wetlands to promote natural uptake of phosphorus while creating habitat.

Impairment: Fragmentation of Habitat

Description: Many species rely on large tracts of territory and/or migration corridors. Land use changes downsize these areas and wildlife may be forced onto fringe lands. This can lead to conditions where wildlife take on new niches that may conflict with new land uses. Fringe species may now have access to forest communities that cannot compete, thus destroying populations of forest dwelling species.

The other problem associated with the degradation of habitat is the loss of riparian corridor canopy. Buffers around stream corridors not only provide shade to maintain cool water temperatures, they also filter nutrients and sediments from entering the stream. Sediments cover sand and gravel beds that are essential spawning grounds for warmwater fish.

Sources: Development of large tracts of land are disrupting continuous area of habitat and the loss of riparian corridors.

Causes: Lack of planning for controlled growth causes haphazard development to occur in the Watershed.

Goal: Protect areas to function as natural systems in the Watershed.

Objectives: Minimize fragmentation of habitats.

Impairment: ***E. Coli***

Description: *E. coli* presence has been suspected in the Sturgeon Creek and may cause sickness in livestock and humans that ingest contaminated water.

Sources: *E. coli* is found in the digestive system of warm-blooded animals and is spread through feces. The detection of *E. coli* often indicates that other dangerous types of bacteria might be present. *E. coli* cannot live for long periods of time outside of a host body, therefore, when found in surface watershed the source must be relatively close. Potential sources include livestock in the stream, wildlife, septic systems, and manure storage areas.

Causes: Unlimited access to streams allows livestock and wildlife to spread bacteria. Leaking and undersized septic systems allow *E. coli* to enter water bodies. Leaching or overflowing manure storage areas can also add bacteria to the streams.

Goal: Keep waters safe for boating, fishing, and swimming in designated areas.

Objectives: Prevent *E. coli* from entering surface waters and meet Michigan Water Quality Standards of 1,000 count/100 mg for partial body contact recreation and 300 count/100 mg for total body contact recreation.

Impairment: **Temperature**

Description: Temperature is also a minor priority to warmwater fisheries.

Sources: Surface runoff, especially near parking lots and heavily paved areas, contributes warm water to streams. Limited groundwater gains to the stream and low base flows prolong exposure to summer heat and solar radiation. Lack of streamside vegetation also exposes the water to the heat of the sun.

Causes: Increases in impervious surfaces reduce infiltration, causing low base flows and increased water temperature. Excessive irrigation also causes low flows which increase temperatures. Removal of streamside vegetation eliminates shading from the sun.

Goal: Improve habitat for warmwater fishery and provide high quality waters for fisheries.
Protect areas to function as natural systems in the Watershed.

Objectives: Preserve and increase canopy on waterways and maintain vegetation on the south and west sides of county drains.

Increase ratio of groundwater recharge to surface runoff by protecting recharge areas and reducing impervious surfaces.

Impairment: **Low Dissolved Oxygen Levels**

Description: Warmwater fish require a minimum dissolved oxygen level of 4 to 5 mg/l. Excessive nutrients can cause algal blooms and prolific amounts of aquatic vegetation. Plants add oxygen to the water column during the day, however, at night plants and algae respire and use available oxygen. When vegetation dies, bacteria decompose the rotting plant matter. This decomposition process also consumes available oxygen.

Sources: Algae blooms, excessive aquatic vegetation, and high Biological Oxygen Demand.

Causes: Excessive nutrients from agriculture and residential runoff. Sediment containing phosphorus can lead to nuisance levels of aquatic vegetation.

Goal: Improve habitat for warmwater fishery and provide high quality waters for fisheries.
Protect areas to function as natural systems in the Watershed.

Objective: Meet warm water minimum for dissolved oxygen of 4 to 5 mg/l by maintaining cool temperatures and limiting nutrient loading.

Impairment: Invasive and Exotic Species

Description: Invasive species, specifically garlic mustard, autumn olive, purple loostrife, and Eurasian watermilfoil, have been found in the Sturgeon Creek watershed. In fringe areas, the brown-headed cow bird has been a threat to song birds.

Sources: Invasive species are spread by physical transport, such as on boats and cars, or through environmental sources such as wind, on birds, and on or inside other animals. Garlic mustard is spread unintentionally by using offsite fill dirt that contains viable seed banks.

Causes: Unstable or disturbed areas are more susceptible to invasion than healthy ecosystems. Lack of knowledge about invasive species often spreads them unintentionally. The extensive drain network in the watershed has acted as a conduit for invasive aquatic species.

Goal: Protect areas to function as natural systems in the Watershed.

Objectives: Minimize spread of invasive and exotic species.

Impairment: Hydrology

Description: Changes in flow affect water levels and the rate of water movement. Flashy flows, signified by swift moving high water shortly after a rain and very low levels during dry periods, can be the result of increased artificial drainage. Changes in land use can increase flooding, erosion, and sedimentation.

High water velocity and ponding of water can do severe damage to vegetation and streambanks. Flooded soils can suffocate roots and create soil surfaces that are too soft for farm equipment. Flooding waters also transport debris, trash, logs, and exotic species throughout the watershed. Once waters subside, streambanks can be bare, sediment has been deposited, stream paths could be altered, and crops are destroyed.

Sources: Alteration of drainage patterns and changes in land use affect the natural hydrology of a stream.

Causes: Establishment and improvements of drains, elimination of wetlands, and increases of impervious surfaces destabilize hydrology.

Goal: Improve habitat for warmwater fishery and provide high quality waters for fisheries.
Protect areas to function as natural systems in Watershed.

Objective: Follow recommendations of hydrologic model and mapping.

Locate areas for potential wetlands restoration to increase storage capacity.
Minimize downstream channelization.

Protect recharge areas by reducing or preventing increases in impervious surfaces.

Threat: Hydrocarbons

Description: Hydrocarbons, usually from automotive petroleum products, contaminate fish and macroinvertebrate populations and may travel great distances downstream.

Sources: Irrigation pumps and other machinery along the banks of the streams can leak fuel and oils. The main suspected source for the Sturgeon Creek Watershed is runoff from parking lots and streets and illegal dumping of motor oil into storm drains.

Causes: Old, inefficient, leaking, or faulty pumps and machines release petroleum by-products into the river. Cars that leak oil or gas onto impervious surfaces.

Goal: Improve habitat for warmwater fishery and provide high quality waters for fisheries.
Protect areas to function as natural systems in the Watershed.

Objective: Reduce oil and grease inputs.

Threat: **Pesticides and Chemicals**

Description: Many types of chemicals may find their way into streams either intentionally or by accident. Fat soluble chemicals can accumulate in the fatty tissue of fish and other wildlife making them toxic to large predators or even humans. Pesticides used for control of insects and weeds in agricultural area poses the greatest threat to wildlife in the watershed.

Sources: Improper storage, transport, or application of chemicals. Runoff from parking lots and impervious surfaces may contain anti-freeze, yard care products, or improperly contained chemical spills.

Causes: Runoff from agriculture is the most likely cause for contamination. Over application of pesticides or application just before a rain event can cause runoff of the pesticide into drain systems and eventually into rivers and streams.

Goal: Improve habitat for warmwater fishery and provide high quality waters for fisheries.
Protect areas to function as natural systems in Watershed.

Objective: Monitor pesticide usage and impact with information from previous MDEQ study on pesticides in the Saginaw Bay Watershed.

Limit contamination due to improper use and storage of pesticides and chemicals.

Threat: **Heavy Metals**

Description: Heavy metals bioaccumulate in all levels of the food web. Plants absorb heavy metals from soil and are eaten by consumers, and consumers are eaten by predators, etc. At each level the metals are concentrated to the point they become toxic.

Sources: Storm water and parking lot runoff.

Causes: Heavy metals present in gasoline are deposited on streets and parking lots from car exhaust.

Goal: Improve habitat for warmwater fishery and provide high quality waters for fisheries.

Protect areas to function as natural systems in the Watershed.

Objective: Investigate levels of heavy metals in the Watershed through Volunteer Monitoring program.

Develop strategies to reduce inputs to meet Michigan Water Quality Standards.

CHAPTER 4 - IMPLEMENTATION STRATEGY

4.1 CRITICAL AREAS OF THE STURGEON CREEK WATERSHED

Critical areas of the Watershed are those areas having specific nonpoint source pollution concerns that need to be addressed with applications of BMPs. Critical areas can be identified as riparian corridors, preservation areas, subcatchments, or discharge contribution areas. The identification of critical areas assists those implementing the WMP by guiding their efforts and funding to those areas with the most needs.

The Technical Subcommittee identified the critical areas of the Watershed using information from the field inventory, current uses of the watershed, and designated/desired uses of the watershed. The condition of the streams and sources of impairments were assessed through the field inventory. Maps of all nonpoint source sites, tile outlets, algal blooms, wetlands and hydric soils, streambank erosion, and rill and gully erosion were examined. Spreadsheets were used to rank each of the impairment types by severity to provide further information in determining the critical areas.

The Watershed has many different land uses. Residential, agricultural, forested, and urban areas have different issues and different needs. As a result, four types of critical areas were created and are delineated in Figure 11.

Residential areas are suspected of contributing nutrients to the streams. Algal blooms were found adjacent to and downstream of residential areas, suggesting that nutrients could be entering the waterways from storm water runoff, carrying fertilizers and pesticides that are not properly used or pet waste. Failing septic systems in rural areas could also be contributing nutrients. The Residential Critical Area is categorized by these localized threats and therefore encompasses a riparian area of 100 feet wide from the top of the streambank for all streams and drains in residential areas.

Agricultural areas contribute sediment and nutrients through rill and gully erosion, manure applications, and drain tile outlets. Bare, plowed fields erode easily and runoff from those fields carry sediment and attached pollutants into the streams. The Agricultural Critical Area includes a 1/4 mile wide riparian area along the streams adjacent to agricultural operations.

The City has a network of storm sewers that contributes directly to the Sturgeon Creek and its tributaries. Parking lots and roadways collect vehicle fluids, heavy metals, and road salts, which enter into the storm sewers during rain events. Storm sewers have often been used as disposal areas for household and other wastes. The storm sewer system in the City of Midland is designed to receive runoff from an area that has a high percentage of impervious surfaces. Natural drainage areas determined by topography are circumvented by the storm sewer system, which alters the watershed boundaries. The entire area in the City serviced by the storm sewer system which conveys storm water directly to the Sturgeon Creek has been included in the Urban Critical Area.

A principle concern for the Watershed is that of preservation. The protection of certain areas in the Watershed will greatly impact water quality. The Steering Committee identified areas that could be considered for implementing land preservation and/or conservation measures to protect the natural resources. The Au Sable State Forest areas are included for preservation and already have a management plan under the state's administration, implemented by the MDNR. A preservation area of a 1/4 mile buffer around the state forest would further protect that natural resource. Other potential areas for preservation include riparian forests, which act as wildlife corridors. The Steering Committee recommended a zone of 300 feet for conservation of these riparian forests to act as habitat and buffer. Landowners in this area may wish to enroll in conservation easement programs to protect the riparian zone. This buffer is not only suitable for habitat and migration corridors, but also acts to reduce nonpoint source runoff to the streams. Tree canopies over the streams help keep temperatures low, which is essential for many species, including cool water fish. Trees reduce disruptive noise pollution in the stream corridor and increase the aesthetics of the stream. Typical BMPs repair problem sites and sources of nonpoint source pollution. Land conservation options work to minimize future impacts of water quality in the Watershed.

4.2 DESIGNATION OF GOALS FOR CRITICAL AREAS

The Prioritization Subcommittee met on March 19, 2002, to recommend BMPs for critical areas in the Watershed based on the impairments. Land uses in the Watershed include commercial, residential, agriculture, forests, and wetlands. The subcatchments were categorized as to their highest percentage of land use as either urban/residental, agricultural or forest/wetland/rangeland as shown in Tables 4.1 through 4.3. Each of these areas has different problems and needs, so will be treated separately.

Table 4.1 - Urban/Residential Subcatchments

Subcatchment	Urban/Residential (%)	Agriculture (%)	Forest/Wetland/Rangeland (%)
Midland City Drainage (5)	42.45%	7.31%	50.25%
Hahn Drain	10.62%	26.32%	59.60%
Jacobs Drain	3.39%	51.61%	39.40%
State Drain	4.11%	34.27%	61.63%

Based on the MDEQ 2000 Land Use Data

Table 4.2 - Agricultural Subcatchments

Subcatchment	Urban/Residential (%)	Agriculture (%)	Forest/Wetland/Rangeland (%)
Harris Drain	0.10%	58.72%	41.18%
Newell Creek	1.00%	53.42%	45.58%
Grass Creek	0.37%	41.25%	58.38%

Based on the MDEQ 2000 Land Use Data

Table 4.3 - Forested/Wetland/Rangeland Subcatchments

Subcatchment	Urban/Residential (%)	Agriculture (%)	Forest/Wetland/Rangeland (%)
Dittmar Drain	0.04%	7.89%	92.07%
Upper Sturgeon Creek	0.05%	24.96%	74.99%

Based on the MDEQ 2000 Land Use Data

Table 4.1 describes the urbanizing areas as the Hahn, Jacobs, State, and Midland Drainage(5) subcatchments. The impairment in these subcatchments is altered hydrology from increased impervious areas, which increase the flashiness of the streams. Runoff moves quickly to the streams and the cumulative effect is a greater volume of water flowing through the streams at a higher velocity, which increases erosion rates. The Jacobs and State Drain subcatchments, where agriculture land use is decreasing, are impaired by fragmentation of habitat.

Table 4.2 describes the agricultural area, which includes the subcatchments of the Harris Drain, Newell Creek, and Grass Creek (Figure 7). These subcatchments are impaired by sediment, nutrients, and fragmentation of habitat. Conventional tillage methods and improper use of fertilizer, livestock operation runoff, and lack of buffers on agricultural land all contribute to the sediment and nutrient loading of the streams. Trends across the state and in Midland County show net loss in agricultural land. Farming is an historic use in the watershed and part of its character and way of life. The interest in preserving farmland is not only of social concern, but also of ecological concern. Loss of woodland and prairies has forced many species to adapt to changes in habitat. Those species that cannot adapt have become locally extinct or have decreasing populations. The conversion of large tracts of agricultural land to residential, commercial, and industrial use destroys open space, food supplies, and cover that many species need to survive.

Table 4.3 describes the forest, wetland, and rangeland areas, which include the Dittmar and Upper Sturgeon. Altered hydrology is impairing these subcatchments. Wetlands are important to the hydrology and natural history of the watershed and should be preserved. Since the Au Sable State Forest is already under the management of the MDNR, which has a passive policy of minimal active management, a recommendation was made for this land to remain protected. Additional preservation areas could include the riparian forest and buffer around the state forest.

The Little Forks Conservancy is an organization working to protect land within Midland County and the Tittabawassee River Watershed. As a private, nonprofit land conservancy, it is recoginzed as a charitable organization by the Internal Revenue Service, which provides the legal mechanism through which watershed landowners can permanently protect the conservation values of their land that are important to sustaining the quality of the watershed. The Little Forks Conservancy provides landowners with a number of options, ranging from limited development to acquisition of the property. By protecting properties in the Sturgeon Creek Watershed, landowners can leave a legacy to future generations. Table 4.4 outlines some of the possible conservation options available to achieve land protection in the Watershed's areas of protection.

Table 4.4 - Conservation Options

Land Protection Option	Description
Conservation easement	Legal agreement between a landowner and a land conservancy, permanently limiting a property's uses.
Donation of land	Land donated to the conservancy.
Remainder interest and reserved life estate	Land donated to the conservancy, but owner (or others designated) continue to live there until death.
Bequest	Land bequeathed to the conservancy through a will.
Bargain sale of land	Land sold to the conservancy below fair market value.
Purchase of land	Situations where protection of a property is important enough to justify purchase at fair market value.

These conservation options, in addition to providing the benefit of permanently preserving land, may also yield potential financial benefits in the form of income tax reduction and estate tax reduction.

To recommend BMPs for the critical areas, the first step was to divide the inventory data by subcatchment. The number and severity of each pollutant source within each subcatchment were analyzed as shown in Table 4.5. Severity of streambank erosion was assessed by calculating length, width, and height of the eroding area. Severity of rill and gully erosion was assessed by calculating the volume. Amount of erosion was used to assess road crossing severity. Amount of erosion and comments were used to determine the severity of tile outlets. Number of algal bloom sites was used to determine the severity of an algae problem in a particular subcatchment. The impact of the pollutants or impairments to the subcatchment was ranked as either high (H), medium (M), or low (L).

Table 4.5 - Pollutant Sources by Subcatchment

Subcatchment	Streambank Erosion	Rill and Gully Erosion	Road Crossings	Tile Outlets	Algae
URBAN					
Hahn Drain	H	H	L	L	H
Jacobs Drain	M	M	L	M	H
State Drain	H	None found	None found	None found	H
AGRICULTURAL					
Grass Creek	M	None found	M	L	L
Harris Drain	L	L	None found	None found	None found
Newell Creek	M	H	M	M	H
FORESTED/WETLANDS/RANGELAND					
Dittmar Drain	L	H	L	M	L
Upper Sturgeon Creek	None found	None found	None found	None found	None found

Based on field inventory 2001-2002

4.3 NONPOINT SOURCE BMP RECOMMENDATIONS

The Steering Committee reviewed the goals and objectives for each impairment to the designated uses and developed recommendations. These recommendations were divided into three categories: Structural and Vegetative BMPs, Policy and Management Recommendations, and Information and Education Recommendations. Table 4.6 lists the recommendations for each objective that were determined for each impairment.

The structural and vegetative BMP recommendations were based on the watershed inventory, which collected information about the sites of nonpoint source pollution in the Watershed. Details about the sites, such as length of gully, height of streambank, and amount of trash were used to determine the extent of the problems. The Prioritization Subcommittee associated implementation costs of applying BMPs to the levels of problems found in the watershed. The total estimates for costs of the BMPs are calculated in Tables 4.7 to 4.12. Recommendations are based on generalizations about sites, but each specific site must be revisited before final plans are made for implementation. The property owner must be a cooperative partner in the decision making process for practices done on his or her land. The Natural Resource Conservation Service (NRCS) and Saginaw Bay RC&D have experience using many of these techniques and are good resources for assessing sites to recommend the most appropriate BMP for each site.

Table 4.6 - Recommendations for the Sturgeon Creek Watershed

Pollutants/Impairments	Objectives	Structural and Vegetative BMP Recommendations	Policy and Management Recommendations	Information and Education Recommendations
Excessive sediment (Total suspended solids and total dissolved solids at Jacobs Drain)	Reduce TSS in areas identified in the MDEQ water quality monitoring studies and volunteer monitoring programs by preventing soil erosion and reducing sedimentation	Install filter strips and windbreaks, practice no-till, and plant cover crops through USDA programs. (see Section 4.2) **Responsibility: MCD, NRCS**	Protect natural systems and increase conservation areas by working with the local land conservancy groups to promote native species, conservation easements, and land acquisition. (see Section 3.6) **Responsibility: Land Conservancy**	Create greenway along waterways in Sturgeon Creek wherever possible to increase natural habitats for indigenous wildlife. (see Section 3.9) **Responsibility: Saginaw Bay Greenway Collaborative**
		Install Soil Erosion and Sedimentation Control measures during construction. (see Section 4.2) **Responsibility: SESC County Enforcing Agency**	Review SESC inspection procedures and enforcement. (see Section 3.6) **Responsibility: SESC County Enforcing Agency**	Create a sustainable Volunteer Monitoring program. (see Table 5.2) **Responsibility: Midland Conservation District**
			Create buffer ordinance to maintain natural buffers along streams to filter sediment. (see Section 3.6) **Responsibility: Townships, City of Midland**	
Excessive nutrients (Total phosphorus at Cook Road)	Reduce phosphorus loading to meet EPA guidance level of 0.1 mg/l P for flowing water and possibly set standards of 50 micrograms/l P for lakes as a bench mark in setting criteria for wetlands	Install filter strips and windbreaks, practice no-till, and plant cover crops through USDA program. (see Section 4.2) **Responsibility: MCD, NRCS**	Require livestock operations to have Nutrient Management plans and crop farmers to use Integrated Crop Management techniques. (see Section 4.2) **Responsibility: MCD, NRCS**	Identify subcatchments which exceed EPA guidance level via a volunteer monitoring program which includes the City of Midland Wastewater Treatment facility. (see Table 5.2) **Responsibility: Midland Conservation District**
			Maintain septic systems. (see Section 3.6) **Responsibility: County Health Department**	Create a sustainable Volunteer Monitoring program. (see Table 5.2) **Responsibility: Midland Conservation District**
			Create septic system ordinance. (see Section 3.6) **Responsibility: Townships**	Create brochure on yard waste, composting, and septic system maintenance. (see Table 5.2) **Responsibility: Midland Conservation District**
			Enforce illegal dumping regulations. (see Section 3.6) **Responsibility: Townships, City of Midland**	

Table 4.6 - Recommendations for the Sturgeon Creek Watershed

Pollutants/Impairments	Objectives	Structural and Vegetative BMP Recommendations	Policy and Management Recommendations	Information and Education Recommendations
	Monitor and reduce nitrogen levels where necessary to meet water quality standards	Install filter strips and windbreaks, practice no-till, and plant cover crops through USDA program. (see Section 4.2) **Responsibility: MCD, NRCS**	Require livestock operations to have Nutrient Management Plans and crop farmers to use Integrated Crop Management techniques. (see Section 4.2) **Responsibility: MCD, NRCS** Maintain septic systems. (see Section 3.6) **Responsibility: County Health Department** Create septic system ordinance. (see Section 3.6) **Responsibility: Townships** Enforce illegal dumping regulations. (see Section 3.6) **Responsibility: Townships, City of Midland** Create buffer ordinance to maintain natural buffers along streams to filter nutrients. (see Section 3.6) **Responsibility: Townships, City of Midland**	Identify subcatchments which exceed EPA guidance level via a volunteer monitoring program which includes the City of Midland Wastewater Treatment facility. (see Table 5.2) **Responsibility: Midland Conservation District** Create a sustainable Volunteer Monitoring program. (see Table 5.2) **Responsibility: Midland Conservation District** Create brochure on yard waste, composting, and septic system maintenance. (see Table 5.2) **Responsibility: Midland Conservation District** Educate farmers about benefits of no-till methods through workshops and demonstrations. (see Section 4.2) **Responsibility: MCD**
	Preserve or restore wetlands and create buffers to filter excess use of nutrients before they flow into rivers and streams.	Restore wetlands through USDA programs (WRP, CREP) U.S. Fish and Wildlife Service (USFWS), Ducks Unlimited (DU), or the Michigan Wildlife Habitat Foundation. (MWHF) (see Section 4.5) **Responsibility: MCD, NRCS**	Protect natural systems and increase conservation areas by working with the local land conservancy groups to promote conservation easements and land acquisition. (see Section 3.6) **Responsibility: Land Conservancy**	Work to form partnerships between landowners and agencies, such as USFWS, MDEQ, MDNR, NRCS, and Conservation Districts to restore wetlands. (see Section 7.4) **Responsibility: Midland Conservation District**
Fragmentation of habitat	Minimize fragmentation of habitats.	Install filter strips and buffers along streams and drains. (see Section 4.2) **Responsibility: MCD, NRCS**	Protect natural systems and increase conservation areas by working with the local land conservancy groups to promote conservation easements and land acquisition. (see Section 3.6) **Responsibility: Land Conservancy** Create tax incentives for conservation easements. (see Section 3.6) **Responsibility: Townships, City of Midland**	Increase awareness of existing greenways and green infrastructures to establish connections of habitats and minimize fragmentation. (see Section 3.6) Responsibility: Saginaw Bay Greenways Collaborative

Table 4.6 - Recommendations for the Sturgeon Creek Watershed

Pollutants/Impairments	Objectives	Structural and Vegetative BMP Recommendations	Policy and Management Recommendations	Information and Education Recommendations
Fecal coliform bacteria (s) (specifically *E. coli*)	Prevent *E. coli* from entering surface waters and meet Michigan Water Quality Standards of 1,000 count/100 mg for partial body contact recreation and 300 count/100 mg for total body contact recreation.	Install livestock exclusion fencing. (see Section 4.2) **Responsibility: MCD, NRCS** Repair leaking septic tanks. (see Section 4.2) **Responsibility: County Health Department**	Require livestock operations to have Nutrient Management Plans. (see Section 4.2) **Responsibility: MCD, NRCS** Create septic system ordinance. (see Section 3.6) **Responsibility: County Health Department**	Create Volunteer Monitoring program to test for *E. coli* in high risk areas. (see Table 5.2) **Responsibility: MCD**
Temperature (s)	Preserve and increase canopy on waterways and maintain vegetation on the south and east sides of county drains.	Install filter strips and buffers along streams and drains. (see Section 4.2) **Responsibility: MCD, NRCS**	Protect natural systems and increase conservation areas by working with the local land conservancy groups to promote conservation easements and land acquisition. (see Section 3.6) **Responsibility: Land Conservancy** Work with MCDC and City of Midland to maintain riparian vegetation without impacting flow and function. (see Section 3.6) **Responsibility: County Drain Commissioner**	
	Increase ratio of groundwater recharge to surface runoff by protecting recharge areas and reducing impervious surfaces.		Promote smart growth and conservation development concepts. (see Section 3.6) **Responsibility: Townships, City of Midland**	
Low dissolved oxygen and unbalanced pH levels (s)	Meet warmwater minimum for dissolved oxygen of 4-5 mg/l by maintaining cool temperatures and limiting nutrient loading.	Install riparian buffers to shade streams. (see Section 4.2) **Responsibility: MCD, NRCS**	Create buffer ordinance to preserve riparian vegetation. (see Section 4.6) **Responsibility: Townships, City of Midland** Require livestock operations to have Nutrient Management Plans. (see Section 4.2) **Responsibility: MCD, NRCS** Incorporate increased infiltration of storm water to maintain groundwater recharge. (see Section 4.6) **Responsibility: County Drain Commissioner, County Planners, Township Planners, City Engineers**	Create Volunteer Monitoring program. (see Table 5.2) **Responsibility: Midland Conservation District** Use low phosphorus fertilizers on lawns. (see Table 5.2) **Responsibility: Midland Conservation District**
	Monitor pH levels for extremes.			Create Volunteer Monitoring program. (see Table 5.2) **Responsibility: Midland Conservation District**

Table 4.6 - Recommendations for the Sturgeon Creek Watershed

Pollutants/Impairments	Objectives	Structural and Vegetative BMP Recommendations	Policy and Management Recommendations	Information and Education Recommendations
Invasive and exotic species (s)	Minimize spread of invasive and exotic species.		Adopt native landscaping ordinance or require city properties to maintain native vegetation. (see Section 4.6) **Responsibility: Townships, City of Midland**	Increase education about the impacts of autumn olive, garlic mustard, and purple loosestrife on native habitats. (see Table 5.2) **Responsibility: Midland Conservation District** Distribute brochures to educate the public about how invasive species are transported to other areas. (see Table 5.2) **Responsibility: Midland Conservation District** Physically remove invasive species where possible and plant native species. (see Table 5.2)
Hydrology	Follow recommendations of hydrologic model and mapping. Locate areas for potential wetlands restoration to increase storage capacity. Minimize downstream channelization. Protect recharge areas by reducing or preventing increases in impervious surfaces.	Restore wetlands through USDA programs WRP, CREP, USFWS, DU, or the MWHF. (see Section 4.5) **Responsibility: MCD, NRCS**	Work with zoning agencies and developers to encourage reduction of impervious surfaces in new developments. (see Section 4.6) **Responsibility: Townships, City of Midland** Adopt wetlands protection ordinance. (see Section 4.6) **Responsibility: Townships, City of Midland**	Develop partnerships with USFWS, DU, NRCS, MDEQ, MDNR, and MWHF to identify opportunities to restore wetlands. (see Section 7.4) **Responsibility: MCD**
Hydrocarbons (s)	Reduce oil and grease inputs	Implement urban storm water BMPs. (see Section 4.2) **Responsibility: City of Midland**	Create storm water management plan. (see Section 3.6) **Responsibility: City of Midland** Enforce illegal dumping regulations. (see Section 3.6) **Responsibility: Townships, City of Midland** Adopt ordinances that require detention of parking lot runoff and harvesting of cattails in detention basins where heavy metals are present. (see Section 3.6) **Responsibility: Townships, City of Midland**	Promote oil recycling, increased street sweeping in urban areas and educational programs such as storm drain stenciling. (see Table 5.2) **Responsibility: Midland Conservation District** Conduct Farm*A*Syst evaluations of fuel facilities. (see Table 5.2) **Responsibility: Midland Conservation District**

Table 4.6 - Recommendations for the Sturgeon Creek Watershed

Pollutants/Impairments	Objectives	Structural and Vegetative BMP Recommendations	Policy and Management Recommendations	Information and Education Recommendations
Pesticides and chemicals (s)	Monitor pesticide usage and impacts with information from previous MDEQ study on pesticides in the Saginaw Bay Watershed.			Work with the local university to create a detection system and monitor for pesticides. (see Table 5.2) **Responsibility: Midland Conservation District**
	Limit contamination due to improper use and storage of pesticides and chemicals.		Use Integrated Crop Management techniques. (see Section 4.2) **Responsibility: MCD, NRCS**	Educate the public on proper storage and use of these chemicals, promote the Clean Sweep program, and continue education about harmful effects of pesticides. (see Table 5.2) **Responsibility: Midland Conservation District**
Heavy metals (s)	Investigate levels of heavy metals in Watershed using ICP and the Volunteer Monitoring program.		Create storm water management plan. (see Section 3.6) **Responsibility: City of Midland**	Work with the local University to test heavy metal levels within the watershed. (see Table 5.2) **Responsibility: Midland Conservation District**
	Develop strategies to reduce inputs to meet Michigan Water Quality Standards.	Implement urban storm water BMPs. (see Section 4.2) **Responsibility: City of Midland**	Create storm water management plan. (see Section 3.6) **Responsibility: City of Midland**	Create an educational storm water pollution prevention program. (see Table 5.2) **Responsibility: Midland Conservation District**

Table 4.7 - BMP Recommendations and Cost Estimates
Streambank Erosion

Site ID	Buffer Width Right	Buffer Width Left	Streambank Erosion Length	Streambank Erosion Height	Erosion Severity	Streambank Erosion	Erosion Area ft^2	Proposed Improvements	Estimated Unit Cost	Estimated Total Cost	Priority	Implementation Schedule
601LAR2001	>10'	>10'	10'-25'	3'-6'	Mostly Bare Bank	Entire Bank	150	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$1,250	H	3-10 years
886MID0602	>10'	-	>100'	<3'	Mostly Bare Bank	Entire Bank	1095	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$9,183	H	1-3 years
8961LIN0103	>10'	1'-3'	10'-25'	>6'	Mostly Bare Bank	Entire Bank	250	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$2,028	H	10-20 years
904LIN2403	>10'	>10'	10'-25'	3'-6'	Mostly Bare Bank	Entire Bank	150	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$1,250	H	10-20 years
04MID0601	lb 3-10, rb>		26-100'	3-6'	Mostly Bare Bank	Entire Bank	600	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$5,000	H	1-3 years
04MID0602	>10'		26-100'	>6'	Washout	Entire Bank	1000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	1-3 years
04MID0603	>10'		26-100'	>6'	Washout	Entire Bank	1000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	1-3 years
04MID0604	>10'		26-100'	>6'	Some washout, mostly bare	Entire Bank	1000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	1-3 years
04MID0607	>10'		26-100'	>6'	Mostly Bare Bank	Entire Bank	1000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	1-3 years
04MID0608	>10'		>100'	>6'	Mostly Bare Bank	Entire Bank	2000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$16,222	H	1-3 years
04MID0609	lb>10', rb3-		>100'	>6'	Mostly Bare Bank, some washout	Entire Bank	2000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$16,222	H	1-3 years
04MID0814	>10'		26'-100'	>6'	Mostly bare bank with some washout	Entire Bank	1000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	1-3 years
04MID0815	>10'		26'-100'	3'-6'	Mostly bare bank with some washout	Entire Bank	600	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$5,000	H	1-3 years
04MID0816	>10'		26'-100'	>6'	Washout	Entire Bank	1000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	1-3 years
04LAR3101	>10'		26'-100'	>6'	Mostly bare bank	Entire Bank	1000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	3-10 years

Table 4.7 - BMP Recommendations and Cost Estimates
Streambank Erosion

Site ID	Buffer Width Right	Buffer Width Left	Streambank Erosion Length	Streambank Erosion Height	Erosion Severity	Streambank Erosion	Erosion Area ft^2	Proposed Improvements	Estimated Unit Cost	Estimated Total Cost	Priority	Implementation Schedule
04LAR3102	>10'		26'-100'	>6'	Washout	Entire Bank	1,000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	3-10 years
04LAR3104	>10'		26'-100'	3'-6'	Mostly bare bank	Entire Bank	600	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$5,000	H	3-10 years
887LAR3302	1'-3'	1'-3'	>100'	>6'	Mostly bare bank	Entire bank	1,000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,444	H	3-10 years
887LAR3303	>10'		>100'	>6'	Mostly bare bank	Entire bank	2,000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$16,222	H	3-10 years
889LAR1602	>10'		26'-100'	>6'	Mostly bare bank	Entire bank	1,000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	3-10 years
04MID0804	>10'		26'-100'	3'-6'	Mostly Bare Bank	Entire Bank	600	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$5,000	H	1-3 years
04MID0808	>10'		26'-100'	>6'	Some washout, mostly bare bank, wants to be gully	Entire Bank	1,000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	1-3 years
04MID0809	>10'		>100'	>6'	Some bare bank, a little washout	Entire Bank	2,000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$16,222	H	1-3 years
04MID0810	>10'		>100'	>6'	Mostly bare bank	Entire Bank	2,000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$16,222	H	1-3 years
04MID0812	>10'		>100'	3'-6'	Mostly bare bank with some washout	Entire Bank	1,200	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$10,000	H	1-3 years
04MID0813	>10'		>100'	3'-6'	Mostly bare bank	Entire Bank	1,200	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$10,000	H	1-3 years
892LAR0601			10'-25'	>6'	Mostly bare bank	Entire bank	200	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$1,639	H	3-10 years
8942MIL2901			<10'	3'-6'	Mostly bare bank	Entire bank	60	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$500	H	10-20 years
901HOP2301			<10'	3'-6'	Mostly bare bank	Entire Bank	60	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$500	H	10-20 years
9031HOP2101	3'-10'	3'-10'	10'-25'	>6'	Mostly bare bank	Entire bank	250	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$2,028	H	10-20 years
9031HOP2201	3'-10'		10'-25'	>6'	Mostly bare bank	Entire bank	250	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$2,028	H	10-20 Years

Table 4.7 - BMP Recommendations and Cost Estimates
Streambank Erosion

Site ID	Buffer Width Right	Buffer Width Left	Streambank Erosion Length	Streambank Erosion Height	Erosion Severity	Streambank Erosion	Erosion Area ft^2	Proposed Improvements	Estimated Unit Cost	Estimated Total Cost	Priority	Implementation Schedule
906MID0701	>10'				Severe - No Data		600	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$4,667	H	1-3 Years
902HOP2701	>10'	>10'	<10'	<3'	Washout	Entire Bank	30	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$267	H	10-20 Years
04LIN0401	>10'	>10'	10'-25'	3'-6'	Mostly bare bank	Entire bank	150	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$1,250	H	10-20 Years
906HOM0103	>10'	>10'	10'-25'	3'-6'	Mostly bare bank	Entire bank	150	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$1,250	H	10-20 Years
906LIN3602	>10'	>10'	10'-25'	3'-6'	Some bare bank	Entire bank	150	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$1,250	H	10-20 Years
903HOP2802	>10'	>10'	10'-25'	>6'	Some bare bank	Top of bank	250	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$2,028	H	10-20 Years
906MID0602	3'-10'	3'-10'	26'-100"	3'-6'	Some bare bank	Entire bank	600	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$5,000	H	1-3 Years
906MID0604	>10'	>10'	26'-100'	3'-6'	Mostly bare bank with some washout	Entire bank	600	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$5,000	H	1-3 Years
906MID0606	>10'	>10'	26'-100'	3'-6'	Mostly bare bank with some washout	Entire bank	600	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$5,000	H	1-3 Years
906MID0610	>10'	>10'	26'-100'	3'-6'	Washout	Entire bank	600	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$5,000	H	1-3 Years
906MID0704	>10'	>10'	26'-100'	>6'	Washout	Entire bank	1000	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$8,111	H	1-3 Years
906MID0705	1'-3'		10'-25'	>6'	Mostly bare bank	Entire bank	250	Bioengineering or tree revetment w/riprap	$10/yd - tree revet. $70/$yd^2$ - riprap	$2,028	H	1-3 Years
60LAR2901	>10'	>10'	10'-25'	>6'	Mostly Bare Bank	Toe	250	Riprap	$70/$yd^2$	$1,944	M	3-10 Years
60LAR2902	>10'	>10'	26'-100'	>6'	Mostly Bare Bank	Toe	1000	Riprap	$70/$yd^2$	$7,778	M	3-10 Years
8871LAR2802	1'-3'	>10'	10'-25'	3'-6'	Mostly Bare Bank	Toe	150	Riprap	$70/$yd^2$	$1,167	M	3-10 Years
8871LAR2803	3'-10'	-	10'-25'	>6'	Mostly Bare Bank	Toe	250	riprap	$70/$yd^2$	$1,944	M	3-10 Years
904LIN2402	>10'	>10'	26'-100'	3'-6'	Some Bare Bank	Toe	600	tree revetment	$10/yd	$333	M	10-20 Years

Table 4.7 - BMP Recommendations and Cost Estimates
Streambank Erosion

Site ID	Buffer Width Right	Buffer Width Left	Streambank Erosion Length	Streambank Erosion Height	Erosion Severity	Streambank Erosion	Erosion Area ft^2	Proposed Improvements	Estimated Unit Cost	Estimated Total Cost	Priority	Implementation Schedule
895MIL3001			26'-100'	>6'	Bare bank w/ rills	Toe	1000	riprap	$70/yd^2$	$7,778	M	10-20 Years
04MID0811	>10'		26'-100"	3'-6'	Some bare bank, washout behind concrete on cul	High water mark	600	riprap	$70/yd^2$	$4,667	M	1-3 Years
892LIN1201			>100'	>6'	Mostly bare bank	Toe	2000	riprap	$70/yd^2$	$16,222	M	10-20 Years
889LAR1604			>100'	>6'	Some bare bank	Top of bank	2000	Bioengineering	$10/yd	$667	L	3-10 Years
901HOP1401	>10'		10'-25'	3'-6'	Mostly bare bank	High water mark	150	Bioengineering	$10/yd	$1,250	L	10-20 Years
903HOP2801	1'-3'				Average - No data		150	Bioengineering	$10/yd	$83	L	10-20 Years
									High Priority/Severe erosion	$271,922		
									Medium Priority/Moderate erosion	$41,833		
									Low Priority/Minor erosion	$2,000		
									TOTAL	$315,756		

Table 4.8 - BMP Recommendation and Cost Estimates
Rill and Gully Erosion

Site ID	Buffer Width Right	Buffer Width Left	Rill & Gully Length	Rill & Gully Height	Rill & Gully Depth	Rill & Gully Width	Rill & Gully Volume ft^3	Proposed Improvements	Estimated Cost/Site	Estimated Total Cost	Priority	Implementation Schedule
908LIN2502	>10'	>10'	20'	3'-6'	3'	5'	300	berm and tube	$1,000	$1,000	H	1-3 Years
893MIL3301	-	-	40'	3'-6'	3'	5'	600	berm and tube, filter strip	$1000 - berm and tube $150/ac - filter strip	$1,150	H	1-3 Years
893MIL3303	-	-	35'	3'-6'	3'	4'	420	berm and tube, filter strip	$1000 - berm and tube $150/ac - filter strip	$1,150	H	1-3 Years
895MIL3002	-	-	20'	3'-6'	3'	5'	300	berm and tube, filter strip	$1000 - berm and tube $150/ac - filter strip	$1,150	H	1-3 Years
9031HOP2103	3'-10'	3'-10'	4'	4'	35'	10'	1400	berm and tube	$1,000	$1,000	H	1-3 Years
9031HOP2202	3'-10'	-	25'	3'-6'	4'	3'	300	berm and tube, filter strip	$1000 - berm and tube $150/ac - filter strip	$1,150	H	1-3 Years
9031HOP2203	3'-10'	-	35'	>6'	4'	4'	560	berm and tube, filter strip	$1000 - berm and tube $150/ac - filter strip	$1,150	H	1-3 Years
909LIN3502	3'-10'	-	25'	>6'	3'	4'	300	berm and tube, filter strip	$1000 - berm and tube $150/ac - filter strip	$1,150	H	3-10 Years
909LIN3503	3'-10'	-	10'	>6'	3'	4'	120	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$750	M	3-10 Years
909LIN3504	>10'	-	25'	3'-6'	3'	2'	150	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$675	M	3-10 Years
907LIN2304	>10'	>10'	25'	3'-6'	2'	2'	100	stone spillway	$600	$600	M	3-10 Years
9081LIN3601	>10'	-	15'	>6'	3'	3'	135	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$675	M	3-10 Years
908LIN2501	>10'	>10'	20'	3'-6'	3'	2'	120	stone spillway	$600	$600	M	3-10 Years
605LAR1601	-	-	12'	3'-6'	4'	5'	240	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$750	M	3-10 Years
888LAR2002	>10'	-	15'	>6'	4'	2'	120	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$675	M	3-10 Years
889LAR1603	>10'	-	15'	>6'	4'	4'	240	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$675	M	3-10 Years
893MIL3302	-	-	30'	3'-6'	3'	2'	180	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$750	M	3-10 Years

Table 4.8 - BMP Recommendation and Cost Estimates
Rill and Gully Erosion

Site ID	Buffer Width Right	Buffer Width Left	Rill & Gully Length	Rill & Gully Height	Rill & Gully Depth	Rill & Gully Width	Rill & Gully Volume ft^3	Proposed Improvements	Estimated Cost/Site	Estimated Total Cost	Priority	Implementation Schedule
893MIL3201	-	-	45'	>6'	2'	3'	270	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$750	M	3-10 Years
8941MIL2901	-	-	15'	3'-6'	4'	3'	180	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$750	M	3-10 Years
902HOP2803	>10'	-	12'	3'-6'	3'	3'	108	stone spillway, filter strip	$600 - spillway $150/ac - filter strip	$675	M	3-10 Years
8872LAR2702	-	>10'	15'	3'-6'	2'	3'	90	GVC, filter strip	$700 - chute $150/ac - filter strip	$775	L	10-20 Years
8941MIL2902	-	-	15'	>6'	3'	2'	90	GVC, filter strip	$700 - chute $150 - filter strip	$850	L	10-20 Years
901HOP1402	1'-3'	-	20'	3'-6'	1'	1'	20	GVC, filter strip	$700 - chute $150 - filter strip	$850	L	10-20 Years
902HOP2801	>10'	-	10'	3'-6'	1'	2'	20	GVC, filter strip	$700 - chute $150 - filter strip	$775	L	10-20 Years
902HOP2802	>10'	-	15'	3'-6'	1'	5'	75	GVC, filter strip	$700 - chute $150 - filter strip	$775	L	10-20 Years
									High Priority	$8,900		
									Medium Priority	$8,325		
									Low Priority	$4,025		
									TOTAL	$21,250		

Table 4.9 BMP Recommendations and Cost Estimates
Tile Outlets

Site ID	Buffer Width Right	Buffer Width Left	Diameter	Tile Outlet Height	Erosion Area ft^2	Proposed Improvements	Estimated Unit Cost	Estimated Total Cost	Priority	Implementation Schedule
04MID0807	-	-	48"	>36"	16	Outlet stabilization	$70/yd^2	$124	H	1-3 Years
892LAR0602	1'-3'	-	5"	>36"	16	Outlet stabilization	$70/yd^2	$124	H	1-3 Years
8962LIN0202	3'-10'	3'-10'	8	12"-36"	12	Replace pipe			H	1-3 Years
896LIN0202	3'-10'	-	8"	12"-36"	12	Outlet stabilization	$70/yd^2	$93	H	1-3 Years
901HOP2701	>10'	-	?	12"-36"	12	Outlet stabilization	$70/yd^2	$93	H	1-3 Years
906HOM0102	>10'	>10'	12"	6"-12"	4	Outlet stabilization	$70/yd^2	$31	H	1-3 Years
906LIN3601	3'-10'	N	12"	6"-12"	4	Outlet stabilization and filter strip	$70/yd^2 - rip rap $150/ac - filter strip	$181	H	1-3 Years
906MID0609	3'-10'	N	2'	0-6"	2	Outlet stabilization and filter strip	$70/yd^2 - rip rap $150/ac - filter strip	$166	H	1-3 Years
04MID0606	>10'	3'-10'	12"	>36"	16	Outlet stabilization	$70/yd^2	$124	H	1-3 Years
901HOP2702	-	-	4"	0"-6"	2	Outlet stabilization and filter strip	$70/yd^2 - rip rap $150/ac - filter strip	$166	M	3-10 Years
60LAR2001	3'-10'	-	12"	0"-6"	2	Outlet stabilization and check inlet	$70/yd^2	$16	M	3-10 Years
60LAR2002	>10'	3'-10'	4"	6"-12"	4	Outlet stabilization	$70/yd^2	$31	M	3-10 Years
907LIN2504	>10'	3'-10'	3"	0"-6"	2	Outlet stabilization	$70/yd^2	$16	M	3-10 Years
60LAR1703	-	-	4"	0"-6"	2	Outlet stabilization	$70/yd^2	$16	M	3-10 Years
892LIN1203	-	-	4"	0"-6"	2	Outlet stabilization	$70/yd^2	$16	M	3-10 Years
906MID0703	>10'	>10'	2'	6"-12"	4	Outlet stabilization	$70/yd^2	$31	M	3-10 Years
907LIN2307	>10'	1'-3'	24"	0"-6"	2	Investigate source, filter strips	$150/ac	$150	L	3-10 Years

Table 4.9 BMP Recommendations and Cost Estimates
Tile Outlets

Site ID	Buffer Width Right	Buffer Width Left	Diameter	Tile Outlet Height	Erosion Area ft^2	Proposed Improvements	Estimated Unit Cost	Estimated Total Cost	Priority	Implementation Schedule
908LIN3602	>10'	-	24"	0"-6"	2	Investigate source, filter strips	$150/ac	$75	L	10-20 Years
60LAR1704	-	-	1"	0"-6"	2	Investigate source, filter strips	$150/ac	$75	L	10-20 Years
889LAR1601	>10'	-	buried	>36"	16	Investigate source, filter strips	$150/ac	$75	L	10-20 Years
893LAR0501	-	-	6"	12"-36"	12	Outlet stabilization	$70/yd^2	$93	L	10-20 Years
906MID0607	3'-10'	3'-10'		12"-36"	12	Investigate source, if from GW, OK	$70/yd^2	$0	L	10-20 Years
04MID0801	-	-				Outlet stabilization	$70/yd^2	$0	L	10-20 Years
							High Priority	$938		
							Medium Priority	$290		
							Low Priority	$468		
							TOTAL	$1,696		

Table 4.10 - Road/Stream Crossing Sites

Site ID	Location	Buffer Width	Erosion Extent	Comments	Proposed Improvements	Estimated Unit Cost	Estimated Total Cost	Priority	Implementation Schedule
886MID0601	Culvert outlet	-	Moderate	Culvert outflow is at 90 degrees to stream channel. At high water outflow impacts the poorly riprapped bank.	Bioengineering and riprap repair	$10/yd - tree revet. $70/yd^2 - riprap	$2,670	H	1-3 Years
907LIN2502	Shoulder/ditch	>10'	Moderate	Gully formed from road through shoulder and down bank. Soft roadbed suggests continued erosion.	Work with Road Commission		$2,000	H	1-3 Years
906MID0605	All given	>10'	Mod-severe		Bioengineering and riprap	$10/yd - tree revet. $70/yd^2 - riprap	$2,670	H	1-3 Years
888LAR2001	Left streambank	-	Moderate		Bioengineering	$10/yd - tree revetment	$330	M	3-10 Years
04MID0806	Culvert outlet	3'-10'	Moderate		Riprap	$70/yd^2	$1,240	M	3-10 Years
887LAR3304	Left streambank	3'-10'	Moderate		Bioengineering	$10/yd - tree revetment	$330	M	3-10 Years
906LIN3603	All given	>10'	Moderate		Bioengineering and riprap	$10/yd - tree revet. $70/yd^2 - riprap	$1,800	M	3-10 Years
906MID0603	Embankment	-	Moderate	Erosion on LB US of crossing and on RB ds from crossing	Bioengineering and riprap	$10/yd - brush mats $70/yd^2 - riprap	$1,500	M	3-10 Years
8941MIL3201	Shoulder/ditch	-	Moderate	Eroded hole forming on shoulder between 2 culverts. Hole depth almost to top of culverts.	Riprap	$70/yd^2	$124	M	3-10 Years
902HOP3301	Culvert outlet	-	Minor	Major sediment input ds at new culvert. Most sediment probably from installation. Water too cloudy to see if current erosion exists.	SESC, riprap	$70/yd^2 - riprap	$124	M	3-10 Years
						High Priority	$7,340		
						Medium Priority	$5,448		
						Low Priority	$0		
							$12,788		

Table 4.11 - BMP Recommendations and Cost Estimates
Trash and Debris Sites

Site ID	Description	Buffer Width Right	Buffer Width Left	Proposed Improvements	Priority	Implementation Schedule	Comments
601LAR2002	Smaller woody debris	>10'	>10'	See obstruction flowchart (Section 4.3)	H	1-3 Years	Debris jam is backing up water flow and causing small (>1') falls . Streambed below jam is exposed clay for ~75 feet to confluence with Newell Drain.
60LAR3003	1 anchored log catching other woody debris	>10'	>10'	See obstruction flowchart (Section 4.3)	H	1-3 Years	Some water backup, more possible.
9041LIN2301	Similar to beaver dam but no beaver sign.	>10'	>10'	See obstruction flowchart (Section 4.3)	H	1-3 Years	Blocking some flow but not much build-up of water. Anchored by 2 fallen trees.
907LIN2306	Smaller pieces	3'-10'	-	See obstruction flowchart (Section 4.3)	H	1-3 Years	Some flow blockage. Densely packed small debris.
907LIN2501	Breached beaver dam	1'-3'	>10'	See obstruction flowchart (Section 4.3)	H	1-3 Years	Some flow blockage. Found 3 mussel shells at dam.
907LIN2505	Breached beaver dam	>10'	-	See obstruction flowchart (Section 4.3)	H	1-3 Years	Breached beaver dam restricting flow from 10' to 4'. Left bank eroded at dam where water flowed around dam.
907LIN2506	Breached beaver dam	3'-10'	-	See obstruction flowchart (Section 4.3)	H	1-3 Years	Breached beaver dam in bend of stream. Some flow restriction.
60LAR2903	Logs and branches	>10'	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	Debris is not blocking, but is diverting, water flow into the left blank causing undercutting and potential erosion.
886MID0501	3 logs collecting debris	>10'	-	See obstruction flowchart (Section 4.3)	M	3-10 Years	A fair amount of water backed up by debris. Leaves and debris sealing jam. Back-up covered w/ sheen and film.
886MID0502	Living tree and debris	>10'	-	See obstruction flowchart (Section 4.3)	M	3-10 Years	A living cedar tree has fallen across the drain and is collecting debris and obstructing flow.
8872LAR2701	Smaller anchored logs and sticks	>10'	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	Debris in and across stream. Possible water backup.
904LIN2401	Wood and trash	>10'	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	Logs, stumps, tires and lumber forming debris jam. Waterflow does not seem to be impeded.
907LIN2301	Tree crown in drain	3'-10'	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	A tree top fell into the ditch. There is no debris accumulation or water blockage.
907LIN2303	Logs and sticks	>10'	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	Natural sticks and logs accumulating across stream. No water blockage.
907LIN2305	Logs and accumulation	>10'	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	Three separate areas of debris within 100'. Some debris accumulation, no flow restriction.
04MID0606	old tires and concrete blocks on rb @50'/some erosion also	-	>10'	Volunteer clean up	M	3-10 Years	-
04MID0817	Logjam w/ twigs, sediment flowing through spot @ 1-2' wide	-	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	-
04LAR3103	Logjam with lots of trash.	-	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	-
04LIN0401	Logs, duckweed, trash	>10'	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	Logs, duckweed, trash

Table 4.11 - BMP Recommendations and Cost Estimates
Trash and Debris Sites

Site ID	Description	Buffer Width Right	Buffer Width Left	Proposed Improvements	Priority	Implementation Schedule	Comments
04MID0802	Large dead trees	-	-	See obstruction flowchart (Section 4.3)	M	3-10 Years	-
903HOP2802	Woody debris behind cattail thicket	-	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	20' long slough on inside of bend. Sediment decreases stream width from 3' to 1'.
906LIN3601	Logs, tires, trash	-	3'-10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	Lots of sand.
906MID0609	Logjams and trash, dumping chips on lb	-	3'-10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	Water us is clear. Water at outlet and ds is gray.
906MID0702	3 large logjams @ elbow, almost total flow blockage at further one us.	-	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	-
906MID0703	Logjam diverting flow and causing erosion around elbow	-	>10'	See obstruction flowchart (Section 4.3)	M	3-10 Years	Added this site after rewalking.
60LAR1701	Logs and sticks	>10'	3'-10'	See obstruction flowchart (Section 4.3)	L	10-20 Years	Extended length of erosion beginning at confl. w/ Clark Dr. Not all of it is actively eroding but potential is high.
907LIN2302	Two logs and smaller pieces	>10'	>10'	See obstruction flowchart (Section 4.3)	L	10-20 Years	Two logs and some smaller pieces of wood collected across stream. Potential to affect flow
04MID0805	Log accumulation w/ trash on lb before site 4	-	>10'	See obstruction flowchart (Section 4.3)	L	10-20 Years	-
906MID0602	Burn pile and debris up to bank. Not bad but contained gas and oil containers. Work w/owner	-	3'-10'	See obstruction flowchart (Section 4.3)	L	10-20 Years	-
60LAR1702	The natural logs and sticks in the stream are not blocking the flow but are catching water	-	-	See obstruction flowchart (Section 4.3)	L	10-20 Years	-
906MID0704	Logjam with trash, bottles, drywall, Styrofoam, etc.	-	>10'	See obstruction flowchart (Section 4.3)	L	10-20 Years	-

Table 4.12 - BMP Recommendations
Other Sites

Site ID	Buffer Width Right	Buffer Width Left	Algae	Other	Comments	Proposed Improvements	Priority	Implementation Schedule
442LIN3101	-	-	Present	Algae Bloom	A thick algae bloom starts just below a dry private side ditch. Both sides of drain are heavily used pasture.	Fencing and filter strips	L	10-20 Years
60LAR0801	>10'	>10'	Present	Algal bloom	Sporadic algal bloom in Newell Dr. above & below Miller Dr. & above Mier Rd. Tile outlet eroded back ~15' from stream forming a 3' wide gully.	Tile replacement, regrading, geotextile/veg	L	10-20 Years
60LAR3001	>10'	>10'		Sediment deposition	Sediment deposition is blocking 2/3 of the bridge under Sturgeon Rd. Source possibly ditch on N side of drain, E side of road.	Diversion of ditch and filter strips	L	10-20 Years
8871LAR2801	1'-3'	>10'		Waterfall	A 4' waterfall has formed, possibly due to erosion caused by two opposing side channels. Streambed below falls is exposed clay.	Regrading and riprap? More info needed	L	10-20 Years
8961LIN0102	-	>10'		Deer carcasses	At least 3 deer carcasses were placed in stream. No algae seen downstream.	Enforcement	L	10-20 Years
907LIN2503	>10'	3'-10'		Deer carcass	A dressed deer carcass was placed in the stream. It is mostly on the bank but partially in water.	Enforcement	L	10-20 Years
907LIN3601	>10'	-		Sediment deposition	Large amount of exposed sediment along bank and washed into stream. No obvious source but it is below a large industrial site.	Filter strips and streambank BMPs	L	10-20 Years
60LAR0401				Heavy equipment	Heavily impacted and obstructed by driving heavy equipment over drain just downstream. The "floodplain" has opened up and used as a dump area-channel dissipates.	SESC enforcement	L	10-20 Years
60LAR0402			Severe	Algal bloom	Algae bloom: Major bloom	Find source, turf management BMPs	L	10-20 Years
891LAR0701			Present	Algal bloom	Visgar Drain has an intermittent and sporadic algae bloom for its entire length. It was through new housing developments, pastures, cropland and residential areas.	Turf management BMPs	L	10-20 Years
893LAR0502			Severe	Surface film	Surface film: A large amount of duckweed and surface film are behind a log floating on the surface above culvert. Film is similar to foam at site 01.	Turf management BMPs	L	10-20 Years
906HOM0101	>10'			Hole in bank	"Hole" dug through bank. No flow but heavy erosion. Former wetland?	Fill, regrade, soil erosion BMPs	L	10-20 Years
906HOM0102	>10'				Eroding in front of and quite a distance behind pipe.	Removal of pipe and riprap	L	10-20 Years
906LIN2701	>10'				Log sidewalls falling in. Erosion control?	Repair or streambank BMPs	L	10-20 Years
8871LAR3201	-	-			Large sediment deposit just below culvert from fairgrounds.	Grassed waterways and filter strips above culvert	L	10-20 Years
903HOP2101				Industrial construction site	Gully along one drain pipe, erosion along another.	Soil Erosion and Sedimentation Control enforcement	L	10-20 Years
04MID0803				Residential/tennis court construction site	Old sea wall	Soil Erosion and Sedimentation Control enforcement	L	10-20 Years
890LAR0901	-	-	Present	Algal bloom	A fairly dense algae bloom begins just below Eastmand Rd. and extends for about 200 yards.	Find source, Turf management BMPs	L	10-20 Years

Table 4.12 - BMP Recommendations
Other Sites

Site ID	Buffer Width Right	Buffer Width Left	Algae	Other	Comments	Proposed Improvements	Priority	Implementation Schedule
904LIN1401	>10'	>10'		Runoff	There is an oily sheen in a side channel near a road crossing. The water in the side channel is not flowing and the is no evidence of the sheen in the drain.	Roadside filter strips	L	10-20 Years
908LIN2503	1'-3'	-	Present	Duckweed/algae	Fairly large algae and duckweed bloom begins just downstream from tile which runs along a residential/commercial property.	Turf management BMPs	L	10-20 Years
442MID0601	>10'	-	Present	Algae bloom	A large amount of red/orange algae coming from a tile on the right side of the drain. Little in main drain.	If iron bacteria no action, normal in groundwater	L	10-20 Years
60LAR3002	>10'	>10'	Present	Algae bloom	A moderate algae bloom present at and below a building. No obvious tile or other source.	Turf management BMPs	L	10-20 Years
60LAR3004	>10'	>10'		Sediment deposition	Two areas of instream sediment deposition below a deeper, slower area. Upstream erosion may be the cause.	J-hooks and filter strips upstream	L	10-20 Years
8871LAR2804	>10'	>10'		Beaver dam	A beaver dam was built then breached. Residual wide channel remains above dam.	See debris BMP flowchart	L	10-20 Years
8871LAR3302	>10'	3'-10'		Beaver dam	A small beaver dam is holding water back just below confluence of Jacobs Dr. and Jacobs Branch #1.	See debris BMP flowchart	L	10-20 Years
8876LAR2701	-	-	Present	Algal bloom	Extensive Red/orange algae in stream. Almost continuous from here to bend in stream (~1/4 mi.)	If iron bacteria no action, normal in groundwater	L	10-20 Years
8961LIN0101	-	-	Present	Algal bloom	As the drain runs along Dublin Rd, the stream has a large algae bloom. There is no obvious source for the nutrient load.	Turf management BMPs	L	10-20 Years
9041LIN1501	>10'	-	Present	Algae/suckweed	Moderate algae/duckweed bloom in drain below large artificial ponds in housing development.	Find source, turf management BMPs	L	10-20 Years
904LIN1402	-	-	Present	Algal bloom	There is an algae bloom along and slightly downstream from a residence with a pond. The pond also has algae.	Investigate type of algae, turf management BMPs	L	10-20 Years
908LIN3601	-	-		Sedimentation	Ditch from industrial site depositing large amounts of sediment into the stream. Ditch has been bermed closed at the drain but without a tile. Water is currently backed up by, and seeping.	Investigate source further, filter strips	L	10-20 Years
904LIN1001				Algal bloom	Algae bloom extends between 2 beaver dams. Sporadic large thick clumps.	Turf management BMPs	L	10-20 Years
904LIN1002				Algal bloom	Sporadic large clumps of algae extend below lowest of 4 beaver dams.	Turf management BMPs	L	10-20 Years
892LIN1202	-	-			Possibly seep from flooded upland. Some sediment input.	If severe sediment input, tile	L	10-20 Years
907LIN2308	1'-3'	-	Present	Duckweed	Sporadic and light to heavy density growths of duckweed and some algae. Starts just above Stark Road and extends for about 300 yards.	Find source, Turf management BMPs	L	10-20 Years

Turf management BMPs = soil testing, filter strips, education, shade trees on south & west sides of stream
Streambank BMPs = depending on severity, live stakes, facines, tree revetments, or worst case riprap

Table 4.13 - Schedule to Implement Recommendations

Structural and Vegetative BMP Recommendations	Schedule	Policy and Management Recommendations	Schedule	Information and Education Recommendations	Schedule
Install filter strips and windbreaks, practice no-till, and plant cover crops through USDA programs. (see Section 4.2) **Responsibility: MCD, NRCS**	1-3 years high priority 3-10 years medium priority 10-20 years low priority	Create buffer ordinance to maintain natural buffers along streams to filter sediment. (see Section 3.6) **Responsibility: Townships, City of Midland**	1-5 years	Create greenway along waterways in Sturgeon Creek wherever possible to increase natural habitats for indigenous wildlife. (see Section 3.9) **Responsibility: Saginaw Bay Greenway Collaborative**	5-10 years
Stabilize streambanks at designated sites (see Section 4.2) **Responsibility: MCD, NRCS**	1-3 years high priority 3-10 years medium priority 10-20 years low priority	Work with County Drain Commissioner and City of Midland to maintain riparian vegetation without impacting flow and function. (see Section 3.6) **Responsibility: County Drain Commissioner, City of Midland**	1-20 year		
Conduct Farm*A*Syst evaluations of chemical storage areas and fuel facilities. (see Table 5.2) **Responsibility: MCD**	1-3 years	Require crop farmers to use Integrated Crop Management techniques. (see Section 4.2) **Responsibility: MCD, NRCS**	5-10 years	Educate the public on proper storage and use of these chemicals, promote the Clean Sweep program, and continue education about harmful effects of pesticides. (see Table 5.2) **Responsibility: Midland Conservation District**	1-5 years

Table 4.13 - Schedule to Implement Recommendations

Structural and Vegetative BMP Recommendations	Schedule	Policy and Management Recommendations	Schedule	Information and Education Recommendations	Schedule
				Work with the local university to create a detection system and monitor for pesticides. (see Table 5.2) **Responsibility: MCD**	5-10 years
Install Soil Erosion and Sedimentation Control measures during construction. (see Section 4.2) **Responsibility: SESC County Enforcing Agency**	1-5 years	Review SESC inspection procedures and enforcement. (see Section 3.6) **Responsibility: SESC County Enforcing Agency**	5-10 years	Create a sustainable Volunteer Monitoring program. (see Table 5.2) **Responsibility: MCD**	1-5 years
				Identify subcatchments which exceed EPA guidance level via a volunteer monitoring program which includes the City of Midland Wastewater Treatment Facility. (see Table 5.2) **Responsibility: MCD**	1-5 years

Table 4.13 - Schedule to Implement Recommendations

Structural and Vegetative BMP Recommendations	Schedule	Policy and Management Recommendations	Schedule	Information and Education Recommendations	Schedule
Install livestock exclusion fencing. (see Section 4.2) **Responsibility: MCD, NRCS**	1-3 years high priority 3-10 years medium priority 10-20 years low priority	Require livestock operations to have Nutrient Management plans. (see Section 4.2) **Responsibility: MCC, NRCS**	5-10 years	Create Volunteer Monitoring program to test for *E. coli* in high risk areas. (see Table 5.2) **Responsibility: MCD**	1-5 years
Repair leaking septic tanks. (see Section 4.2) **Responsibility: County Health Department**	1-5 years	Maintain septic systems. (see Section 3.6) **Responsibility: County Health Department**	5-10 years	Create brochure on yard waste, composting, and septic system maintenance. (see Table 5.2) **Responsibility: Midland Conservation District**	1-5 years
		Create septic system ordinance. (see Section 3.6) **Responsibility: Townships**	5-10 years	Create Volunteer Monitoring program to test for *E. coli* in high risk areas. (see Table 5.2) **Responsibility: Midland Conservation District**	5-10 years
Implement urban storm water BMPs. (see Section 4.2) **Responsibility: City of Midland**	1-5 years	Enforce illegal dumping regulations. (see Section 3.6) **Responsibility: Townships, City of Midland**	1-5 years	Use low phosphorus fertilizers on lawns. (see Table 5.2) **Responsibility: MCD**	1-5 years

Table 4.13 - Schedule to Implement Recommendations

Structural and Vegetative BMP Recommendations	Schedule	Policy and Management Recommendations	Schedule	Information and Education Recommendations	Schedule
		Create storm water management plan. (see Section 3.6) **Responsibility: City of Midland**	1-5 years	Promote oil recycling, increased street sweeping in urban areas and educational programs such as storm drain stenciling. (see Table 5.2) **Responsibility: MCD**	1-5 years
		Incorporate increased infiltration of storm water to maintain groundwater recharge. (see Section 3.6) **Responsibility: County Drain Commissioner, County Planners, Township Planners, City Engineers**	5-10 years	Create an educational storm water pollution prevention program. (see Table 5.2) **Responsibility: MCD**	1-5 years
		Work with zoning agencies and developers to encourage reduction of impervious surfaces in new developments. (see Section 3.6) **Responsibility: Townships, City of Midland**	5-10 years	Work with the local University to test heavy metal levels within the watershed. (see Table 5.2) **Responsibility: MCD**	5-10 years
		Adopt ordinances that require detention of parking lot runoff and harvesting of cattails in detention basins where heavy metals are present. (see Section 3.6) **Responsibility: Townships, City of Midland**	5-10 years		

Table 4.13 - Schedule to Implement Recommendations

Structural and Vegetative BMP Recommendations	Schedule	Policy and Management Recommendations	Schedule	Information and Education Recommendations	Schedule
		Adopt wetlands protection ordinance. (see Section 3.6) **Responsibility: Townships, City of Midland**	1-5 years	Work to form partnerships between landowners and agencies, such as USFWS, MDEQ, MDNR, NRCS, and Conservation Districts to restore wetlands. (see Section 7.4) **Responsibility: MCD**	1-20 years
Restore wetlands through USDA programs WRP, CREP, USFWS, DU, or the Michigan Wildlife Habitat Foundation. (see Section 4.5) **Responsibility: MCD, NRCS**	1-5 years	Adopt native landscaping ordinance or require city properties to maintain native vegetation. (see Section 3.6) **Responsibility: Townships, City of Midland**	5-10 years	Increase education about the impacts of autumn olive, garlic mustard, and purple loosestrife on native habitats. (see Table 5.2) **Responsibility: MCD**	1-5 years
Physically remove invasive species where possible and plant native species. (see Table 5.2) **Responsibility: MCD**	1-5 years	Protect natural systems and increase conservation areas by working with the local land conservancy groups to promote native species, conservation easements and land acquisition. **Responsibility: Land Conservancy**	5-10 years	Distribute brochures to educate the public about how invasive species are transported to other areas. (see Table 5.2) **Responsibility: MCD**	1-5 years

Table 4.13 - Schedule to Implement Recommendations

Structural and Vegetative BMP Recommendations	Schedule	Policy and Management Recommendations	Schedule	Information and Education Recommendations	Schedule
		Create tax incentives for conservation easements. (see Section 3.6) **Responsibility: Townships, City of Midland**	5-10 years		
		Promote smart growth and conservation development concepts. (see Section 3.6) **Responsibility: Townships, City of Midland**	1-20 year		

STREAMBANK EROSION

Many techniques have been demonstrated to reduce streambank erosion. Hard structures, such as riprap, can protect the toe of a streambank. Tree revetments, fascines, and live plantings are softer methods that are generally preferred since they absorb energy from the stream rather than reflect it downstream as riprap often does. Bioengineering, an integrated approach based in physics, chemistry, and engineering principles that uses biological methods of control, can be very effective in establishing longterm and adaptable solutions to erosive problems. Bioengineered systems are designed using non-destructive techniques that often have the ability to adapt to changing conditions over time. Materials can usually be found locally or even onsite, reducing cost and incorporating native resources. Sites, potential BMPs, and costs are given in Table 4.7. Each site should be examined and the principles described in this section should be applied.

Cooperation with the MCDC on work proposed for county drains is necessary. The remedies must not interfere with the regular maintenance and cleaning of the drains. Generally, most vegetative remedies, such as grasses and shrubs are acceptable, but trees may interfere with access for drain maintenance. Mixtures of rhizomatous woody shrubs and herbaceous plants are ideal unless the goal is to reduce water temperature. Trees may be used on the south and west sides of drains, because the canopy shade helps keep the water cool and is good for habitat and reduces algal growth.

The U.S. Army Corps of Engineers has an experimental station in which testing is done on different techniques. Recommendations are available at their website: http://www.wes.army.mil/el/ecubed/contlist.html. Brush bundles and tree revetments incorporate the use of plant material to protect the bank in slow and moderate flows. Brush bundles and tree revetments catch sediments from streambank runoff and from suspended loads. This sediment will settle into cracks and crevasses in the tangle of brush and stakings and provide soil substructure to revegetate streambanks. In heavier flows, especially those with tall banks, live stakes of trees and shrubs with rhizomatous roots, such as red osier dogwoods and willows can be used to hold down brush mattresses or coir logs, rolls of coconut fiber. The live staking is done in late autumn or early spring when the trees are dormant. These stakes will grow into short shrubby trees with complex root systems as the growing season progresses.

Tree revetments are placed at the toe of a streambank to divert the flow away from the bank and catch sediment which will deposit and accumulate behind the revetment and stabilize the bank. Many sites within the City of Midland could benefit from this vegetative remedy to just divert the flow rather than needing bank protection. Previous projects implementing this river restoration technique have average bid costs of $320 per 100 feet of streambank.

The Prioritization Committee recommended that riprap be used on the toe of a slope if it has failed due to groundwater seepage from a perched water table or frequent channel forming flows. A tile could also be placed along the stream to catch the groundwater flows and direct them to a stable outlet. The placement of riprap must follow NRCS standards and specifications, which include placing geotextile under the riprap. The site preparation is often expensive. Estimates for riprap for streambank erosion using D50 stone is $70/square yard, which includes the delivery to the site. Riprap tends to be less cost effective and does not meet as many of the goals outlined in this plan as the bioengineering techniques. Therefore, it should only be used where flow velocities and direction will not sustain bioengineering.

The priority designated use in the Watershed is a warmwater fishery. Many bank protection structures can have fish habitat measures incorporated. These structures include lunkers and J-hooks, which are used to create riffles, spawning sites, and cover for fish. Half logs with wood block spacers underneath provide the same cover as tree revetments, but can be used in areas where erosion is not occurring.

GULLY AND RILL EROSION

Gully and rill erosion is generally found in agricultural areas where fields are tilled by conventional methods and plowed up to the streambank where no filter strips exist. Typical BMPs include drop structures, weirs, and stone spillways. Sites, recommended BMPs, and costs are listed in Table 4.8. All structures need adequate preparation to ensure the water flows were intended. The NRCS has installed many of these structures over the years. Average costs per site are $600, assuming reasonable accessibility and using 4 inches to 12 inches of crushed limestone of various sizes. Geotextile vegetated chutes are designed for smaller sites with less runoff. The construction costs are estimated to be $700 per site.

The construction of a berm and tube structure must ensure stable vegetation, good compaction around the outlet, and adequate overflow protection. The outlet must be 1 foot off the bottom of the streambed and protected with a splash pad. The average cost for this BMP is $1,000.

Cover crops can be an effective remedy to rill and gully erosion, and are relatively inexpensive to implement. Programs through the NRCS offer land owners a conservation incentive to remove highly

erodible soil or land that has a high conservation priority (for example, drained wetlands) from agricultural production. In the Sturgeon Creek Watershed, over 14,000 acres of land would be eligible for these types of programs. For a more comprehensive listing of available programs and eligibility, please refer to Chapter 7 - Sustainability.

Filter strips are also beneficial in preventing gully and rill erosion. Buffer programs typically offer rental rates for taking that land out of production and a 75% cost share rate for the establishment of the buffer. Cost estimates for this BMP assumed 0.5 acres for each buffer and a cost of $150 per acre/year for rental and establishment. The implementation of filter strips might be covered under the CREP if program funding is available. Please refer to Chapter 7 for more details about the CREP program.

TILE OUTLETS

Outlets should be upsized when constructed to plan for future capacity needs. Rodent guards should always be included. The outlet should be lined with geotextile and stone should be placed in the trench. Many sites in the Watershed are eroding where the tile outlets are eroding back into the streambanks and causing gullies. Tiles can be installed next to the gullies and outletted upstream. Catch basins and old tile lines could be adding sediment to the stream system. Stabilizing a tile outlet has an average cost of $70 per square yard of riprap. Sites, recommendations, and cost totals are shown in Table 4.9.

ROAD/STREAM CROSSINGS

An initial survey of the road stream crossings in the Watershed yielded few problems. Only eight sites were reported as having any erosion and most were gullies forming along the sides of the structures. Undersized or blocked culverts can be replaced with box culverts or bridges. A more extensive Road/Stream Crossing inventory will be conducted in the future. The results of that inventory will be included in the updated version of this plan. Cost estimates cannot be included at this time, but brief site descriptions are listed in Table 4.10.

TRASH AND DEBRIS

Log jams and beaver dams are common in the Watershed. These are natural parts of the ecosystem, but often they can cause flooding of structures or crops and erosion at the banks or streambed. Sites, basic recommendations, and costs are listed in Table 4.11. The obstruction flowchart will assist with decision making at each site. Representatives from agencies that would be involved with the permitting process, if necessary in removing the obstructions, should be present at the site assessment. The coordination of efforts of the Fisheries & Wildlife Department, Land & Water Management Division, Surface Water Quality

Division, the Conservation District, the land owner, and any other interested party will result in the best possible improvement overall.

OBSTRUCTION FLOWCHART

1. Is there trash present?

Yes - Remove trash and go to Question No. 2.
No - Go to Question No. 2.

2. Has or will flooding of structures or cropland occur?

Yes - Investigate hydrology and remove blockage if warranted, then go to Question No. 3.
No - Go to Question No. 3.

3. Has or will the obstruction cause erosion at the streambank or streambed?

Yes - Go to Question No. 4.
No - If there are no other substantial reasons for action, do nothing.

4. Are the erosion causing flows slow to moderate?

Yes - Go to Question No. 4.
No - Use of riprap or bioengineering may be warranted. Design appropriately.

5. Are the erosion causing flows directly toward the bank or are they from groundwater seep?

Yes - Use of riprap or bioengineering may be warranted. Design appropriately.
No - Go to Question No. 5.

6. Can the obstruction be used as a revetment?

Yes - Assess flow pattern and bind the limbs to the bank according to flow.
No - Design proper bioengineering system of BMPs with other resources.

Sturgeon Creek and its tributaries are often treated as dumping grounds for unwanted items. Flooded areas can pick up trash from yards and roadways, carrying it back into the streams as the water recedes. Tires, bottles, drywall, concrete, and garbage were found at numerous sites in the Watershed. Stream cleanup efforts can remove these items from the waterways. Long-term educational efforts about the impacts of litter and debris in the streams will increase the stewardship of the watershed and encourage residents to recognize the value of their water resources. A volunteer cleanup grant should be sought to involve local residents in stewardship activities. Community involvement not only promotes respect for and interest in the Watershed, but also provides an enthusiastic workforce. Local match for the grant can include the use of canoes, dump trucks, landfill tipping fees especially if tires are included, and communication radios for safety. It is important to inform volunteers of safety concerns and have release of liability forms for them to sign.

OTHER SITES

Other pollutants were found in the Watershed that did not fit into the established categories and were collected under the “other” category. Most of these sites identified excessive algal growth. Some of the sites were areas where dead livestock or deer were dumped. These would have to be evaluated on a site-by-site basis to determine the costs for removal or finding the source of the excessive nutrients entering the streams, but a list of sites and basic recommendations are listed in Table 4.12.

Sediment has been identified as the major pollutant in the Watershed. Sections 91 and 51 of Public Act 451 were established to regulate soil erosion and sedimentation control during construction or earthmoving activities. Phase II of the National Pollutant Discharge Elimination System (NPDES) is requiring sites of 1 acre or greater or are within 500 feet of a waterway to obtain permits and be inspected regularly for compliance with soil erosion and sedimentation control regulations. The enforcement of these rules by the appointed county or municipal enforcing agency is imperative in the southern region of the Watershed, where development is occurring rapidly.

4.4 BEST MANAGEMENT PRACTICE PLANNING

The BMP recommendations and cost estimates are prioritized in Tables 4.7 to 4.12. Costs are given as estimates and based on worst case scenarios from the given description. For example, a site listed with a recommendation of riprap should not be treated according to the recommendations described in this narrative and not automatically given a treatment of riprap where it is not warranted. Costs will change as each site is investigated, and generally costs are lower when multiple sites are done simultaneously. Those sites requiring immediate attention were determined to be high priority and scheduled to be completed within 3 years. Those of medium priority were scheduled to be implemented in 3 to 10 years. Those of low priority were scheduled to be implemented in 10 to 20 years.

The agricultural BMPs will generally be addressed by programs available through the MCD and NRCS. Landowners will contribute local match with in kind services. The urban BMPs and storm water management will be coordinated with the City, landowners, and local businesses. The residential BMPs will be implemented by the landowners with assistance through the MCD and townships.

Some areas of the Watershed are still lacking a complete inventory. The remaining areas were of low priority and the inventory will continue in the spring and summer of 2003. Additional nonpoint source pollution sites will be added to the watershed inventory list and BMPs will be recommended in a similar format to the completed inventory lists located at the end of this chapter. Field inspections of implemented BMPs and additions to the inventory data will be updated on an annual basis.

The Policy and Management Recommendations were based on the Policy Review Document, summarized in the following section, and the discussions from the members of the Technical Committee.

The Information & Education Recommendations were based on the Information & Education Strategy, which is presented in Chapter 5.

The recommendations were evaluated as either short- term (1 to 3 years) implementation, long-term (3 to 10 years) implementation, or a sustainable program (1 to 20 years). The implementation schedule is presented in Table 4.13.

4.5 FUTURE PLANNING RECOMMENDATIONS

Counties have found diverse uses for GIS on many scales and it is recommended that Midland County form a GIS Department. GIS is a useful resource on many levels. It is most importantly a planning tool, allowing the expression of many types of data together in visual format. GIS adds capabilities of calculating and retrieving various sets of information combinations quickly. It can be used for such tasks as generating mailing lists based on residency next to a specific stream, or in a particular watershed, while sorting for land use types, etc. It can also be used to calculate areas, distances, and enumerate specific types of information. Needs for GIS have been found in Midland, especially related to mapping.

In the future, the MCD wishes to investigate flood mitigation projects. It has become obvious that land use changes in sensitive parts of the watershed have contributed to flooding toward the outlet of Sturgeon Creek. While backflows from the Titabawassee River have also contributed to flooding, most of the floodwater comes from within the Watershed. Recommendations from the hydrologic model, Section 3.4 suggest ways to mediate the effect of increased runoff from development, restore stability to the streams, and reduce flooding. Stabilizing flows in the Watershed will have a significant impact on improving streambank stability, thereby reducing sediment inputs to the watershed.

In addition to the flood mitigation projects an additional investigation into sediment traps has been suggested in the Sturgeon Creek Lagoon. The lagoon was dredged in 1956 to a depth of 12 feet where the creek mouth joins with the Titabawassee River. Since then, the lagoon has filled in with sediments at a rapid rate. A study of long-term impact of dredging stream channels for use as sediment traps is desired in the lagoon and other areas upstream in the watershed.

4.6 WETLAND ASSESSMENT AND RESTORATION

Many ecological benefits result from restoring wetlands. Water quality is usually greatly improved as it passes through a wetland system. A fully functioning wetland has a large amount of biomass and biological activity. Wetlands are complex ecosystems that include submergent and emergent herbaceous plants, shrubs, trees, algae, migratory and resident birds, amphibians, reptiles, mammals, insects, microorganisms, and fish. Biological activity occurs above and below the water surface, in the mucky bottom, and at the fringe of the wetland. Many communities maintain trails along wetlands and educate citizens so that they might fully appreciate the diversity of animals and plants in this ecosystem.

Hydrologic benefits are also realized from wetlands restoration and preservation. Developments increase the amount of impervious surfaces, such as rooftops, roads, and parking lots, which reduce water infiltration and groundwater recharge. Water runs off into surface waters with greater speed and volume, causing peak flows of fast moving water. Flooding and erosion often result, followed by low flows if groundwater recharge is greatly reduced. Wetlands act like a sponge and allow infiltration over a longer period of time. Water volumes and velocities are more constant and stable, which may reduce flooding and erosion problems downstream.

IDENTIFICATION OF WETLAND RESTORATION SITES

Wetlands are characterized by distinctive plant communities, soil types, and hydrology. When soil is saturated for long periods of time, a unique ecosystem evolves at its surface. Wetland soils, also known as hydric soils, often have a high organic matter content or have gray subsoil due to chemically reduced iron and manganese compounds.

Wetland vegetation, also known as hydrophytic vegetation, consist of plants that exhibit adaptations to germinate or propagate, with their root systems in water or saturated soil. Plant species are categorized according to their frequency of occurrence in wetland areas. Plant species categorized as obligate, facultative wetland, and facultative are good indicators of wetlands because they generally thrive in areas with long term inundation, seasonal flooding, or a high groundwater table.

While most wetlands do have standing water at some time during the year, it is not necessary for a wetland to have standing water at all times. In fact, while some wetlands have standing water all year, and others are flooded only seasonally, some wetlands may never exhibit standing water.

Figure 10 shows the presence of wetlands and hydric soils in the Watershed. The areas in green contain existing wetlands according to the combined results of the National Wetlands Inventory (NWI) conducted in the early 1980s and the 2000 MDEQ Land Use Data. The locations of hydric soils were obtained from the SSURGO database. The light green areas indicate where the mapped wetlands and wetland soils overlap. Where a hydric soil is present but was not mapped as a wetland, the area was probably artificially drained. Where a wetland is mapped on a non-hydric soil, the area may have recently become a wetland, possibly due to displacement of water or construction of a retention pond. The wetlands and soils maps may not be completely accurate, but they are useful for planning purposes. Decisions about individual areas should not be made without a field survey.

PRIORITIZING SITES FOR WETLANDS RESTORATION

The determination of wetland restoration sites depends considerably on the presence of hydric soils. Areas, where hydric soils are present, and were historically wet, are more likely to have good chemical and physical properties for wetlands than upland soils. Where wetlands have been eliminated by artificial drainage, restoration may be as simple as plugging a ditch or breaking a tile that drains the wetland area. Studies have shown that wetlands constructed in historically upland areas are not as successful and do not have the functional capacity of restored wetlands, therefore, hydric soils should be sought. The most amenable areas are usually agricultural fields that remain wet during the spring planting season or frequently flood during the growing season. Other idle fields or pasture areas are also good possibilities.

Flooding has been documented to be a problem in downstream sections of the Sturgeon Creek. Imperviousness and storm sewer conveyance have added to the flashiness of the flows. Development is occurring at a rapid pace on the northern border of the City. Au Sable State Forest has large tracts of forested wetlands which provide a great amount of storm water storage capacity for the upper reaches of the Watershed. Wetland restoration activities upstream of the forest would have little effect on the flooding downstream. Subcatchments that contribute flow downstream of the State Forest are developing rapidly and wetland restoration activities would have an effect on flow as Sturgeon Creek passes through the City. Wetland restoration activities anywhere in the watershed would have a positive impact on water quality, groundwater recharge, and wildlife.

PROGRAMS AVAILABLE FOR FUNDING AND TECHNICAL ASSISTANCE

Programs are available to landowners wishing to restore wetlands on their property. The most common programs for agricultural land are the Wetland Reserve Program (WRP) and the Conservation Reserve Program (CRP). Each of these programs provides technical assistance and other resources toward wetland restoration. Under the WRP, landowners are compensated on the appraised agricultural value of the land. Under the CRP, landowners receive payments based on the soil rental rates established for the county. Both programs target existing farmland to take out of agricultural production, however, WRP allows for the possibility of enrolling some non-agricultural land. The Sturgeon Creek Watershed is within the larger Saginaw Bay Watershed, which qualifies landowners to participate in the Conservation Reserve Enhancement Program (CREP). WRP and CRP are federal programs implemented on a site-by-site basis and administered by the USDA NRCS and the Farm Service Agency (FSA). CREP is administered by the State of Michigan Department of Agriculture, jointly with the FSA.

Cost estimates for wetland restoration vary widely. A typical restoration of a wetland site in the WRP has been calculated at $750 to $1,000 per acre. This figure may include upland restoration work as well.

The United States Fish and Wildlife Service (USFWS), through their Partners for Wildlife Program, and private non-profit organizations, such as Ducks Unlimited (DU) and Michigan Wildlife Habitat Foundation (MWHF), are active in restoring wetlands for wildlife throughout the state. Generally, these organizations will provide technical assistance (biological and engineering designs), as well as finding contractors and paying all costs associated with construction. Inmost cases, landowners are not responsible for any of the costs, nor does the land have to be agricultural use to be eligible.

Homeowners can enhance their properties through backyard habitat programs offered through the MCD.

ALTERNATIVES TO WETLAND RESTORATION

Storm sewers convey water quickly to the receiving waters rather than allowing slow infiltration. The City has adopted storm water regulations for development that require new developments to have a discharge rate of 0.2 cfs. The MCDC has rules for new developments or redevelopment that set limits for the amount of discharge that is allowable to county drains at 0.33 cfs per acre unless a storm water management plan or hydraulic study signed by a professional engineer advise otherwise.

Constructed wetlands can be used to filter water from urban runoff, storm sewers, or combined sewer overflows. Wetland plants extract excess nutrients and heavy metals out of the water, and though it is not always necessary, harvesting these plants, especially in more polluted waters, can be a way to remove the nutrients and metals from the system. Two well known success stories of this process are the Tollgate Wetlands in Lansing and the Inkster Wetlands near Detroit. More information is available at http://www.wcdoe.org/rougeriver/wetlands/inkster/index.html.

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

4.7 POLICY REVIEW DOCUMENT

PURPOSE

Water resources are a vital component when determining land use decisions at the local level. Certain land uses require access to water, while other land uses feature water as an attraction or as a necessary component of production. Residents of the City of Midland (Midland) might want to live by the water for aesthetic reasons or for recreation. Industries might be located near water to use for processing and wastewater discharging. The examination of existing policies is crucial to create a carefully crafted municipal code that reflects the diverse community of Midland. A report issued by the House Democratic Land Use Task Force in November 2001 stated that environmental concerns associated with land use planning included loss of wetlands, degradation of waterways, and the increased pollution related to urban sprawl and uncontrolled growth.

Midland's Master Plan (Master Plan) shapes the path of development in Midland. The Policy Review Document for Midland presents an analysis of the subdivision codes, zoning regulations, parking and street standards, and other local ordinances that collectively enable that path to be followed. The current path of development in Midland can be assessed through this process of analysis and then redirected if necessary. Careful attention to these rules can help Midland reach a level of sustainable development, which combines economic growth with the protection of natural resources.

Residents, business owners, and local planners are not always aware of the impacts that their individual actions might have on their natural surroundings. Cumulative effects of these actions are not considered in most development and land use decisions. A watershed planning perspective will encourage local planners and developers to look at the entire area contributing to a water body and determine its needs for management and protection. The adoption of local ordinances is one of many tools that local municipalities can use to protect their water resources. Ordinances may not be effective or influential when enforced on their own, but combined with other programs that are part of a comprehensive land use plan, ordinances can be very successful in meeting the goals of conservation and preservation of water resources. Midland is taking the first step in realizing the regional consequences of their land use decisions, and other communities will look to Midland's lead in developing their own set of development rules.

A Watershed Management Plan (WMP) has been developed for the Sturgeon Creek Watershed (Watershed). One of the basic concepts accepted in watershed planning is that the amount of impervious cover in a watershed directly relates to its water quality. Increased urbanization results in natural vegetation being replaced with hard surfaces, such as rooftops, roadways, and parking lots. The additional impervious area increases the rate and volume of runoff and decreases water infiltration into the ground. Studies have shown that an impervious cover of just 10% to 12% in a watershed can degrade streams and waterways (Schueler, 1995). Development often reduces base flow, since water is not infiltrating, which causes natural low flow streams to become intermittent streams. When more of the water enters the streams as surface runoff, the full channel flows create highly erosive conditions. Impervious surfaces also heat up in the summer, thus raising the temperature of water flowing over those surfaces before entering the streams. A study in 1991 calculated that for every 10% increase in imperviousness, a 1°F increase in temperature of the water occurs, which is significant enough to disrupt the natural balance of the ecosystem in coldwater streams (Galli, 1991). Other concerns of impervious surfaces include higher concentrations of phosphorus in higher volumes of water runoff and increased occurrences of heavy metals, such as copper. Bacteria can also be an indicator of increased urban runoff. This chapter introduces Best Management Practices (BMPs) that can reduce the amount of impervious cover in a watershed and also recommends actions that can prevent excessive construction of impervious surfaces in a watershed. The purpose of this document is to assist Midland in the implementation of better development designs and also to identify the impediments to innovative site design.

METHODOLOGY

The analysis of the existing development rules in Midland was based on techniques created by a Site Planning Roundtable under the direction of the Center for Watershed Protection (CWP, 1998). The theory behind the process is that protecting the quality of the local environment requires the reduction of impervious cover and the management of impervious cover requires a systematic reform of the local development rules that create impervious cover. The method involves a four stage process that enables communities to adapt their local development rules to follow the ideals of the model development principles. The four stages are:

1. Identify the existing local development rules.
2. Analyze the existing rules in conformity to the model development principles.
3. Recommend which rules would be most beneficial or possible to change.
4. Begin community discussions and decision-making.

Existing local development rules were identified by searching for key documents that shape the development in Midland. The planning and zoning process starts with the Master Plan, which outlines the vision of how the residents and leaders of Midland want the City of Midland to look in 20 years. The Master Plan is the foundation on which the zoning ordinance and Code of Ordinances are developed. The primary mechanisms that Midland uses to achieve the goals of the Master Plan are zoning ordinances, subdivision controls, access management, land acquisition for public facilities, the long-range Capital Improvement Program, and the Midland Urban Growth Area (MUGA). The City of Midland's Land Use Plan, which illustrates the goals of the Master Plan, has been continually updated and reaffirmed by the Planning Commission. The city engineer had developed new storm water regulations, which address the increase in storm water runoff. The ordinances were updated with any addendums and amendments that had recently been adopted before being reviewed. The administration and enforcement of the development rules are carried out by many different agencies, which were contacted to complete the information in Table 4.14.

The comparison of the existing development rules to the model development rules is the next stage of analysis. The Code and Ordinance Worksheet (COW), developed by the Center for Watershed Protection, was used for this comparison (see Page 9). The COW examines established bench marks for site planning that affect the natural environment, such as dimensions of minimum street widths, standard parking spaces, and landscaping requirements.

The continuation of the process evaluates the results of the comparison to the model ordinances and determines if the rules make sense to change or modify in Midland. The bench marks identified in the COW and the language in the model ordinances are only recommendations, which should be closely examined before any changes are made. The zoning ordinances and the development rules affect many different people and agencies, thus any proposed changes need to be brought forth and discussed with these individuals and groups. An important consideration was also the coherence to the goals of the WMP. Midland is participating in the Watershed Steering Committee (Steering Committee) prioritization process of identifying areas of concern within the Watershed. The highest concern for the health of the Watershed was excessive sediment and nutrients impairing the designated uses of supporting a warmwater fishery and indigenous life and other wildlife. The goals of the WMP are stated in Chapter 3 - Water Quality Summary. The recommendations for policy changes are assessed according to the goals and objectives of the WMP. Prioritized goals and objectives of the WMP do not necessarily need to match the priorities of Midland to change their rules, as long as the overall goals are not compromised. The local officials on the Steering Committee have the responsibility to identify and raise the important issues.

TABLE 4.14 - RESPONSIBILITIES FOR DEVELOPMENT

Development Responsibility		State	County	City
Establishes master plan	Agency		Planning Department	Planning Commission
	Contact Name		Cindy Winland	Jon Lynch
	Phone Number		(989) 832-6879	(989) 837-3374
	Email			
Establishes zoning ordinances	Agency			City Council
	Contact Name			Jack Duso
	Phone Number			(989) 837-3302
	Email			
Establishes subdivision ordinances	Agency			City Council
	Contact Name			Jack Duso
	Phone Number			(989) 837-3302
	Email			
Reviews/establishes storm water management or drainage criteria ordinances	Agency	MDEQ - SWQD	Drain Commissioner	City Council
	Contact Name	Keith Noble	Doug Enos	Jack Duso
	Phone Number	(989) 686-8025	(989) 832-6770	(989) 837-3302
	Email			
Reviews/approves subdivisions plans	Agency		Drain Commissioner	Building Department
	Contact Name		Doug Enos	Dennis Wolf
	Phone Number		(989) 832-6770	(989) 837-3392
	Email			
Sets road standards	Agency	MDOT	Road Commission	Engineering Department
	Contact Name	Terry Stepanski		Bradd Maki
	Phone Number	989-773-7756	(989) 687-9060	(989) 837-3351
	Email			
Provides fire protection and fire protection code enforcement	Agency			Fire Department
	Contact Name			
	Phone Number			(989) 837-3411
	Email			

TABLE 4.14 - RESPONSIBILITIES FOR DEVELOPMENT

Development Responsibility		State	County	City
Oversees stream buffer or floodplain ordinances	Agency	MDEQ - LWMD	Drain Commissioner	Engineering Department
	Contact Name	Joy Brooks	Doug Enos	Bradd Maki
	Phone Number	(989) 686-8025	(989) 832-6770	(989) 837-3351
	Email			
Oversees wetland ordinances	Agency	MDEQ - LWMD		Engineering Department
	Contact Name	Amy Lounds		Bradd Maki
	Phone Number	517-241-8169		(989) 837-3351
	Email			
Establishes grading requirements or oversees erosion and sediment control program	Agency	MDEQ - LWMD	Drain Commissioner	Engineering Department
	Contact Name	Matt Johnstone	Doug Enos	Bradd Maki
	Phone Number	231-775-3960	(989) 832-6770	(989) 837-3351
	Email			
Reviews/approves septic systems	Agency	MDEQ - SWQD	Health Department	Not permitted in City
	Contact Name	Matthew Campbell		
	Phone Number	517-335-4178	(989) 832-6380	
	Email			
Review/approves utility plans (water and sewer)	Agency		Dept. of Public Works	Utility Department
	Contact Name		Marty McGuire	Noel Bush
	Phone Number		(989) 835-2531	(989) 837-3343
	Email			
Review/approves forest conservation/tree protection plans	Agency		Parks and Recreation	
	Contact Name		Robert Eggers	
	Phone Number		(989) 832-6870	
	Email			

The summary provided at the end of this chapter will assist Midland in determining where to begin the process to change or not change the development rules. Midland is encouraged to pursue these recommendations to meet the goals set forth in their Master Plan and in the WMP.

EXISTING RULES OF DEVELOPMENT

State government rules for watershed protection are limited to the administration of floodplain development, soil erosion and sedimentation, health regulations, subdivision rules and regulations, storm water discharges, and wetland ordinances and regulations. Townships and cities are responsible for developing land use plans and zoning ordinances, as well as ensuring their implementation. Land use plans and zoning ordinances are the regulatory tools that can be used to protect surface water and groundwater. The Master Plan identifies goals for the future development in the City of Midland. The Code of Ordinances is intended to provide the rules and regulations that will "preserve the peace, health, and safety and welfare of the inhabitants of the City of Midland." Design manuals and construction specifications, for development, guide the alterations of land and water necessary for the growth of Midland. All of these policies must be integrated to ensure that none of their goals and objectives are incompatible. The COW requires the examination of all of these documents to be able to assess the capacity of Midland to continue to grow and prosper while protecting the natural resources.

Theories of BMPs for storm water management might differ somewhat in the prioritization of implementation, but the overall concept follows the steps of protection and source reduction, then mitigation and structural site controls. Protection and source reduction includes preserving natural areas, decreasing impervious surfaces, and using natural areas as much as possible in storm water management designs. Mitigation and structural site controls consist of resource based land use planning (cluster housing and open space developments), maximizing infiltration techniques, and retention and detention basins. The following categories of the COW address these concepts:

- Residential streets and parking lots (habitat for cars)
- Lot development (habitat for people)
- Conservation of natural areas (habitat for nature)

The COW was completed using information from the zoning ordinances, and the Master Plan. For each category, specific questions are asked that relate to regulation governing how development happens in the City. Ordinances and rules were evaluated based on their ability to protect natural landscaping, decrease impervious areas, promote resource land use planning, or implement BMPs. The complete annotated version of the COW is included in the "Policy Review Document" prepared for the City of Midland.

FINDINGS

A review of the responses in the COW reveal specific areas of the existing development rules that are generally good in their efforts of watershed protection and other areas that need improvement. Assessing the current development rules and the identification of the impediments to innovative site design will assist Midland to create and implement better development designs. The COW organizes the review of the ordinances to a more workable format for assessing the strength of resource protection in Midland.

Principles 1 through 10 addressed the rules that create the habitat for cars. Parking lots, roadways, and driveways in suburban areas are the largest contributors to imperviousness in communities overall. Parking ratios and minimum sizes for parking stalls were consistent with recommendations in the COW. The most obvious impediment to better site design was the established minimum widths for local roads and the requirement for curbs and gutters on public roads. Private roads allow much more flexibility in construction standards; however, City services are not available on private roads. The establishment of private roads must take both of these factors under consideration. Grassed swales can serve as storm water collection areas, where water can infiltrate, rather than be directed down a curb and into a storm sewer.

Principles 11 through 16 concentrate on the habitat for people. The appearance of a neighborhood depends on the sizes and shapes of lots, the housing density, the amount of open space, and the overall design of the development. The allowance of Planned Unit Developments (PUDs), which require 40% of the land to remain open space, is an important step toward natural resource protection in Midland. An impediment to developers to apply for a PUD is the extra procedures and extended time to go through the PUD approval process. Although the requirement of 40% of open space in the PUD is noteworthy, regulations do not require the open space to preserve any part in its natural state.

Principles 17 through 22 assess the rules that govern the habitat for nature. The protection of existing natural areas can be accomplished through regulations that incorporate buffers and open spaces into new developments. Midland provides protection to riparian areas through the establishment of parks along most of the streams.

Midland is developing a Community Development Toolbox to review its Zoning and Subdivision Ordinances. Leaders recognize that the ordinances are valuable tools to shape Midland's future. Midland's citizens, business owners, and developers, have been invited to help sharpen these two important community tools. Midland’s current involvement in the Community Development Toolbox project will keep their rules and ordinances in line with how the community desires to grow and develop. The

COW completed in this review, together with the Toolbox, will strengthen the environmental protection aspect of the ordinances and work toward meeting the goals of the WMP.

RECOMMENDATIONS

The principles presented in this document can be adapted to reflect the goals and objectives outlined in the Master Plan. Not all of the principles will be applicable to Midland and should be considered as guidelines rather than milestones. The use of the principles to begin discussion on these issues will eventually lead to protecting the natural and aquatic resources and revise the Master Plan if necessary.

MASTER PLAN

Midland's Master Plan includes two goals that address resource protection. Goal 10 is to "protect the natural features which contribute to the desirable character, appearance and image of the City." The first action that is recommended to meet this goal is to encourage preservation of woodlands and native landscapes as an element in the design of new development. The second action is to discourage intensive development of wetlands and other environmentally sensitive areas.

Policy Recommendations:

- Add development standards to the zoning ordinance to ensure that adequate consideration is given to sensitive environmental features and low impact development concepts are promoted.

Goal 11 in the Master Plan is to provide parks and open space in proximity to residential neighborhoods. Recommended actions to meet this goal are to encourage development of common open space to preserve environmentally sensitive areas, and to provide natural areas for the enjoyment of residents. Currently, the PUD guidelines require 40% of the area to remain as open space, but the guidelines also require that the open space be evenly distributed throughout the area. Larger, unfragmented areas are much more desirable for both wildlife habitat and ecosystem preservation.

Policy Recommendations:

- Revise the PUD requirements to allow for the open space to be condensed into one area.

Chapter 3 of the WMP outlines the goals and objectives to reduce nonpoint source pollution in the Watershed. The recommendations for changes to policies that reflect these goals and objectives are as follows:

Impairment: **Sediment, Nutrients, Low Dissolved Oxygen Levels**

Environmental land use planning ordinances promote habitat preservation by requiring buffer strips in riparian areas, which prevent soil erosion and reduce sedimentation in river and streams.

Policy Recommendations:

- Establish buffer criteria in city parks.
- Review SESC inspection and enforcement procedures.

Impairment: **Degraded habitat**

Habitat fragmentation can be minimized by promoting the use of buffer strips and discouraging the clearing of the stream canopy along land, particularly on the south and west sides of stream banks.

Policy Recommendations:'

- Establish buffer criteria in city parks.
- Revise PUD requirements to allow for open space to be condensed into one area.
- Consider tax incentives for conservation easements.

Impairment: ***E. coli***

E. coli sources are not a significant threat in Midland due to the restriction on septic systems and absence of agricultural activities. However, pet waste and urban wildlife, such as raccoons and possums, have been determined to be contributing an increasing amount of *E. Coli* to urban waterways. Storm water management policies need to address the proper disposal of pet waste and prevent other wastes from entering surface waters in order to meet applicable water quality standards.

Policy Recommendations:

- Consider pet waste disposal ordinance.

Impairment: **Invasive species**

The spread of exotic species can be minimized by increasing public awareness of exotic species introduction and transport and the effects on native communities.

Policy Recommendations:

- Consider native landscaping ordinances

Impairment: **Hydrology**

Stream flows can be stabilized to moderate hydrology and increase base flows by requiring all developments and construction to have onsite detention or retention. The new storm water regulations currently being drafted by the city engineer address this concern and will work toward stabilizing stream flows by detaining storm water and limiting impervious surfaces. Hydrology can also be stabilized through wetland restoration and preservation.

Policy Recommendations:

- Consider wetland protection ordinance.
- Consider planning ordinances that limit impervious surfaces.
- Consider tax incentives for conservation easement.
- Promote low impact development concepts.

Impairment: **Hydrocarbons, Chemicals, and Heavy Metals**

The potential for hydrocarbon, chemical, or heavy metals contamination of surface water can be reduced by improving storm water management techniques and reducing the amount of these contaminants used in the Watershed.

Policy Recommendations:

- Implement storm water management practices.
- Consider planning ordinances that limit impervious surfaces.
- Consider ordinances that require detention of parking lot runoff and harvesting of cattails in detention basins to remove heavy metals, if necessary.

The WMP also recommends sites for wetland restoration to mitigate flooding occurrences in Midland and to improve water quality. The success of the wetlands functioning in either of these capacities requires protection of the land and restrictions on adjacent land uses. The development of a wetlands ordinance that requires buffers around these wetlands would ensure their protection.

Another recommendation in the WMP is to provide support for the development of a county Geographic Information System (GIS). One area in which this system would benefit planning efforts would be to conduct a build-out analysis for Midland and the townships in the Watershed. The methodology that the analysis entails is to attach density values to each of the land use categories. Estimates of the total population, if every acre is developed to its maximum potential, can then be determined. This information is entered into the GIS to illustrate the changes that would occur in an area if current zoning and land use regulation are fully utilized. If the resulting increases in imperviousness and loss of natural resources and open space are inconsistent with the desires of the community, adjustments can be made in the ordinances and the future planning efforts redirected.

The formation of a committee to oversee the systematic review of the development rules of Midland is a beneficial step to determine if changes can or should be made. Communities that have taken the next step and formed a committee to incorporate better site design, followed these recommendations to have an effective committee (CWP, 1998):

- Encourage planners to consider the model development principles when evaluating their local zoning codes, subdivision ordinances, and landscape ordinances.

- Encourage the development community to incorporate these model development principles in their land development projects.

- Encourage the formation of local committees to adopt and adapt these model development principles within the context of local growth and environmental protection goals.

- Encourage the lending and insurance communities to consider these principles and examine their role in land development.

- Encourage local, state, and federal agencies to provide the technical support, financial incentives, and regulatory flexibility needed to promote the model development principles.

- Encourage environmental groups, watershed organizations, and the general public to use these principles as educational tools.

The elements of a successful strategy for Midland to protect Sturgeon Creek and other water bodies within its jurisdiction by adjusting development rules are as follows:

1. Encourage community minded, public spirited individuals to serve on the planning commission, zoning board of appeals, and city council. Provide training for these individuals to develop the skills that are required to properly review proposed development sites for adequate water quality protection.

2. Review the Master Plan and zoning ordinances periodically to assess if revisions or a total update are necessary. Compare the City's Master Plan with Midland County's Comprehensive Plan to ascertain if goals are aligned. Be aware of changes in State legislation that might impact plans or ordinances.

3. Support a zoning administrator who communicates well with the residents. Ensure that the administrator understands the Master Plan and the zoning ordinances and is able to administer them as the planning commission so intended. Enable the zoning administrator to help create effective regulations and rules that provide the incentive and the enforcement measures necessary to ensure that the permitted land use activities do not harm water quality.

4. Implement educational programs for residents, developers, contractors, local planners, and other landowners who should be educated about the impacts that all of their activities together can have on a watershed. Individual actions, such as properly installing silt fencing at construction projects, maintaining private septic systems, and preserving riparian can provide cumulative improvements to water quality.

CONCLUSIONS

Midland has taken a proactive role in the control of development and enforces stricter rules than the County overall. Midland has an opportunity to work cooperatively with landowners, developers, and planning commissions to change rules through the community Tool Box project and the Watershed project. The WMP and the PRD have demonstrated that individual landowners and local governments are both important in recognizing the effects that their actions have on water quality. A committee, consisting of representatives from Midland city government, area developers, and the environmental community, could create new development rules that are best suited to achieving sustainable development and protecting the natural resources within Midland's legal authority This document is a starting point for this committee in their review of the current ordinances and regulations.

Potential members of such a committee are:

Planning Commission
Building Department
City Engineer
Department of Public Services
Public Works
Parks and Recreation
Downtown Development Authority
Developers
Land Trusts
Realtors
Real Estate Lenders
Civic Associations
Dow Gardens
Engineering Consultants
Homeowner Associations
Chamber of Commerce
Urban Foresters
Site Plan Reviewers
Storm Water Management Authorities
Watershed Residents and Landowners
Health Department
Land Use Attorneys

Members of the Watershed Steering Committee voiced concerns that a model plan for developers in the Watershed does not exist. Developers are often looking for guidance to create desirable living spaces for the community, and if design rules and criteria exist, they know that their plans will be approved more easily if the rules are followed. Midland supports continued educational and outreach opportunities for the development community through workshops, tours, and demonstration sites. Concepts of Low Impact Development and Smart Growth can be incorporated into training sessions and seminars sponsored by Midland, and incentives to adopting these practices should be established.

Most townships in the Watershed have not updated their Master Plans and little coordination of plans occurs in the Watershed. The application of the concept of managing on a “townshed” level could be explored. A “townshed” is the area of adjacent townships with acreage in a common watershed. A “townshed” committee could coordinate efforts and prioritize by subbasins with different management strategies to select the most appropriate BMPs.

The recommendations presented in this document will be considered by Midland, and if adopted, could be used as a model for the other local governments in the Watershed. Additional funding is being sought for the communities to conduct a review of their policies. The Townships of Larkin, Lincoln, Mills, and Hope could all benefit from such an analysis as these communities continue to grow at a pace that outraces their development rules.

This PRD will provide helpful information if the Michigan Department of Environmental Quality determines that Midland is mandated to submit an NPDES Phase II Storm Water permit application. The information and resulting changes to the existing ordinances could be combined to create a storm water ordinance, which is required under the permit.

Although this document identifies areas where improved ordinances could further protect natural resources, the enforcement and implementation of the current rules and regulations was not identified. Local officials must ensure that the capacity to administer new rules and ordinances exists within their departments and that the revisions have substantial local support. The development of a decision making system will assist Midland in responding to the effects of growth and development.

MODEL ORDINANCES

Many communities around the country have adopted ordinances using model ordinances developed by organizations, such as the EPA and the Center for Watershed Protection. A model ordinance should be used as a framework for developing ordinances that include the unique features in the community. For example, wetland and native vegetation ordinances could include more specifics about local vegetation resources that are particular to the City area. The following list of websites and resources lists ordinances that could provide aid in developing ordinances for the City to further protect its natural resources.

1. SOIL EROSION AND SEDIMENT CONTROL

Erosion and Sediment Control/Grading Ordinance

This document borrows language from the model erosion and sediment control ordinance for Westchester County, New York. Some additional features that prevent erosion and sedimentation and protect natural resources are incorporated into this model. For example, the ordinance emphasizes limited clearing and grading, and requires that contractors be certified to maintain and inspect erosion and sediment control practices.

http://www.stormwatercenter.net/Model%20Ordinances/esc_model_ordinance.htm

Erosion and Sediment Control Ordinance from Minneapolis, MN

Provides a few technical guidelines and references an existing technical document. An example of a very strict ordinance in terms of the sites that are required to submit sediment and erosion control plans.

http://www.epa.gov/owow/nps/ordinance/escontrol.htm

Clearing and Grading Ordinance from Olympia, WA

An example of regulating clearing and grading separately from erosion and sediment control.

http://www.epa.gov/owow/nps/ordinance/clearingord.htm

Erosion and Sediment Control Inspection Checklist from the Lower Platte South Natural Resources District, NE

A good example of a tool that can help contractors or government inspectors effectively maintain erosion and sediment control measures.

http://www.epa.gov/owow/nps/ordinance/inspection.htm

Small Site Design Guideline from the Indiana Department of Natural Resources

An example of a small site guideline. For sites that are not regulated by the ordinance, guidance material like this might help to reduce erosion and sedimentation.

http://www.epa.gov/owow/nps/ordinance/indiana.htm

Pre-Construction Meeting Notice from Montgomery County, MD

An example notice for a public meeting. Materials like this notice help support the ordinance language and ensure that erosion and sediment control measures are properly installed.

http://www.epa.gov/owow/nps/ordinance/preconstruction.htm

2. NATIVE LANDSCAPING AND TREE PRESERVATION

Forest Resource Ordinance, Frederick County, MD

This ordinance limits the amount of forest that can be cleared in new developments, and requires tree planting to mitigate site clearings.

http://www.epa.gov/owow/nps/ordinance/documents/E6-Frederick.wpd

John Marshall Law Review, Model Modified Weed Ordinance

The appendix attached to this document is intended to be a working model of a fair and workable weed ordinance by redefining the term, unmanaged vegetation.

https://chicago.glnpo.net/glnpo/greenacres/weedlaws/JMLRApndx.html#APPENDIX%20A

EPA Green Acres Website

Example Lawn Management Laws that allow Native Vegetation Landscaping

https://chicago.glnpo.net/glnpo/greenacres/weedlaws/index.html

http://www.epa.gov/grtlakes/greenacres/toolkit/index.html

Weeding Out Bad Vegetation Control Ordinances

http://www.for-wild.com/weedlaws/weeding.htm

http://www.for-wild.com/hotlinks.htm

The Wild Ones Handbook

http://www.epa.gov/greenacres/wildones/

3. WETLANDS PROTECTION

Wetland and Watercourse Protection and Restoration

This ordinance was developed for Michigan communities for the control and preservation of wetlands and watercourses. The ordinance specifies methods for the location, maintenance, and protection of natural and mitigated wetland areas.

http://www.crwc.org/projects/scwetlands/modelwetlandord.html

Wetlands and Watercourse Ordinance, Croton-on-Hudson, NY

The example ordinance, attached to this document, protects wetlands by restricting development and requiring measures that prevent runoff pollution from new development adjacent to wetland areas.

http://www.stormwatercenter.net/Model%20Ordinances/misc__wetlands.htm

Clinton River Watershed Council Wetland Protection Master Plan

This example Township Master Plan describes the overall goals to preserve and protect wetland areas and native vegetation to reduce the amount of storm water runoff.

http://www.crwc.org/projects/scwetlands/masterplan.html

City of Boulder, CO Wetland Protection Legislation

Boulder, CO has assembled a very comprehensive wetland preservation ordinance that outlines wetland definitions and required protection methods.

http://www.ci.boulder.co.us/cao/brc/9-12.html

Michigan Department of Environmental Quality's Local Government Guide to Wetland Protection

A good online guide for Michigan Planners and Officials that answers many of the frequently asked questions about the complex wetland protection legislation.

http://www.michigan.gov/deq/0,1607,7-135-3313_3687-10466--,00.html

4. OPEN SPACE DEVELOPMENT

Open Space Model Ordinance

The reduction of impervious surfaces in new developments is the goal of this ordinance by reducing setback requirements and the amount of area that needs to be cleared for development. The open space that is afforded using this method of planning can be used as storm water collection areas that filter storm water runoff before it enters a watercourse.

http://www.stormwatercenter.net/Model%20Ordinances/open_space_model_ordinance.htm

Land Preservation District Model Zoning from Montgomery County, PA

This ordinance would also require the preservation of open space in certain districts.

http://www.stormwatercenter.net/Model%20Ordinances/open_space_land_preservation_ord.htm

Open Space Ordinance from Hamburg Township, MI

This ordinance incorporates commercial land uses (e.g., mixed use) for projects of a certain size, and provides an example of the application procedure for one community.

http://www.stormwatercenter.net/Model%20Ordinances/open_space_zoning_hamburg.htm

Metropolitan Northern Georgia Water Planning District

This model ordinance was drafted for Georgia communities to use in residential areas that wish to preserve open and green space to reduce storm water runoff.

http://www.northgeorgiawater.com/pdfs/DrModSWOrdTask9/8-16-02cons-sub-openspace.pdf

5. AQUATIC BUFFER

Aquatic Buffer Ordinance

This stream buffer model ordinance protects water quality in streams by protecting existing riparian buffers and includes wording that can be used to establish stream buffer zones. Much of the model is based on the regulations of Baltimore County, Maryland, for water quality protection in floodplains, streams, and wetlands.

http://www.stormwatercenter.net/Model%20Ordinances/buffer_model_ordinance.htm

Language from Baltimore County, MD

Includes specific language specifying the expansion of buffers for erodible soils and steep slopes.

http://www.epa.gov/owow/nps/ordinance/language.htm

Rhode Island Coastal Zone Program

An example of a buffer ordinance in a coastal region.

http://www.epa.gov/owow/nps/ordinance/rhdisland.htm

Ordinance on Riparian Habitat Areas, Napa, CA

A buffer ordinance for a region with few native trees. This ordinance focuses on the preservation of other native vegetation.

http://www.epa.gov/owow/nps/ordinance/napa_buffer_ordinance.htm

Portland Metro Floodplain Preservation Ordinance

Focuses on management of the floodway.

http://www.epa.gov/owow/nps/ordinance/portland.htm

Model Land Trust Agreement (Natural Lands Trust)

An example of a land trust agreement. Such documents are often needed to ensure the long-term integrity of the buffer.

http://www.epa.gov/owow/nps/ordinance/land.htm

Connecticut Rivers Joint Commission

Community Guidelines for developing a model ordinance and master plan that aims to protect and preserve riparian buffers.

http://www.crjc.org/buffers/Guidance%20for%20Communities.pdf

REFERENCES

House Democratic Land Use Task Force. November 2001.

Center for Watershed Protection. August 1998. *Better Site Design*: *Handbook for Changing Development Rules in Your Community*. Prepared for the Site Planning Roundtable. Ellicott City, Maryland.

Schueler, Tom. 1995. Site Planning for Urban Stream Protection. Center for Watershed Protection, Ellicott City, Maryland. Prepared for the Metropolitan Washington Council of Governments, Washington, DC.

CHAPTER 5 - INFORMATION AND EDUCATION STRATEGY

A key part of the Watershed project is to involve the landowners and other interested individuals through a public awareness campaign, educational programs, and volunteer opportunities. Although public awareness will be highlighted throughout the project, it will be emphasized during the planning phase while the volunteer opportunities will be developed mainly during the implementation phase. The educational programs will take place throughout the project and afterwards as the funding permits.

5.1 PUBLIC PARTICIPATION PROCESS

Three public meetings have been held for the Watershed project. Each of these meetings have been held in a different region of the watershed to facilitate contact with groups of people with similar concerns, visions, and interests.

All of the meetings were publicized using the same methods. The residents in the region of the Watershed where the meeting was taking place were each sent an invitation postcard. An advertisement/invitation was also placed in the Midland Daily News to invite any other interested citizens.

The speakers at each meeting varied, but in general delivered comparable information to each group. The meetings began with an introduction by the MCD, explaining their mission, followed by an overview of the project delivered by the Sturgeon Creek Watershed Project Coordinator. The next item on the agenda was a presentation on the water quality monitoring program, followed by comments and support from the MCDC. The Drain Commissioner spoke in general about the benefits of preventing the sediment and nutrient input into the drains and streams in terms of delaying the onset of dredging operations to clean out county drains, which in turn saves the taxpayers money in the long-run. A speaker from the local land trust organization then presented areas of concern and the potential for land preservation through conservation easements within the Watershed. Finally, the Midland Conservation District Administrator spoke on public involvement and volunteer opportunities. At the meeting in the City, the Assistant City Engineer spoke on storm water regulations.

- The first meeting was aimed at the citizens of the City and was held at H.H. Dow High School on April 2, 2002, from 7 p.m. to 9 p.m. The turnout was excellent. Approximately 65 people attended the meeting.

- The second meeting was held in the western half of the Watershed at the Sanford Senior Citizens Center on June 6, 2002. Residents from Hope, Homer, and Lincoln Townships were invited to this meeting. Approximately 20 people were in attendance.

- The third meeting was held in the eastern half of the Watershed at the old Larkin Township Hall. Residents from Larkin and Mills Townships were targeted with this meeting. Attendance at this meeting was an impressive 43 people.

The first two meetings had citizens that were very concerned about their individual property rights being infringed upon. They also had concerns with the blockage of water flow by 'natural' woody debris, out of control vegetative growth, beaver dams, and small culverts. By the third meeting, people seemed much more interested in the project as a whole and less concerned with paving the channel, or people trespassing on their property. Interest was high in the planning process and helping with the development of the WMP.

At each meeting, the participants were asked to sign-in and to fill out a response form at the end of the meeting if they had any comments or interest in assisting the project or wanted to be added to the mailing list.

In addition to the public meetings mentioned above, the MCD had a booth at the Riverdays event in downtown Midland on Friday, July 19, 2002, and Saturday July 20, 2002. This booth had information focusing on the Watershed project. The District also attended the Midland County Fair with this same informational booth in August 2002.

5.2 GOALS OF THE INFORMATION AND EDUCATION STRATEGY

The goal of the I&E Strategy is to increase awareness that there is a group focused on the development of a sustainable water quality improvement plan for the Watershed and to involve landowners and other interested groups and individuals in the planning, implementation, evaluation, and sustainability of the program. This strategy will serve as a guide on how to develop and implement the objectives. An I&E Subcommittee has been formed from members of the Steering Committee and other stakeholders (Table 5.1). This group will work to develop this strategy and its direction.

Table 5.1 - Information and Education Subcommittee

Member	Affiliation
Mr. Charlie Bauer	Michigan Department of Environmental Quality
Mr. Bruce Campbell	Stakeholder
Ms. Debbie Anderson	Midland Conservation District
Mr. Bill Page	Stakeholder
Ms. Deborah Rogers	Midland Conservation District
Mr. Mike Stein	Midland Board of Realtors
Ms. Deb Bloom	Stakeholder

5.3 I&E STRATEGY OBJECTIVES

The following objectives, presented to the general public but geared more toward the landowners along the stream and drains, will lead the I&E Strategy toward its goals:

- Increase awareness of the existence of the Sturgeon Creek Watershed Project and its goals and objectives.

- Provide information regarding the need for such a project and the benefits it will provide.

- Provide educational opportunities concerning improving water quality through watershed management and how to reduce or eliminate nonpoint source pollution inputs through land use activities.

- Allow the public direct access, through participation, and indirect access, through newsletter and newspaper articles, to the different phases of the project to improve awareness, acceptance, and approval.

- Develop, maintain, or advance partnerships with stakeholders by sharing resources, organizing cooperative programs, and creating a sense of responsibility. This will increase awareness and interest in land use management.

5.4 IDENTIFYING TARGET AUDIENCES

The following target audiences, individually referred to as stakeholders, were developed after conducting an inventory of the Watershed. Identifying current and potential impacts, as well as community interests and concerns helped to develop these target audiences.

1. Urban and Rural Residential Land Owners - Those people living, or just owning property, within the watershed. Special attention will be given to those who live along the Creek or its tributary drains. Individuals along the Creek and drains were identified through comparing the city and county tax bases to the MCDC's maps. Those within the Watershed but away from the water were asked to identify themselves through newspaper and newsletter articles.

2. Agricultural Producers - Those who own active farmland or who lease land for agricultural production within the watershed. This audience, a subset of the landowners group, was identified in the same manner as the landowners.

3. Recreational Users - Those who use the land within the watershed for recreational purposes regardless of where they live. This audience will be identified through surveys covering Midland County.

4. Local Government Officials - County, City, or Township elected or appointed officials who have legislative authority over the land within the watershed. These individuals were identified through the City, County, and Township personnel rolls and have been contacted individually or in groups.

5. Groups and Organizations - Schools, youth groups, environmental organizations, and sporting groups that are interested in conserving and protecting the land within the Watershed. Those groups that did not identify themselves to project personnel in order to become involved in it, were sought out and presented with the project and invited to become involved.

6. Area Businesses - Those businesses that sell products or provide services to those living, working, or recreating within the watershed. These businesses will include but not be limited to, developers, farm product dealers, landscape and lawn care companies, and sport shops.

The basic message regarding the WMP, its goals, objectives, and the benefits to the community, as well as general messages concerning sources, causes, and BMPs will be offered to all of the above audiences.

5.5 PRIMARY MESSAGES

Before any specific messages can be relayed to any of these target groups, general messages such as defining the project, identifying its purpose and benefits, and delineating and locating the watershed will be presented. Once the entire project has been explained, specific messages can be separated out and directed toward specific audiences. The most basic message of identifying the project and its purpose and benefits will be presented to the public at large from the very beginning. The methods that have already been used are newspaper articles announcing the project and its progress, informational handouts, public meetings, and brochures distributed at public events. These techniques will continue through the life of the project. Information and educational materials from other watershed projects will be used as templates for developing more targeted messages. A map outlining the watershed and showing its location within the county has been displayed at every event mentioned above and will be included in the brochure, newsletters, and other publications produced for the project.

Explanations of the goals and objectives of the WMP will give the audiences an idea of how the needs will be addressed and the benefits will be made available. They will also create a sense of responsibility and let the audiences know how they may be able to get involved. The general issues and concerns relating to the Watershed, the project, and the pollutants will be addressed at all levels. One of the primary concerns of the public is how they will be directly and indirectly affected by the project.

5.6 DELIVERY MECHANISMS

Because of the highly varied messages that need to be relayed to a large number of diverse audiences, a combination of passive and active processes and media will be used to deliver these messages. The following are among some of the methods that may be used to address the issues and concerns of the public.

- Brochures* - Informational on a general level, to be handed out at all events, programs, and meetings as well as passively available at locations.

- Direct Mail* - Self-published postcards or letters used to promote events, programs, or meetings.

- Demonstration Watershed - A hands-on tabletop model of a watershed used to teach the values of a healthy watershed and the effects of various land uses on the system.

- Educational Programs* - Geared toward target audiences to convey intensive messages. Can be conducted in a classroom or in the field and can include various levels of audience participation.

- Event Participation* - A portable display to be installed in booths at various events sponsored by the Watershed project itself, partner organizations, or unrelated groups. Handouts and personnel available to offer further information or answer questions.

- Exhibition Projects - Long-term projects developed to present an environmentally sound example of a BMP or land use. They can be passively available to the general public or presented to a specific audience during a tour or educational program.

- Landowners Handbook* - A guide to present to urban and rural landowners that contains general information on watersheds, water quality, and land use practices as well as more specific information on BMPs, resources, and regulations.

- Newsletters* - Single- or multiple-page publications distributed independently or within other newsletters with articles, calendars, and illustrations. Response forms will be included to provide additional information by request and to evaluate effectiveness.

- Personal Contact - Used to convey very specific messages to individuals or small groups. May be organized or spontaneous conversations during chance encounters.

- Press Releases - Articles written by staff reporters with the Midland Daily News and other local daily or weekly publications about significant developments within the project. Also articles about specific portions of the project may be submitted for publication in the forum section of the newspaper.

- Project Logo* - A simple design created to promote awareness of the project. It will be present on all publications and products.

- Public Meetings* - Organized to inform large general groups or specific target audiences about the project in general or various issues and/or concerns.

- Roadside Signs* - Designed, created, and placed at strategic locations within the watershed to develop awareness and recognition of the logo.

- Volunteer Programs - Organized programs developed to allow the public to become involved in the project. May include Storm Sewer Stenciling, Adopt-A-Stream, Water Monitoring, and other programs.

- Watershed Tour - Provided to groups and individuals, the tour will provide a sensory intensive educational opportunity. Targeted messages will be presented to general audiences to provide information not normally received.

*These delivery mechanisms will include the use of the project logo.

5.7 I&E IMPLEMENTATION

Public awareness, involvement, and acceptance are the key components of the Information and Education Strategy. All the objectives are reliant upon each other for the program to be successful. The approach of the I&E Strategy is to complete tasks by building on the previous accomplishments. In this manner programs will progressively develop greater public awareness of their watershed and increase their involvement and acceptance of water quality programs. The timeline for implementing the strategies is shown in Table 5.2.

Table 5.2 - Overview of the Implementation Plan for Information and Education Strategy

Target Audience	Delivery Mechanism	Occurrence	Timeline	Evaluation	Estimated Costs
All	Public Meetings	3/year	Years 1 and 3	Attendance, return of response forms	$150
	Brochures	Continual	Years 1-4+	Response, requests, comments	$500
	Press Releases	Quarterly	Years 1-4+*	Response after publication	$0
	Use and Promotion of Logo	Continual	Years 1-4+	Survey results	$0
	Roadside Signs	Continual	Indefinite	Response to phone number, comments	$1,000
Urban and Rural Land Owners	Direct Mail	3/year	Years 1 and 3	Calls, attendance	$2,300
	Newsletters	Biannually	Years 1-4+	Return of response forms	$3.200
	Watershed Tour	Yearly	Years 2-4+	Attendance	$400
	Workshops for landscapers and homeowners	Quarterly	Years 2-4+	Participation	$350
	Brochures	Continual	Years 1-4+	Response, requests, comments	$500
	Public Meetings	3/year	Years 1 and 3	Attendance, return of response forms	$150
	Personal Contacts	Frequent	Years 1-4+	Number of people contacted	$15,0000
	Landowner's Handbook	Once	Year 3	Requests	$7,500
Agricultural Producers	Newsletters	Biannually	Years 1-4+	Return of response forms	$1,900
	Demonstration Projects	Continual	Years 3-4+	Attendance	$10,000
	Brochures	Continual	Years 1-4+	Response, requests, comments	$500
	Personal Contacts	Frequent	Years 1-4+	Number of people contacted	$7,500
Recreational Users	Newsletters	Biannually	Years 1-4+	Return of response forms	$500
	Volunteer Programs	Continual	Years 2-4+	Participation	$1,000
	Brochures	Continual	Years 1-4+	Response, requests, comments	$500
	Event Participation	Quarterly	Years 2-4+	Participation	$400
Local Government Officials	Watershed Tour	Yearly	Years 2-4+	Attendance	$400
	Personal Contacts	Frequent	Years 1-4+	Number of people contacted	$360
	Direct Mail	3/year	Years 1 and 3	Calls, attendance	$250

Table 5.2 - Overview of the Implementation Plan for Information and Education Strategy

Target Audience	Delivery Mechanism	Occurrence	Timeline	Evaluation	Estimated Costs
Groups and Organizations	Demonstration Watershed	Quarterly	Years 2-4+	Participation	$10,000
	Event Participation	Quarterly	Years 2-4+	Participation	$360
	Education Programs	Quarterly	Years 2-4+	Participation	$350
	Volunteer Programs	Continual	Years 2-4+	Participation	$4,000
Area Businesses	Personal Contacts	Frequent	Years 1-4+	Number of people contacted	$500
	Education Programs	Quarterly	Years 2-4+	Participation	$400
				Total	**$69,970**

* (+) signifies a continuation of the mechanism beyond the term of the project.

PUBLIC AWARENESS

The preliminary step of the I&E Strategy process will be to increase public awareness of not only the project but of the Watershed, water quality, and land use management. This will initially be directed toward the general public with targeting of individual groups to come later. The concept of public involvement will be introduced and interested groups and individuals will be identified and kept informed of program development.

PUBLIC INVOLVEMENT

Educational and volunteer opportunities will be developed in order to increase the general public's knowledge of, and feeling of responsibility for, their impacts upon the land within the watershed and how they may help conserve and protect it. These programs will normally be geared more toward target audiences and will relay messages.

PUBLIC ACCEPTANCE

Cooperation during the implementation phase of the project, participation in programs, comments, and responses will be a measure of the acceptance of the project by the public. Personal requests for information concerning the implementation of environmentally-sound land uses will be an additional gauge of acceptance. These same factors will also act as an evaluation of the I&E Strategy as a whole.

5.8 EVALUATION

Evaluating the I&E Strategy is an ongoing task that will allow adjustment as needed to keep the plan on track. This evaluation will also allow the project manager to know when and where to proceed with the implementation phase of the project.

Several tools of evaluation are listed in Table 5.2. Another tool that will be used for evaluating the strategy will be a community survey. This survey will consist of a questionnaire to be presented to members of the general public in person, through the mail or via the internet. Information collected will include:

- Knowledge of the Watershed, the project, and its logo.
- Knowledge of, and interest in, land use issues.
- Knowledge of, and interest in, suspected water quality impairments by low dissolved oxygen levels, pH, pesticides, oil and grease, and metals.
- Where/how they gained this knowledge.
- Plans to adapt current land use practices to implement this information.

This survey will be conducted in the early stages of the project, at the end and, if possible, two or three years after the completion of the project. This will show the effectiveness of the strategy and its success in relaying its messages.

The “Activity Summary Sheet” (Chart 5.1) will be completed after each I&E event. This will provide for an easy to read summary of the event and a measurable component of the public outreach strategy allowing the event to be evaluated at different levels.

5.9 SUSTAINABILITY

The I&E subcommittee has offered ideas for ways to sustain the effectiveness of the messages being relayed during this project. Among them include: Continuing the volunteer programs within the watershed and extend them to include areas within other watersheds; either continue the water quality monitoring program at the project level or adapt it to become a volunteer effort; develop a watershed council made up of individuals representing a variety of organizations to gather data for watersheds throughout the county, and act as a clearinghouse for other watershed management and land use information.

Community support has surpassed the district's expectations. The City has contributed $41,500 for the hydrological analysis and GIS mapping and engineering of the WMP. The Dow Foundation has contributed $13,000 for public education, employee training, and an in-stream water-monitoring system. The Gerstacker Foundation granted $1,428 toward the purchase of two GPS units and computer. The Steering, Technical, Information/Education, and Water Monitoring Committees are made up of citizens at large, industry, businesses, and technical persons who have volunteered countless hours towards the development of the WMP. A total of 33 active committee members have each volunteered no less that 4 hours per month since the onset of the watershed planning project.

Potential funding sources include the Watershed Assistance Grant Program for the development of a watershed council in the amount of $14,400. Saginaw Bay WIN for the watershed educational display for $10,000, and a one-year Section 319 Watershed Education Grant for $60,000. Mini grants for volunteer programs will be sought on a continual basis for such programs as river clean ups, adopt-a-stream, programs, storm sewer stenciling, and volunteer water monitoring.

Chart 5.1 - Activity Summary Sheet

Sturgeon Creek Watershed Project
Information and Education
Activity Summary Sheet

Activity

Name: _____ Location: _____ Date: _____

Type: _____

Message: _____

Audience

	Target	Specific
☐	City Landowners	
☐	County Landowners	
☐	Agricultural Producers	
☐	Recreational Users	
☐	Local Government Officials	
☐	School/Youth Group	
☐	Environmental Organization	
☐	Area Businesses	
☐		

Contacts

Number Contacted _____

Number in Attendance _____ _____ % of those contacted

Number of Responses _____ _____ % of those attending

Costs

Time	$	Speaker	$	Transportation	$		
Postage	$	Facilities	$		$		
Materials	$	Equipment	$		$		
						Total	$

Comments _____

CHAPTER 6 - EVALUATION METHODS

Evaluation of the Watershed project will be a two-phase process. The first phase evaluates the success of the planning process as outlined in Table 6.1. The second phase will assess the methods and strategies of the implementation of the WMP.

6.1 PLANNING PROCESS EVALUATION CRITERIA

The planning process of the Watershed project began on August 1, 2001, and is scheduled to end on July 31, 2003. The evaluation of the planning process is based on the goals set forth in the work plan originally submitted with the grant. Table 6.1 presents the goals of the planning process and includes information about the evaluation techniques, units of measurement, measurable goals, and the date of completion for each goal.

Table 6.1 - Evaluation Techniques for Sturgeon Creek Watershed Project Planning Phase

Goals	Evaluation Techniques	Units of Measurement	Measurable Goals	Scheduled Completion
Form Sturgeon Creek watershed steering committee	Documentation of stakeholder participation	Number of committed members and diversity of representation	Increase number of returning members and groups represented by 25% in the second year	June 2003
Establish information & education subcommittee and create educational strategy	Documentation of stakeholder participation and educational strategy	Number of committed members and diversity of representation, creation of educational strategy	Increase number of returning members and groups represented by 25% in the second year, and completion of educational strategy	June 2003
Establish technical subcommittee and draft water quality statement	Documentation of stakeholder participation and water quality statement	Number of committed members and diversity of representation, and creation of water quality statement	Increase number of returning members and groups represented by 25% in the second year, and completion of water quality statement	June 2003
Analyze local projects, programs, and ordinances	Code and ordinance review	Correlation with model ordinances	Increase COW ranking	June 2003

Table 6.1 - Evaluation Techniques for Sturgeon Creek Watershed Project Planning Phase

Goals	Evaluation Techniques	Units of Measurement	Measurable Goals	Scheduled Completion
Prepare resource library	Extent of bibliography	Number of references and documents collected	Categorized list of resources	June 2003
Conduct watershed tour	Record attendance of watershed tour	Attendance of watershed tour and positive feedback	Minimum 50% attendance of Steering Committee and over 50% positive feedback responses	June 2003
Secure continued water quality monitoring	Record participation of partners and receipt of water quality monitoring results	Participation of water quality monitoring partners and number of water quality monitoring data sets	Steady participation of partners with reliable monthly water quality data reports	June 2003
Increase amount of local match toward implementation	Calculate percent of local match	Percentage change of local match	Net positive change in local match	June 2003
Develop an approvable watershed management plan	Watershed management plan approved by MDEQ	MDEQ letter of approval	Have plan approved by July 2002	June 2003
Present watershed management plan to individual stakeholders	Lessons learned presentation	Number and type of comments received and utilized	More than 50% of comments are positive and all comments responded to or incorporated into revised plan	June 2003

Additional activities that resulted in an evaluation of portions of the planning process include the quarterly reporting of accomplishments in the project, levels of stakeholder participation, and water quality monitoring.

QUARTERLY REPORTS

The progress of the project will be continually monitored by quarterly reports submitted to the MDEQ. These reports will consist of a narrative summary of accomplishments, a detailed budget explaining expenditures and local match, copies of any products and deliverables generated during that quarter, and explanation of problems that caused a deviation from the work plan. The Steering Committee will comment on activities to accomplish during the next quarter.

STAKEHOLDER PARTICIPATION

The level of stakeholder participation in both the planning and implementation processes is key in determining the effectiveness of the Community Outreach as well as the Information and Education portions of this project. Stakeholders have been included already in this project in the capacity of membership on the Technical or Steering Committees, as well as the I&E, Water Quality Monitoring, and Prioritization sub-committee. Attendance and participation throughout this process has been recorded and will be used to determine the number of committed members and the diversity of the stakeholders represented. In addition, public meetings have been held for stakeholder input and education; attendance at these meetings has been recorded. The I&E measures taken to publicize the project during the planning phase will be reviewed for their effectiveness.

WATER QUALITY MONITORING

A baseline survey of water quality is being implemented in the planning phase of this project. The survey is an analysis of three components of water quality: physical, chemical, and biological.

- *Physical* - temperature, depth, type, and amount of sedimentation/substrate composition, conductivity, flow, velocity, turbidity, total suspended solids, depth, etc.

- *Chemical* - pH, nitrogen, phosphorous, ORP, Bio-chemical Oxygen Demand (BOD), dissolved oxygen, presence of heavy metals, etc.

- *Biological* - macro- and micro-invertebrates, plant life (plankton and algae), coliform bacterial levels, etc.

The monitoring will occur at nine pre-designated sites at an interval of two collection dates per season for the following seasons: summer and fall 2002 and spring, summer, and fall 2003. This monitoring will begin in July 2002. In addition to these set times for monitoring, in the event of major weather events, additional data will be taken to help indicate runoff effects.

This baseline evaluation of water quality is being performed under the coordination of MCD Staff by the following:

- The City's waste water treatment facility under the direction of Steve Young.
- The Chemistry Department at Saginaw Valley State University under the direction of Bob Lehmann.
- A volunteer monitoring group comprised initially of the science departments of two of the local high schools; overseen by Dorothy Horan (H.H. Dow High School) and Paul Schroll (Midland High School).

Table 6.2 details which agency will be collecting and performing each test indicated.

Table 6.2 - Organizational Chart of the Water Quality Monitoring Process

Test for	Agency Collecting Sample	Agency Testing Sample
Temperature	Bob Lehmann - Saginaw Valley State University using the Quanta by Hydrolab	
Dissolved oxygen		
pH		
ORP		
Specific Conductance		
Depth		
Vented Level		
Turbidity		
Salinity		
Nitrogen - Nitrate	Public Schools	Public Schools
Nitrogen - Ammonium	Public Schools	Public Schools
Phosphorous	MCD, SVSU	City of Midland
Coliform Bacteria	MCD, SVSU	City of Midland
Heavy Metals	Saginaw Valley State University	Saginaw Valley State University
Invertebrates-Macro*	Public Schools	Public Schools
Invertebrates-Micro*	Public Schools	Public Schools

*Note: The MDEQ will be performing a one-time survey of the fish, macro- and micro-invertebrates for initial baseline data.

6.2 IMPLEMENTATION EVALUATION CRITERIA

The second phase of evaluation will measure the success of the project following the implementation of the prioritized BMPs as outlined in Table 6.3. The evaluation was based on the pollutants identified as impairments to the designated uses. This evaluation will determine the level and rate of water quality improvement, which are achieved in areas of physical, chemical, and biological improvements. In addition, the I&E phase of this plan will be appraised in terms of the success in imparting a sense of ownership, pride, and knowledge of the watershed for area residents. The following methods of evaluation will be used to monitor the success of the project both immediately following implementation and for continual monitoring of the water quality.

Table 6.3 - Evaluation Techniques for Sturgeon Creek Watershed Project Implementation Phase

Impairment/Source/Cause	Evaluation Techniques	Units of Measurement	Measurable Goal
Sediment	Pollutant Reduction Calculations	Tons of sediment prevented from entering surface water	Prevent 10,000 tons/year of sediment from entering surface waters
	BMPs implemented to reduce sediment	Number and location of BMPs implemented	Implement BMPs on all identified NPS sites of sediment loading
	Photographs of BMPs installed to reduce sediment	Before and after photographs	Portfolio of photographs with supporting documentation
	Cost/benefit ratio	Cost of BMP implementation and pollutant load reduction	Economic impact of pollutant load reduced outweighs cost of BMP implementation
	Macroinvertebrate surveys	Water quality rating (from SOS: Stream Quality Survey, Saginaw Bay Watershed Council)	Increase rating of water quality
Nutrients	Pollutant Reduction Calculations	Pounds of phosphorus and nitrogen prevented from entering surface water	Prevent 5,000 pounds/year of phosphorus and 10,000 pounds/year of nitrogen from entering surface water
	BMPs implemented to reduce nutrients	Number and location of BMPs implemented	Implement BMPs on all identified NPS sites of nutrient loading
	Photographs of BMPs installed to reduce nutrients	Before and after photographs	Portfolio of photographs with supporting documentation

Table 6.3 - Evaluation Techniques for Sturgeon Creek Watershed Project Implementation Phase

Impairment/Source/Cause	Evaluation Techniques	Units of Measurement	Measurable Goal
	Cost/benefit ratio	Cost of BMP implementation and pollutant load reduction	Economic impact of pollutant load reduced outweighs cost of BMP implementation
Destruction of wetlands and floodplain forest communities	Wetland inventory and assessment	Acres of and photos of wetlands protected or restored	Increase acres of wetlands in watershed and protection of high quality wetlands
Fecal Coliform * Specific *E. Coli* 2 times randomly samples	Water quality monitoring	Bacteria counts/100 ml	Meet water quality standards for partial body contact recreation (1,000 count/100 ml) in all waterbodies in the watershed
	Eliminate sources	Number and location of sources eliminated	Eliminate all identified *E. coli* contributing sites
	Cost/benefit ratio	Cost and health risk of eliminating source and pollutant load reduction	Economic impact and health risk reduction of *E. coli* reduced outweighs cost of BMP implementation
Degraded fish populations	MDEQ biological surveys	Populations and diversity of fish species	Increase fish community rating to acceptable level
	Creel survey of fishers	Amount, size, and species of fish caught	Establish baseline use and increase number of fishers using the streams and the number of fish caught
Hydrology	Hydrologic Analysis	Peak flows shown on hydrographs	Reduce peak flows on hydrographs by limiting impervious cover, minimizing channelization of streams, and restoring wetlands
Temperature	MDEQ biological surveys	Habitat evaluation	Increase ratings for stream cover
	Impervious cover calculations	Amount of impervious cover by subwatershed	Changing development rules to limit amounts of impervious cover in developments

Additional criteria not directly related to impairments to the designated uses will be valuable evaluation tools for the project.

STAKEHOLDER PARTICIPATION

The level of participation in educational workshops as well as the success in implementing the proposed BMPs will further measure the participation of stakeholders. The workshop participation numbers should be compared to the public meeting participation during the planning phase to measure the change in interest.

BEST MANAGEMENT PRACTICE IMPLEMENTATION

The actual number of BMPs installed will be compared to the goals set forth in the WMP to determine the percent of completion of the project. The number of landowners participating is another indicator of the success of the project. Records will be kept throughout the project to calculate a rate of participation. In addition, the number, location, and type of BMPs implemented will be recorded and monitored for stability of the improvement. The installed BMPs will be periodically monitored to determine if they are meeting expected performance standards through both visual inspection and interviewing landowners to determine difficulties with installation and maintenance, etc. The compliance of any implementation maintenance agreements with the landowners will be monitored.

The amount and type of BMPs successfully installed will be compared with the goals of implementation. This should occur on a regular basis to ensure that the goals of the project are not being overlooked and adjustments can be made to refocus effects. Pollutant reduction calculations are a good tool to measure progress toward goals and the efficiency of work. This figure can be used to compare the cost of the BMP implementation to the amount of pollutant reduced. Some BMPs may offer greater amounts of pollutant reduction, but cost may mean that it is not feasible on a large scale. A combination these BMPs with many smaller BMPs, such as natural, uncut riparian strips in residential areas, will increase effectiveness across the entire watershed and help meet the diverse goals.

PHOTOGRAPHIC RECORD OF SITES BEFORE AND AFTER IMPLEMENTATION

The detailed inventory performed in the initial planning stage of the project included photographs of all of the major problem sources and sites in the Watershed. Pictures will be taken after the BMPs have been installed at these sites to provide a visual documentation of improvements in the Watershed which should give rise to water quality improvement.

WATER QUALITY MONITORING

At the conclusion of the implementation phase of this project, attempts will be made to continue the water quality monitoring on a quarterly basis to track the sustainability of the improvements to water quality. Hydro lab is available at the MCD for volunteers to use.

6.3 LESSONS LEARNED

This is one of the most important sections in any project evaluation, because it takes into account not only the specific project's successes and short falls, but also indicates the improvements that could be made for future projects. This evaluation will also give data as to which BMPs were the most successful in this Watershed in terms of pollution reduction as well as cost effectiveness.

6.4 PARTNERS IN CONDUCTING EVALUATIONS

Each member of the various committees has shown interest in improving water quality in the Watershed, and has made a valuable contribution. Many of these members will continue to serve as vital players during the implementation phase. Strong interest has been shown in sustaining the Steering Committee, with commitments to meet at least quarterly. The Technical Committee has been combined with the Steering Committee to oversee much of the structural and vegetative implementation process. The I&E Committee has proven to be a team which is effective in delivering messages to the community and fostering stewardship, a very important part of the Watershed project. While the committees provide much of the structure and organization of the Watershed project, it is what happens "on the ground" that ultimately matters most. All the committee members take what they have learned back to their organization, but many have more specific roles to play.

The MCD will take the lead in involving landowners in implementing water quality improving BMPs on their land. Other partners will include the MDEQ for permitting and technical advising, as well as the NRCS for design assistance. The MCDC will take the lead on improvements to designated county drains. The Little Forks Conservancy, Ducks Unlimited, the Saginaw Bay WIN, and other non-profit organizations will assist with conservation and preservation efforts.

Professional organizations, such as the Midland Homebuilders Association and the Midland Board of Realtors, will provide two-way communication and information exchange between the Watershed committees and their members. This will foster joint efforts and compatible goals. Commercial and industrial sites, such as the Mid-Michigan Medical Center, have a vested interest in protecting their property and resources, but can also serve as demonstration sites for good stewardship.

The Townships and the City are responsible for enacting ordinances that help meet the goals of their community. Many ordinances and rules promote good practices. The Townships and City must not only instruct their citizens, but must act in a manner which demonstrates their concern for resource protection.

The most important partners are the members of the Sturgeon Creek Watershed community itself. Those who live, work, recreate, and simply enjoy its wildlife all shape the future of the Watershed. They are the stewards of the land, water, and air.

The educational community, consisting of the public school system, private schools, and Saginaw Valley State University (SVSU), are partners in educating both children and adults in the community. They are also proponents of responsible research and gaining understanding of the world around us. SVSU and the Midland Public Schools will be conducting water quality monitoring of the Watershed.

CHAPTER 7 - SUSTAINABILITY

Members of the Steering Committee provided information about existing water quality projects, programs, and ordinances in the watershed through the planning process. The Saginaw Bay area has many organizations that are working toward a common goal of improved water quality. Building upon and coordinating with these identified programs will help meet the goals of this watershed management plan for Sturgeon Creek. Long-term sustainability is possible for restoring this watershed due to the high level of involvement in preserving and protecting the unique resource of the Saginaw Bay. The Steering Committee will be able to join forces with these efforts to continue its own mission of providing direction for the development of a community-based, sustainable watershed management plan for the Watershed.

7.1 LONG-TERM PLANNING

The goals of the watershed management plan have been prioritized as to immediate, short-term, and long-term concerns. The plan outlines the actions over the next 20 years that stakeholders can take to continue the implementation of the plan. Immediate and short-term remedies need to fit into the overall long-term planning for a community. Growth and development can be guided in ways that are sustainable and appropriate for the community. Policies can be put in place that can collectively shape how development happens in a watershed. Specific rules and regulations can be implemented through zoning and other ordinances that address those long-term concerns.

Long-term improvements to the Watershed through physical measures of BMPs depend on the type of structures and the operation and maintenance plans. Often, ongoing maintenance is neglected, resulting in shortened life spans of BMPs or even detrimental conditions depending on the type of BMP. Costs and responsibilities should be revisited on a regular basis, such as when annual budgets are recalculated. Private landowners who are interested in implementing structural BMPs must ensure that time and money are allocated to maintain and repair these structures. A well designed system should withstand most weathering, but some systems may require regular maintenance such as cleaning sediment basins or harvesting vegetation (necessary where cattails absorb heavy metals from urban runoff or excessive nutrients from agricultural or lawn care runoff in basins).

7.2 EXISTING MANAGEMENT STRATEGIES

Prior to the Watershed project, many organizations have participated in watershed management in the Watershed without the use of a comprehensive WMP. Their efforts range from managing storm water to managing beavers, and from development planning and zoning to environmental education. The coordination of these efforts would build a stronger coalition to improve not only Sturgeon Creek but the entire Saginaw Bay.

Much of the center portion of the watershed includes the **Au Sable State Forest**, which is managed by the MDNR. Some logging has occurred, but currently the MDNR is taking a hands off approach and does little active management besides occasionally removing an obstruction that could possibly cause flooding on property outside of the forest.

An update to the Saginaw Bay **Remedial Action Plan** (RAP) was prepared in August 2000. The document addressed the designation of the Saginaw Bay as an AOC. Water quality has greatly improved in the Bay as a result of dedicated individuals and concerted efforts to reduce nonpoint source pollution. The purpose of the document was to assess the current conditions of the Bay area to determine if water quality has improved enough to have Saginaw Bay removed from the AOC listing. Sturgeon Creek is within the Saginaw Bay Watershed and the goals that were established in the RAP will promote continued interest in the watershed to meet the water quality improvement criteria.

The **City** is the center of economic activity in the region. Their policies affect those who live, work, shop, and visit in the community. The development of storm water management criteria and a storm water ordinance will set a standard for neighboring communities to follow in learning how to control and manage the impacts of development.

The **townships** within the Watershed are Hope, Mills, Larkin, Lincoln, and Homer. Larkin Township has developed a Master Plan, which defines management strategies for future growth.

The following land use issues were identified in the Larkin Township Master Plan and should be addressed by all townships in the Watershed to coordinate future land use decisions.

- **Conflicts:** Commercial areas located close to residential development can result in strip linear development, frequent curb cuts, and deteriorating neighborhood property values.

- **Poor Parceling:** Bowling alley splits, characterized by long narrow lots, often limit alternative measures to preserve and protect natural features and land use opportunities for the landowners.

- **Frozen Lands:** Land use analyses must consider the physical and social impacts of the large tract of land in the Au Sable State Forest on the rest of the Township.

- **Accessibility:** Commercial uses at major interchanges off of US-10 must provide adequate buffering techniques and rational transition of land use. Accessibility to properties adjoining proposed subdivisions must be considered when planning plats. Township should develop subdivision regulations to provide future access and other issues regarding development of subdivisions.

- **Public Utilities:** A water study was conducted to assess the need for central water facilities in the southern half of the township, outside the Midland Urban Growth Area Boundary. This information was essential for the Township to understand future needs of their infrastructure.

Mills Township is in the process of developing its Master Plan. Other townships can follow their lead of implementing sustainable rules, regulations, and ordinances that can help guide the growth of the area while maintaining a high quality of life.

7.3 ONGOING PROGRAMS AND OPPORTUNITIES

The **USDA Farm Services Agency (FSA) and NRCS** provide technical and financial assistance to landowners to address resource concerns of soil, water, air, plants, and animals. The agencies offer cost-share opportunities through many federal programs and coordinate with state and local programs to maximize benefits. http://www.mi.nrcs.usda.gov/

The **Wetland Reserve Program (WRP)** is administered by the Natural Resource Conservation Service. The landowner controls access to the land and may use it for recreational activities such as hunting and fishing. Three options are offered for the WRP.

1. 10-Year Cost Share Agreement:

This agreement is a cost share program where the NRCS pays 75% of the restoration costs and the landowner signs an agreement to keep the wetland in place for 10 years. This option is very similar to the US Fish and Wildlife Service's Partners for Wildlife Program.

2. 30-Year Easement Option:

The NRCS "purchases" a 30 year conservation easement over the property. The NRCS will pay 75% of all restoration costs and pay the landowner 75% of the appraised agricultural value of the property under the easement.

3. Permanent Easement Option:

The NRCS "purchases" a permanent conservation easement over the property. The NRCS will pay 100% of all restoration costs and pay the landowner 100% of the appraised agricultural value of the property under the easement.

An example of a successful wetlands restoration is the Mullet Muck Farm Restoration in Sanilac County Michigan. The 836-acres restoration was originally under a 30-year easement, but has now been transferred to the MDNR. Serpentine channels were created in the previously leveled farm field, which resulted in more shoreline for wading birds. http://www.nrcs.usda.gov/

The **Conservation Reserve Program** was created in 1985 as part of the Food Security Act. The farmer may enter into a long-term contract to set aside land and establish a permanent cover. In return, the farmer receives an annual per acre rent and up to half the cost of establishing cover on land that has recently been farmed and is highly erodible or environmentally sensitive. In the first five years of the program, 33.9 million acres were enrolled in CRP. Additional Acts in 1990, 1996, and 2002 have allowed continued enrollment and expanded the scope from reducing soil erosion to include habitat conservation. The CRP has the different components: regular CRP, continuous CRP, and CREP. Regular CRP has scheduled times for landowners to enroll in the program, which occurs annually or as the market indicates. Regular CRP is a competitive process and landowner applications are scored with those scoring highest receiving the funding. A few of the practices available through the regular CRP are listed below:

- Filter Strips
- Riparian Buffers
- Shelterbelts, Field Windbreaks, and Living Snow Fences
- Grass Waterways
- Shallow Water Areas for Wildlife
- Salt-Tolerant Vegetation
- Certain Approved Public Wellhead Protection Areas

The continuous CRP allows landowners to enroll at any time, provided the acreage and producer meet certain eligibility requirements, applications are automatically accepted into the program.

Today, the EBI is used to prioritize land offered for enrollment. Scores are based on a cost factor, plus six environmental factors, as follows:

- Wildlife
- Water Quality
- Erosion
- Enduring Benefits
- Air Quality Benefits from Reduced Wind Erosion
- State or National Conservation Priority Areas (CPAs). The Great Lakes, along with Long Island Sound, the Chesapeake Bay, the Longleaf Pine region, and the Prairie Pothole region comprise the national CPAs.

The CREP is an extension of the Conservation Reserve Program and is funded by a joint federal and state partnership. The USDA states “the objective is to share costs and resources to address specific local and environmental problems in a designated target area.” The Saginaw Bay is one of the three watersheds in the State of Michigan currently enrolled in CREP. The program requires 20% of the funding to be provided by the state, which was approved in the Michigan Department of Agricultures budget.

The following State of Michigan organization and agencies have also participated in the implementation of the programs:

- Michigan Association of Conservation Districts (MACD)
- Ducks Unlimited
- Pheasants Forever
- Michigan United Conservation Clubs (MUCC)
- Michigan Department of Environmental Quality (MDEQ)
- USDA Farm Service Agency (FSA)
- USDA Natural Resource Conservation Service (NRCS)
- United States Geological Survey (USGS)
- Michigan Department of Natural Resources
- United States Fish and Wildlife Service (USFW)
- Michigan Farm Bureau
- Michigan State University

The goals of CREP in Michigan focus on reducing nonpoint source pollution, specifically, sediment (by 784,000 metric tons), nitrogen (by 1.6 million pounds), and phosphorus (by 0.8 million pounds) over the next 15 to 20 years. Goals also include protecting water supplies used by over one million people and improving wildlife habitat. This program seeks to protect 5,000 linear miles of streams against sedimentation.

States that participate are allowed up to 100,000 acres to set aside into the program and Michigan has chosen areas equal to approximately 80,000 acres for the first round. The selected areas are the River Raisin Watershed near Detroit, the Saginaw Bay Watershed, and the Lake Macatawa Watershed. The possibility exists of a second round of CREP that will enroll an additional 20,000 acres.

In CREP, similar to continuous CRP, landowners voluntarily enter into long-term (15-year) contracts for eligible practices. The list of eligible practices includes the following:

- Filter Strips
- Wetland Restoration
- Shallow-water Wildlife Areas
- Field Windbreaks
- Permanent Vegetative Cover
- Riparian Buffers
- Conservation Easements
- Livestock Access

The incentives are high in CREP and landowners that enroll benefit financially. Landowners are paid 140% of the cost of associated with implementing the aforementioned BMPs. In addition, they are paid 140% of the soil rental rate (SRR). Producers may get a free assessment to see if they qualify.

The **Farmland Protection Program** in the recently enacted Farm Bill has up to $50 million in funds to assist in the purchase of development rights on agricultural lands. Development pressure on the urban fringe causes large amounts of land to be converted to non-agricultural uses. Proposals must be submitted to the NRCS state offices. The American Farmland Trust is an organization that works toward sustainable agriculture through education and financial assistance to communities and landowners. http://www.farmland.org/.

7.4 PARTICIPATING STAKEHOLDER ORGANIZATIONS

The **MCDC** assists with surface water activities that are associated with designated drains. Some projects, such as subdivision development, require specific site plan criteria. The Drain Commissioner is responsible for drain improvements and keeping the integrity and appropriate function of the drains intact. Most of the waterways in the Sturgeon Creek Watershed are county drains.

The WIN is an organization designed to "enhance the quality of life in the Saginaw Bay Watershed," by promoting projects that demonstrate sustainability, pollution prevention, wildlife stewardship, water resources, land use, and communication. WIN provides assistance in the form of grants and endowment funds to local and regional organizations to link the economic, social, and environmental well being of communities. WIN's funding priorities for 2002 are in the areas of wildlife habitat, water resources, land use, agriculture/pollution prevention, communication/eco-marketing/education, and sustainable business strategies. These grants could assist in the implementation of the WMP recommendations.

The LFC is a non-profit organization that works to conserve significant natural and cultural resources within the Tittabawassee River Watershed. The LFC seeks the protection of riparian natural areas, wetlands, forests, and other land features that have importance to the local community. The LFC is non-regulatory and completes transactions based upon the voluntary decisions of the landowner. The LFC will assist in obtaining conservation easements and acquiring property to protect the waterways in the Watershed.

The Nature Conservancy is a well known conservation organization that selects exemplary, unique, and threatened sections of land from around the world to be preserved. This advocacy group helps local communities preserve tracts of land through the use of promotional educational activities and projects which explain the importance of conserving unique natural heritage sites. http://nature.org/. The local group works with the LFC in preserving ecosystems in the Midland area.

The **Innovative Farmers** is a group of agricultural producers interested in new sustainable practices and techniques which are environmentally and financially sound. The producers work as a community, sharing resources to develop demonstration projects that use innovative techniques. This farmer-based research can be shared with other Innovative Farmers groups and applied in other areas.

Michigan State University Extension utilizes the resources of Michigan State University and works on community outreach, especially with agriculture and families. MSU Extension offers a wide variety of technical assistance and employs individuals with high levels of expertise in their area of concentration to meet specific needs of producers. They are also involved with research to better the services and technology available. Demonstration plots and training workshops involve the landowners in the implementation of practices they can adopt to address resource concerns.

The **4-H Club** is the youth education branch of the Cooperative Extension Service, and is associated with MSU Extension. The 4-H KATCH (Kids are True Conservation Heroes) Grant supports projects which involve children in land and water conservation. An application is being submitted to involve the local 4-H youth in implementing BMPs as part of the Watershed project. http://www.msue.msu.edu/learnnet/newgrant_111501.htm

Ducks Unlimited protects and preserves wetland habitats through restoration, preservation, or acquisition of wetlands and potential wetland sites.

Saginaw Valley State University (SVSU) is a significant partner in water quality monitoring in the Watershed. SVSU offers a major in Environmental Chemistry with many courses in environmental chemistry and ecology. Classes in the environmental sciences will be participating in water quality monitoring and analysis for the Watershed project. This partnership could extend past the life of the watershed project and create the much needed baseline water quality information for this area.

Delta Community College (DCC) offers programs in Water Environmental Technology. DCC offers advanced courses associated with watershed management.

The **Midland School District** has been involved with the planning stage of the Watershed project. The school district has biology and science classes that involve environmental education. The Watershed will serve as part of their laboratory and students will be involved on many levels, from stream monitoring to web design, and will post water quality sample results on the internet. An Environmental Club is being developed, which will have the primary responsibility of water sampling and testing.

The **Future Farmers of America** involves youth in farming activities and teaches them skills they will need to be farmers including soil identification and livestock care. There is an opportunity to involve them in implementation of BMPs on farms in the Watershed.

The **Boy Scouts of America and the Girl Scouts of the USA** involve many children in Midland County with personal growth and community stewardship. Boy Scouts and Girl Scouts work on community and natural resource projects and learn through service. The collaboration of the Watershed project and these groups would have mutual benefits. The highest honor a boy scout can earn is becoming an Eagle Scout. Candidates must follow strict requirements for this prestigious award, one of which is to design and implement a project that benefits the community. Many Eagle Scouts do their projects in association with natural resource awareness, such as building boardwalks at wetlands or interpretive trails at nature centers. Many opportunities in the Watershed project exist to work with an Eagle Scout candidate to help him achieve his goals and improve the watershed.

Many local **philanthropic organizations** fund projects to benefit the Midland community. The Dow Chemical Company, Dow Corning Corporation, and several local foundations associated with the founders and leaders of the Dow Chemical Company have already assisted with projects in the Watershed.

7.5 SUSTAINABILITY OPTIONS

The Steering Committee discussed innovative ideas for sustainable natural resource use. Funding opportunities are plentiful for many innovative demonstration projects.

AGRI-TOURISM

Value added agriculture uses products from production more creatively to add sources of income. Many examples of this can be seen at Farmer's markets. Tourists and even local residents pay substantial amounts of money for crafts made from farm products which might otherwise have been discarded. Selling straw for various purposes to local people can bring a higher marginal profit for excess straw. Alternative livestock, such as llamas and goats, offer other sources of income such as llama oil and goat cheese. Farms that offer "pick your own" fruit and vegetables decrease some of the expense of harvesting and provide educational and recreational family opportunities in the community.
http://www.nrcs.usda.gov/technical/RESS/altenterprise/.

ANIMAL WASTE MANAGEMENT

Animal Waste Management is becoming a more high profile issue in Michigan. Assistance is available through the Natural Resource Conservation Service and MCD.
http://www.wcc.nrcs.usda.gov/water/quality/frame/animalws.html.

BACKYARD CONSERVATION

Homeowners can participate in conservation by composting and providing wildlife habitat in their own backyards. Vermicomposting uses specific species of worms to more quickly and efficiently transform kitchen scraps and yard waste into mulch and fertilizer for gardens. Even homeowners with small yards can benefit from having their soil tested at the nearest Michigan State University Extension office or garden center. This test allows homeowners to determine what types of fertilizers and chemicals are necessary to have a healthy lawn and garden without wasting money and energy on unwarranted additional fertilizers and chemicals. Wildlife can be attracted to a yard with specialized landscaping, feeders, birdhouses, and bat boxes. More information is available from many organizations such as the MCD and the MDNR, which has an excellent guide to designing backyards for wildlife. http://www.midnr.com/wildlife/landowners_guide/index.htm.

The sustainability of any watershed project is to ensure that the continuity has been passed on to appropriate agencies and organizations that have the capacity to meet the goals and objectives recommended in the WMP. The ideas presented in this chapter will be continually reviewed with the Steering Committee in the following years to identify the partners in implementation.

CHAPTER 8 - RESOURCES

Many resources were available for use in the creation of this document. Individuals who served on the various committees played the most important role in bringing together concerns and resources to make this an effective plan for the Watershed. Committee members shared knowledge and created a network of concerned stakeholders that will lead the Watershed project through the implementation phase with enduring stamina into an ever-changing environment.

A collection of literature pertaining to the Watershed is housed at the MCD and is available for public use. Agendas and minutes from all of the Steering Committee, Technical Committee, and Public meetings are also available. The MCD is located at 1031 East Saginaw Road, Sanford, Michigan, telephone (989) 687-9760.

8.1 WATERSHED RESOURCES AVAILABLE AT THE MIDLAND CONSERVATION DISTRICT

ENVIRONMENTAL EDUCATION MANUALS

Environmental Resource Guide: Nonpoint Source Pollution Prevention (A series of classroom activities for Grades K-2". Air & Waste Management Association. Developed by Tennessee Valley Authority Environmental Education Section; August 1993 (owned by the City).

Environmental Resource Guide: Nonpoint Source Pollution Prevention (A series of classroom activities for Grades 3-5). Air & Waste Management Association. Developed by Tennessee Valley Authority Environmental Education Section; May 1993. (owned by City)

Firehock, Karen. *Save Our Streams: Volunteer Trainer's Handbook.* The Izaak Walton League of America, Gaithersburg, Maryland: 1994.

Give Water a Hand Action Guide: A youth program for environmental action. USDA Cooperative State Research Education and Extension Service. University of Wisconsin: 1996. (owned by City)

Surface Water: The Student's Resource Guide. Water Pollution Control Federation: 1988 (owned by the City).

GOVERNMENTAL PUBLICATIONS

A Biological Survey of Sturgeon Creek, Midland County. MDNR Surface Water Quality Division: Staff Report, February 1992.

A *Biological Survey of the Tittabawassee River Watershed Clare, Gladwin, Isabella, and Midland Counties, Michigan: June, August and September 1997.* Michigan Department of Environmental Quality Surface Water Quality Division: December 2000.

Degraded Urban Detention Ponds-Recognizing Problems and Finding Solutions. U.S. Environmental Protection Agency, Soil Conservation Service, and U.S. Fish & Wildlife Service. February 1993.

D*esign of Waterway Outlets for waterways with Less Than 100 Acres of Drainage Area*. USDA Natural Resources Conservation Service. Des Moines, Iowa: December 1994.

Draft - Saginaw Bay Watershed Prioritization Process. MDNR: December 1994.

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Field Manual of Urban Stream Restoration" U.S. Environmental Protection Agency (Region 5), Illinois Environmental Protection Agency. Springfield, IL: 1998 - 2nd Edition June 2001.

Floristic Quality Assessment With Wetland Categories and Computer Application Programs for the State of Michigan. MDNR Wildlife Division Natural Heritage Program: March 1996.

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Institutional Support for Storm Water Management Programs. U.S. Environmental Protection Agency, Watershed Management Unit, Water Division, Region V. Chicago, IL: February 1991; Reprint, April 1993.

Midland County River Protection Plan - Self-Help Guidebook" John D. Warbach, Mark A. Wyckoff, Mark Eidelson, Brenda Moore. Midland County Department of Planning, Parks and Recreation Department, Parks and Recreation Commission, and Planning Commission. February 1992.

Qualitative Biological and Habitat Survey Protocols for Wadable Streams and Rivers. Michigan Department of Environmental Quality Surface Water Quality Division, Great Lakes and Environmental Assessment Section. Revised January, 1997.

Retrofitting Storm Water Management Basins for Phosphorus Control. U.S. Environmental Protection Agency, Office of Water, Nonpoint Source Branch. Washington, DC: August 1989; Reprint, May 1996.

Rural Roads: Pollution Prevention and Control Measures" U.S. Environmental Protection Agency, Region 6, Water Management Division, Water Quality Management Branch. Dallas, Texas: February 1994.

Sand Filter Design for Water Quality Treatment. U.S. Environmental Protection Agency, Watershed Management Unit, Water Division, Region V. Chicago, IL: April 1992.

Schueler, Thomas R. T*he Stream Protection Approach: Guidance for Developing Effective Local Nonpoint Source Control Programs in the Great Lakes Region*. U.S. EPA, Terrene Institute, Arlington, Virginia: January 1994 - Reprint January 1995.

Section 319 Nonpoint Source National Monitoring Program: Successes and Recommendations. Prepared for the U.S. EPA by NCSU Water Quality Group Biological and Agricultural Engineering Department North Carolina Cooperative Extension Service, NC State University, Raleigh, North Carolina. November 2000.

Soil Survey of Midland County, Michigan. United States Department of Agriculture, Soil Conservation Service: April 1979.

Storm Water Management Ordinances for Local Governments. U.S. Environmental Protection Agency, Region 6, Water Management Unit, Water Division, Region V. Chicago, IL: February 1994.

Streambank Erosion Inventory: Rifle River Michigan. U.S. Department of Agriculture, Soil Conservation Service: October 1994.

Strecker, Eric W., Joan M. Kersnar, Eugene D. Driscoll, and Richard R. Horner. The Use of Wetlands for *Controlling Storm Water Pollution.* In conjunction with the EPA, Washington, DC: April 1992.

Urban Runoff and Storm Water Management Handbook. U.S. Environmental Protection Agency, Water Division. Chicago, IL: 1990.

Urban Storm Water Runoff Management: A Strategy for Communities in the Saginaw Bay Watershed to Develop and Implement Storm Water Runoff Controls in their Watersheds. MDNR, Surface Water Quality Division, Saginaw Bay District Office.

LANDOWNER RESOURCES PUBLISHED BY NON-GOVERNMENTAL AGENCIES

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Great Lakes Better Backroads Guidebook: Clean Water By Design. Huron Pines Resource Conservation & Development Area Council, Inc., Grayling, Michigan; December 2000.

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GLOSSARY

Area of Concern - One of the 42 regions designated by the International Joint Commission which adversely contributes to the Great Lakes or St. Lawrence River.

Anthropogenic - Caused or produced by humans.

Attenuation (hydrograph) - The reduction of the slope of a hydrograph, whereby the flow is extended over a longer period of time.

Baseflow - The part of the stream flow that is not due to direct runoff from precipitation; it is usually supported by water draining from natural storage in groundwater bodies, lakes, or wetlands.

Benthic - Referring to the stream or lake bottom.

Best Management Practice (BMP) - Structural devices or nonstructural practices that are designed to prevent pollutants from entering storm water flows, to direct the flow of storm water, or to treat polluted storm water flows.

Clean Michigan Initiative (CMI) - A bond approved by Michigan voters in 1998, which designates $165 million for structural and managerial enhancements which improve water quality in Michigan.

Clean Water Act 303(d) Non-Attainment List - A list of water bodies that do not meet water quality standards that must be produced by each state every two years.

Coldwater Fishery - A stream or reach in which summer temperatures must not exceed that which are able to sustain trout, with optimum temperatures between 50°F and 60°F for coldwater and 60°F to 70°F for cool water fisheries.

Confluence - The point at which two or more watercourses intersect.

Conservation - The use of a resource within the limits which are set.

Critical Area - That part of the watershed that is contributing or has the potential to contribute a majority of the pollutants and is having the most significant impacts on the water body.

Culvert - a covered channel or a large diameter pipe that directs water flow below the ground level.

Designated Use - One of the uses designated by the State of Michigan which every surface water in Michigan must meet.

Desired Use - Uses that are determined important by local stakeholders that do not fall into the categories designated by the State of Michigan.

Detention Basin - A storm water structure in which part of the runoff is detained, and the remainder is contained in a permanent pool.

Discharge - A release or flow of storm water or surface water, usually expressed as cubic feet per second.

Dissolved Oxygen - The amount of gaseous oxygen (O_2) dissolved in an aqueous solution (water).

Drain - A waterway which has been placed under the jurisdiction of a county drain commissioner.

***E. coli (Escherichia coli)* -** Bacterium used as an indicator of the presence of waste from humans and other warm-blooded animals.

Eutrophication - The process of enrichment of water bodies by nutrients, which may lead to increased growth of algae or rooted plants. The process can be natural or accelerated by human activity (cultural eutrophication).

Filter Strip - A grassed area adjacent to a water body which is used to filter nonpoint source pollution.

Flashy Flow - The dramatic reaction of a river or stream to a storm event, producing high fast flows during and immediately following a storm event.

Floodplain - The area in a river valley covered with soil deposited by floods.

Geographic Information System (GIS) - A system that analyzes and models data in a spatial context and displays digitally recreated map layers.

Geotextile - Fabric which is used in soil erosion control for the purpose of retaining soil until vegetation is established.

Glaciolacustrine - Of an ancient lakebed formed by glaciers, having fine grained texture sediment which results from ground debris in glacial melt water.

Groundwater - The subsurface water supply in the saturated zone below the water table.

Gully Erosion - Severe erosion in which trenches are cut to a depth greater than 30 centimeters (1 foot).

Headwaters - The origin and upper reaches of a river or stream.

Hydraulic Model - Prediction of the behavior of flows within a channel.

Hydric Soil - A wetland soil, characterized by high moisture, low oxygen, and low ability to exchange electrons.

Hydrograph - A chart which shows the relationship between flow and time, used to assess the behavior of the watershed.

Hydrologic Model - Prediction of the behavior of overland flows and their reaction to storm events.

Hydrologic Soil Group - A classification of the infiltration rates of soils types.

Imperviousness - The amount of surfaces through which little or no water will move. Impervious areas include paved parking lots and roof tops.

Infiltration - The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls.

Land Cover - Classifications based on aerial imagery which show the type of vegetation and structures, including classification of forest types and other vegetative classifications.

Land Use - Classification of the practices which occur on the land, such as residential or recreational park.

Macroinvertebrate - Animals without vertebrae that are large enough to be seen without a microscope, such as many insect larvae and crawfish.

Nitrogen - A colorless, odorless, gaseous element that constitutes about four-fifths of the volume of the atmosphere and is present in combined forms in animal and vegetable tissues, especially in proteins used chiefly in the manufacture of ammonia, nitric acid, cyanide, explosives, fertilizers, and dyes (as a cooling agent). Also an essential nutrient needed by healthy plants. An element that at certain levels can cause excessive algae and aquatic weed growth.

Nonpoint Source Pollution (NPS) - Pollution that is not traceable to one particular source and is occurring at locations scattered throughout the drainage basin; typical sources include erosion, agricultural activities, and urban runoff.

Open Space - Agricultural land, greenbelt, parks, golf courses, and other areas in which human structures are minimal or nonexistent.

Phosphorus - An element that at certain levels can cause excessive algae and aquatic weed growth. Also, a necessary element for bones, nerves, and embryos; its compounds are used in matches and phosphate fertilizers. An essential nutrient needed by healthy plants.

Planned Unit Development (PUD) - A development design that allows the creation of a more desirable environment through the application of flexible and diversified land development techniques. PUDs consist of residential buildings clustered or laid out with reduced setbacks, if amenities such as adequate open spaces and other design provisions are provided.

Point Source - Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

Pollutant - Any substance of such character and in such quantities that when it reaches a body of water, soil, or air, it contributes to the degradation or impairment of its usefulness or renders it offensive.

Preservation - Restrictions on all consumptive use of a resource.

Reach - A segment of a river or stream. The EPA's Reach File Version 3.0 lists over 3.2 million reaches across the United States and its territories. Each reach is given an identifying number according to its location and watershed.

Retention - Capturing storm water and slowly releasing it through infiltration into the ground.

Rill Erosion - Erosion consisting of a series of small channels eroded into the soil by surface runoff.

Riprap - A permanent cover of rock used to stabilize streambanks, provide in-stream channel stability, and provide a stabilized outlet below concentrated flows.

Riparian - Shore area of a lake or bank of a river or stream.

Road/Stream Crossing - Where a road crosses over a stream, normally a bridge or a culvert.

Sediment - Soil that is transported by air and water and deposited on the stream bottom.

Soil Erosion and Sedimentation Control (SESC) - A program that regulates the pollution derived from construction sites.

Stakeholder - Any organization, governmental entity, or individual that has a stake in or may be affected by a given approach to environmental regulation, pollution prevention, or energy conservation.

Storm Water Runoff - Surface water movement resulting from a storm event, snow melt runoff, or surface runoff and drainage.

Subcatchment - Smaller drainage area within a watershed or river/stream basin.

Sustainable - The principle that the needs of the present should be met without compromising the ability of future generations to meet their own needs.

Tile - A semi pervious pipe that facilitates drainage from the soil to surface waters.

Toe of Streambank - The bottom of the streambank where the bank meets the streambed.

Warmwater Fishery - Water bodies able to maintain fish populations of bass, pike, walleye, or pan fish.

Waters of the State - A water body under jurisdiction of the State, normally defined as having the ability to float a log.

Watershed - The geographical region within which water drains into a particular river, stream, or body of water. Watershed boundaries are defined by the ridges separating watersheds.

Watershed Management Plan (WMP) - A plan to create an environmentally and economically healthy watershed that benefits all who have a stake in it.

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