Willow Creek Watershed Protection and Improvement Plan




May 2011

Prepared for:

Sheboygan River Basin Partnership

Prepared by:

Stantec

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Sheboygan County, Wisconsin

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(In cooperation with grant funding from the Wisconsin Department of Natural Resources)
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Contents

Attachments

1.0 Executive Summary

The intent of this plan is to summarize water quality conditions for Willow Creek and identify current watershed issues and opportunities for improving waterway and watershed conditions.

This plan was developed based on previous baseline studies, stakeholder involvement and analysis of watershed inputs. It provides a framework for improving Willow Creek watershed conditions in the future. The following tasks were completed as part of this project:

- Field data collection of channel dimension and inventory of fish migration barriers
- GIS data acquisition and mapping
- Watershed analysis and basin delineation
- Hydrologic/hydraulic watershed modeling
- Pollution load analysis in existing and future development conditions
- Evaluation of fish passage impairments
- Identification of watershed improvement alternatives
- Facilitation of stakeholder involvement meetings
- Evaluation of non-native invasive shrub species on public lands
- Identification of potentially restorable wetlands and floodwater storage areas
- Reporting

Opportunities to improve water quality within this watershed have been developed in conjunction with stakeholder input. Watershed opportunities include the following:

- Communicate the results of this plan with stakeholders and the public
- Perform ongoing water quality monitoring data analysis
- Minimize and treat runoff from agricultural areas
- Minimize and treat runoff from developed areas
- Restore and manage key wetlands, woodlands, shorelands, and riparian buffers
- Improve fish passage
- Manage invasive species on public lands
- Provide incentives for increased storm water management by private landowners, businesses, and municipalities
- Provide opportunities for citizens, businesses, municipalities and government agencies to increase their awareness, understanding and participation in watershed stewardship.

2.0 Introduction

Today we are challenged with finding ways to balance our use of land and water with our need to protect, restore and enhance the natural resources in the Willow Creek watershed. A watershed is the area of land that drains surface runoff to a particular lake, river, stream or wetland. Activities on the land have an effect at the point of origin and throughout the watershed basin.

Willow Creek is located in a rapidly urbanizing region of Sheboygan County within east-central Wisconsin that includes a 5.75-mile long waterway with a mix of agricultural, urban, and undeveloped land uses crossing five municipal boundaries, including the following: 1) City of Sheboygan, 2) Town of Sheboygan, 3) Village of Kohler, 4) City of Sheboygan Falls, and 5) Town of Sheboygan Falls (Figure 1). The eastern 1.5 mile segment of Willow Creek is classified as a cold water Class II trout fishery. It is the only known coldwater Wisconsin tributary to Lake Michigan that supports naturally reproducing anadromous salmonid populations of Coho Salmon, Chinook salmon, and Steelhead as well as brook trout and brown trout, making Willow Creek a unique feature on the Lake Michigan coastline. Willow Creek is also a tributary to and adjacent to the Sheboygan River Area of Concern (AOC), one of 43 impaired waters within the Great Lakes basin, which is currently being considered by the U. S. Environmental Protection Agency (USEPA) for delisting following implementation of a variety of habitat improvement projects.

Historic land use practices (agricultural, residential, commercial, and transportation) within the watershed have altered the stream channel through straightening, re-routing, and culverts enclosures. Greater than 50 percent of the upper stream reaches from Interstate 43 (I-43) to Woodland Road have been altered (Figure 2). The most notable channel realignment areas include approximately 2,000 linear feet of stream channel that was re-routed and partially enclosed into two box culverts from I-43 to County Trunk Highway Y (CTH Y). Construction of the I-43 and State Trunk Highway 23 (STH 23) corridors also impacted historic wetlands and increased storm water runoff from increased impervious surfaces and conveyance features. In addition, a total of fifteen road/culvert crossings (average of one crossing per one-third of a mile) exist within the stream channel, totaling approximately 2,500 linear feet of stream channel, most of which is in two large double barrel box culverts. These changes in the watershed have created significant stream hydrologic and morphologic changes, evident by the incised channel, unstable eroding stream banks, increased turbidity and impacts to the aquatic community including fish movement. The single largest threat facing Willow Creek is uncontrolled development within the watershed. For the past several years, plans to develop parts of the watershed, including lands adjacent to Willow Creek, have been completed, and additional development is anticipated. Proposed land use changes, loss of riparian habitat, and changes in the hydrologic flow regime within the watershed could have a significant impact on the water quality and stream habitat, which could impact the ability of Willow Creek to support cold water aquatic species and natural salmonid reproduction in the future.

This plan was completed through U.S. Environmental Protection Agency (USEPA) Section I 604(b) Stimulus grant funding provided to the Wisconsin Department of Natural Resources (WDNR). The Sheboygan River Basin Partnership (SRBP) received the funding from WDNR and retained Stantec Consulting Service, Inc. (Stantec) (formerly Natural Resources Consulting, Inc. (NRC)). Mr. Jon Gumtow, of Stantec, has extensive history with the SRBP, including previous work to preserve and protect Willow Creek. Stantec subcontracted watershed analysis services to Mr. John Ferris, a Professional Hydrologist and Professional Engineer with Shaw Environmental and Infrastructure. Mr. Ferris has over 20 years of experience in the development of watershed, storm water and TMDL planning and has assisted the SRBP with other grant applications and data analysis for the Willow Creek watershed.

3.0 Objective

The objective of this project is to compile baseline information and bring together stakeholders within the watershed, including five municipalities and agency staff, to develop a watershed plan with recommendations to preserve and restore water quality conditions in the watershed. This plan will be used by local decision makers and regulators to make future land development and management decisions. The project includes estimates of stream hydrology and assessment of potential pollutant sources in current and development conditions. The analysis also identifies problem areas with recommendations for both structural and nonstructural BMPs and management policies to preserve and protect the watershed.

4.0 Stakeholder Participation

A Willow Creek Watershed Stakeholders Group was organized as part of this project. Stakeholder meetings were held at Maywood Environmental Park to educate, brainstorm, and obtain input to be used in development of the Willow Creek Protection and Improvement Plan. Two stakeholder meetings and a face to face meeting with each community were completed during the watershed management plan development period. Periodic email correspondence was also completed as plan development checkpoints. PowerPoint presentations were prepared as part of the stakeholder meetings to convey project information. A presentation of the results was also provided at a public SRBP sponsored event.

The following members of the Stakeholder Group contributed time or resources to this document:

- Bruce Neerhof, Village of Kohler
- Ryan Sazama, City of Sheboygan
- Bill Bittner, City of Sheboygan
- Steve Sokolowski, City of Sheboygan
- Joel Tauschek, City of Sheboygan Falls
- Bill Blashka, Town of Sheboygan
- Steve Bauer, Town of Sheboygan Falls
- Pat Miles, Sheboygan County
- Shawn Wesener, Sheboygan County
- Aaron Brault, Sheboygan County
- Mike Patin, NRCS
- Dexter Porter, Citizen (retired NRCS)
- Vic Pappas, WDNR (advisory)
- Laurel Last, WDNR (advisory)
- John Masterson, WDNR (advisory)
- Deb Beyer, UWEX (advisory)

The results of the stakeholder meetings are summarized below:

July 2010 meetings: The purpose of these meetings was to explain to the Stakeholder Group the intent of the plan and to obtain any project background information specific to the watershed area within each stakeholder's jurisdiction. Input received during these meetings was used in development of the plan, including the status of regulatory storm water compliance, future projects and growth patterns.

September 20, 2010 meeting: The purpose of this meeting was to discuss the intent of the watershed plan, educate stakeholders on watershed issues and opportunities, and obtain input into the needs and wants of the stakeholders. Input received during this meeting included the following:

1. Willow Creek is an important resource to the area.
2. Urban communities are complying with mandated storm water rules.
3. Rural communities are not required to institute storm water controls at the local level and rely on State codes.
4. Communities need an incentive to require practices above and beyond local ordinances or State codes.
5. Communities would consider a storm water banking program to assist in meeting future mandated storm water requirements.

January 5, 2011 meeting: The purpose of this meeting was to discuss the results of the watershed analysis, evaluate issues and opportunities, and develop recommendations for future activities. Input received during this meeting included the following:

1. Interest in promoting the social and habitat value of Willow Creek in the local communities.
2. Urban communities need an incentive to require practices above and beyond local ordinances or State codes.
3. Interest by urban communities to pursue a pilot project that allows storm water pollution banking.
4. Communities require grant funding or outside moneys to justify implementing innovative storm water management approach to elected officials.

5.0 Watershed Description

The Willow Creek watershed is located within the Sheboygan River basin in eastern-central Sheboygan County. Sheboygan County is located in southeast Wisconsin and is one of 11 Lake Michigan coastal counties.

Willow Creek is an approximately 5.75-mile long waterway with a watershed that drains approximately 2,543 acres and discharges into the Sheboygan River in the city of Sheboygan. The eastern 1.5 mile segment of Willow Creek is classified as a cold water Class II trout fishery. It is the only known coldwater Wisconsin tributary to Lake Michigan that supports naturally reproducing anadromous salmonid populations of Coho Salmon, Chinook salmon, and Steelhead as well as brook trout and brown trout, making Willow Creek a unique feature on the Lake Michigan coastline (Lyons, 2006 personal communication).

The Willow Creek watershed is comprised predominantly of agricultural and urban land uses (Figure 3). Agriculture is the most dominant land use in the watershed (37%), grassland is the second most dominant land use (28%), and urbanized areas are the third most dominant land use (18%) (Turyk, 2007). Water quality is impacted by rural and urban nonpoint source pollution. Shoreland management practices adjacent to Willow Creek are variable. Along some stretches of the stream there are vegetative buffers to provide habitat and water quality benefits. The segment of Willow Creek east of Interstate I-43 contains an extensive wooded natural riparian buffer.

The topography of the watershed is characterized by rolling hills with steeper hills near the confluence to the Sheboygan River. The elevation of Willow Creek ranges from approximately 700 feet above mean sea level (msl) in the headwaters to approximately 580 msl at the Sheboygan River confluence. Figure 4 shows the location of the 14 sub watersheds which make up the watershed.

5.1 Ecological Landscapes

The Willow Creek watershed is located within the Central Lake Michigan Coastal Ecological Landscape. The Central Lake Michigan Coastal Ecological Landscape stretches from southern Door County west across Green Bay to the Wolf River drainage, then southward in a narrowing strip along the Lake Michigan shore to central Milwaukee County. The influence of Lake Michigan in the eastern part of this landscape generally results in cooler summers, warmer winters, and precipitation levels greater than at locations farther inland. Figure 5 illustrates Wisconsin's Ecological Landscapes.

Dolomite and shale underlie the glacial deposits within the Central Lake Michigan Coastal Ecological Landscape. The dolomite Niagara Escarpment is the major bedrock feature, running across the entire landscape from northeast to southwest. Series of dolomite cliffs provide critical habitat for rare terrestrial snails, bats, and specialized plants. The primary glacial landforms are ground moraine, outwash, and lake plain. Certain landforms, such as sand spits, clay bluffs, beach and dune complexes, and ridge and swale systems, are associated only with the shorelines of Lake Michigan and Green Bay. The topography is generally rolling where the surface is underlain by ground moraine, variable over areas of outwash, and nearly level where lacustrine deposits are present. Important soils include clays, loams, sands, and gravels.

Most soils within the Willow Creek watershed are well drained. Much of the area adjacent to the creek is surrounded by poorly drained and moderately poorly drained soils. The dominant soil texture of the Willow Creek Watershed is the silt loam. Sand loams and clay loams are also present in the watershed.

Historically, most of this landscape was vegetated with mesic hardwood forest composed primarily of sugar maple, basswood, and beech. Hemlock and white pine were locally important, but hemlock was generally restricted to cool moist sites near Lake Michigan. Areas of poorly drained glacial lake plain supported wet forests of tamarack, white cedar, black ash, red maple, and elm. Lake Michigan shoreline areas feature beaches, dunes, interdunal wetlands, marshes, and highly diverse ridge and swale vegetation. Small patches of prairie and oak savanna were historically present in the southwestern portion of this landscape.

5.2 Wisconsin Natural History Inventory

Eleven species on WDNR's Natural Heritage Inventory (NHI) Working List have been documented near the watershed within the past 30 years. Of these 11 species, two are listed as Wisconsin Endangered, two are listed as Wisconsin Threatened, and six are listed as Wisconsin Special Concern. There are no known occurrences of State-listed or Federal-listed species present within the watershed. Table 5-1 summarizes NHI data near the Willow Creek watershed.

Table 5-1. Summary of NHI Data near Willow Creek

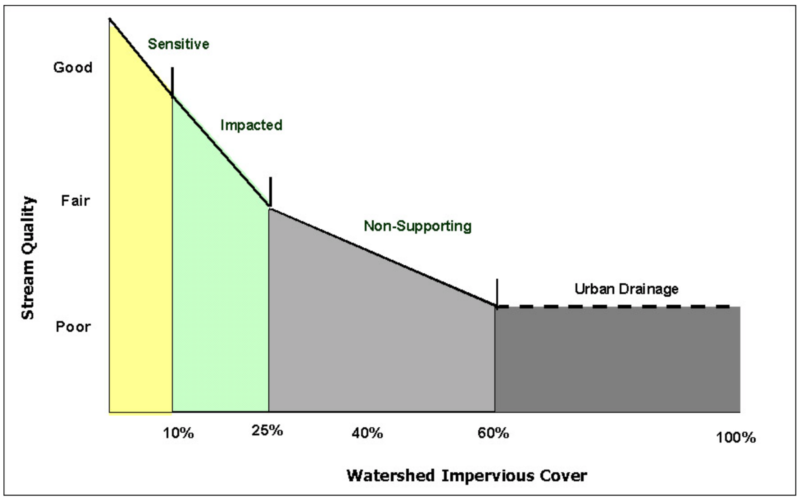
Common Name	Scientific Name	State Status	Group Name
Forked Aster	Aster furcatus	THR	Plant
American Sea-rocket	Cakile lacustris	SC	Plant
Swamp Bedstraw	Galium brevipes	SC	Plant
Marbleseed	Onosmodium molle	SC	Plant
Hairy Beardtongue	Penstemon hirsutus	SC	Plant
Seaside Crowfoot	Ranunculus cymbalaria	THR	Plant
Fragrant Sumac	Rhus aromatic	SC	Plant
Small Skullcap	Scutellaria parvula var. parvula	END	Plant
Peregrine Falcon	Falco peregrines	END	Bird
Bald Eagle	Haliaeetus luecocephalis	SC/P	Bird
Northern Mesic Forest	Northern mesic forest	NA	Community

5.3 Watershed Issues

5.3.1 Development Pressure

The single largest threat facing Willow Creek is uncontrolled development. Drainage basins range from undeveloped to 65 percent covered by impervious area. The Willow Creek Watershed averages 22 percent covered by impervious area. Willow Creek watershed is already showing signs of the affects of urbanization on the morphology and biota in the creek. Most indicators of stream quality shift to poor once the impervious area in the watershed reaches around 25 to 30 percent, which is equivalent to most medium density residential lots. The Center for Watershed Protection (2003) developed an impervious cover model (Graph 5-1), based on available research, to demonstrate the impacts of impervious area on stream quality.

Graph 5-1. IMPERVIOUS COVER MODEL
(*Center for Watershed Protection, 2003*)



Creation of impervious surfaces (pavement, buildings, etc.) increases the amount of runoff and decreases groundwater recharge and eventually stream flow (Turyk, 2007). Figure 3 presents a land cover map for the watershed. Attachment B presents a summary of the land cover within each subwatershed. Updated future land use mapping is being prepared by Bay Lakes Regional Planning Commission (BLRPC) and is not available at the time of this publication.

Land use changes, loss of riparian habitat, and changes in the hydrologic flow regime within the watershed could have a significant impact on the water quality and stream habitat, which could impact the ability of Willow Creek to support cold water aquatic species and natural salmonid reproduction in the future. Although increased urbanization puts pressure on water resources, thoughtful development patterns and conservation land use practices can minimize water quality impacts.

As the cities of Sheboygan, Kohler, and Sheboygan Falls grow, urban land use will increase within the watershed. When urbanization occurs there is an increase in the amount of impervious surfaces, such as parking lots and rooftops. By increasing the amount of impervious surfaces there is both a decrease in water that infiltrates into the ground, which may become groundwater, and an increase in surface water runoff. Groundwater provides the primary base flow during dry periods of the year. Additional runoff increases flow and erosion in the short term and reduces groundwater that feeds the creek over the long term. Turyk (2007) estimated future development could result in a 6% increase in surface water runoff in this watershed. Increased runoff can become problematic because it transports additional sediments, nutrients, and contaminants to streams. An increase in fine sediment into streams can reduce the quality of habitat for organisms at the bottom of the food chain and fish spawning beds. Contaminants from urban storm water, such as metals and organic chemicals, can have toxic effects on aquatic life. Nutrients carried by non-point runoff can also cause excess aquatic plant growth and algal blooms. Sediment and nutrient inputs can affect Willow Creek, Sheboygan River, and Lake Michigan.

Additional runoff can also alter the flow regime of a stream. Initially after rain events and snowmelt the flow to the stream becomes much greater than natural flows. Increased stream flows can cause additional streambank erosion, degrade aquatic habitat, and increase sediment loads. Increased runoff from greater impervious surfaces can also reduce the amount of water stored as groundwater, which will affect stream baseflow during periods of low precipitation.

5.3.2 Runoff from Agricultural Areas

Agriculture is the dominant land use within the Willow Creek watershed (approximately 725 acres). Dairy and row crop farming, along with pasturing, are the main types of agricultural activity within the watershed.

Conservation practices, including conservation plans, crop rotation, nutrient management plans, crop residue management, grassed waterways, and stream buffers have been implemented on farms within the watershed, in addition to subsurface drainage of poorly drained agricultural areas (Patin, 2011). Use of these conservation practices has a beneficial impact on water quality. However, runoff from agricultural lands and subsurface drainage continues to impact water quality in the watershed, and there is a need to continue to reduce water quality impacts from agriculture.

5.3.3 Runoff from Urban Areas

Urban land uses within the watershed are generally increasing. A majority of the urban land use is within the Village of Kohler. Urban runoff can have a significant negative impact to water quality. Impervious surfaces and storm sewer drains provide immediate delivery of pollutants to the waterways without any filtering capabilities. Construction sites within urban or suburban areas can also lead to significant delivery of sediment to waterways. Uncontrolled runoff degrades water quality and aquatic habitat by transporting sediment and nutrients, increasing suspended solids and covering aquatic habitat.

The City of Sheboygan, the City of Sheboygan Falls, the Village of Kohler, and the Town of Sheboygan have WDNR NR 216 MS4 municipal storm water permits that include a number of requirements to reduce pollutant loadings from storm sewers and other runoff. As part of these permits, these municipalities are required to develop and implement a storm water runoff management ordinance that require new development to reduce peak discharge rates and nonpoint source pollution in their storm water runoff. The permits also require municipalities to reduce the estimated pollutant loads for total suspended solids (TSS) by 40 percent by the year 2013. The Village of Kohler and City of Sheboygan Falls report that their estimates of annual loads indicate that both of these communities have achieved the required 40 percent reduction in TSS average annual loadings. The City of Sheboygan report that their estimates of TSS average annual loadings is 19.9 percent. Interviews with representatives with these communities indicated that there are development projects proposed within the watershed and future developments that will be completed in accordance with existing local and State storm water requirements.

5.3.4 Loss of Aquatic Habitat, Wetlands, Woodlands, and Riparian Vegetation Buffer

Historically, wetlands comprised approximately three times more area in the watershed than they currently do (Turyk, 2007). Agricultural and urban development has resulted in significant loss of wetlands and riparian buffers in this watershed. In addition to providing valuable fish and wildlife habitat, wetlands also provide additional important watershed functions, such as filtering out pollutants, maintaining summer base flow in streams, and alleviating flooding concerns along waterways. This reduction in wetlands may not only affect the habitat near Willow Creek, but also the hydrology. Wetlands act as sponges, reducing the amount of water that runs off on the land and slowly releasing water to the creek (Turyk, 2007).

Based on current land uses, there is approximately 100 acres of potentially restorable wetland (PRW) in the Willow Creek watershed. Figure 6 shows the existing mapped wetlands and PRWs which are located primarily within the upper reaches of the watershed.

The Willow Creek channel has undergone a number of changes. The original channel traveled through what is now the area that contains Woodlake in the Village of Kohler. Following the construction of Woodlake, Willow Creek was relocated north and rejoins the original Willow Creek channel near the outflow of Wood Lake at CTH Y.

The channel has also been altered downstream of CTH Y through channelization and construction of three large road culverts, including the following: 1) one approximately 400-foot long double box culvert within an abandoned roadway segment southeast of the Interstate I-43 and STH 23 interchange; 2) one approximately 400-foot long double box culvert under Interstate I-43; and 3) one approximately 40-foot long double concrete culvert under Greendale Road. These culverts are impairments to fish migration during low water flow conditions (see Section 5.6).

5.4 Water Quality Conditions

5.4.1 Volume

Sources of water to Willow Creek include direct precipitation, runoff, and groundwater. In an undeveloped landscape in this region of the state, about a third of the precipitation falling in a watershed soaks into the ground and becomes groundwater (Turyk, 2007). This water is slowly released to the creek and is the major source of water during periods of little or no precipitation. As a watershed is developed, compacted soil or hard surfaces like roads and rooftops prevent the precipitation from soaking into the ground to become groundwater and may instead cause runoff towards wetlands, storm sewers, and streams. This extra runoff results in an increase in stream flow during snowmelt or storm events and reduces the amount of groundwater that later feeds the creek. Because of reduced groundwater storage, the stream flow can be significantly less during dry periods, which results in warmer water temperatures and potentially lower concentrations of dissolved oxygen. Low water levels may also make passage by trout and spawning salmonids difficult or impossible. Stream discharge measurements completed in 2006/2007 at two Willow Creek sites, Greendale Road and Woodland Road, showed the area upstream Woodland Road site has less baseflow than Greendale Road. Contribution areas to baseflow conditions occur from the outlet to Woodlake and east of Woodland Road (near STH 23) in Basin 6 and from groundwater seeps located in Basins 10 and 11. This study concluded that groundwater discharge and improved baseflow conditions exist downstream from CTH Y (Turyk, 2007). A portion of the baseflow observed at CTH Y is likely attributed to surface water discharge from Woodlake.

5.4.2 Thermal

Surface water temperatures are critical to sustaining the existing coldwater segments of Willow Creek and the associated aquatic species located east of I-43 (Class II trout fishery). Water temperature within streams is often used as an indicator of groundwater discharge. In-stream measurements indicate groundwater discharge significantly influences water temperatures downstream from I-43 with the lowest water temperatures recorded near Greendale Road (Masterson, 2006). This thermal data corresponds to the good water quality data (Turyk, 2007) and good aquatic habitat conditions (Wiater, 2007) (Masterson, 2006) observed in this segment. This segment of stream channel also benefits from the existing wooded riparian buffer, which provides shade to maintain cooler water temperatures.

5.4.3 Chemical

Water chemistry within Willow Creek indicates fair water quality based on water quality sampling completed in 2006/2007 for nitrogen, phosphorous, total suspended solids, chloride, and dissolved oxygen. In general, levels of phosphorous and nitrogen were higher in the upper reaches of the watershed. Total phosphorous concentrations ranged from 153 ug/l to 752 ug/l at Woodland Road and from 28 ug/l to 344 ug/l at Greendale Road. The USEPA's recommended total phosphorous concentration for streams in this eco-region is 33 ug/l. Concentrations of nitrate exceeded the federal drinking water standard (10.0 mg/L) upstream of I-43 (11.9 mg/L) and upstream of Woodland Road (21.0 mg/L). Total suspended solids (TSS) and chloride levels were comparable between the upper and lower parts of the watershed (Turyk, 2007).

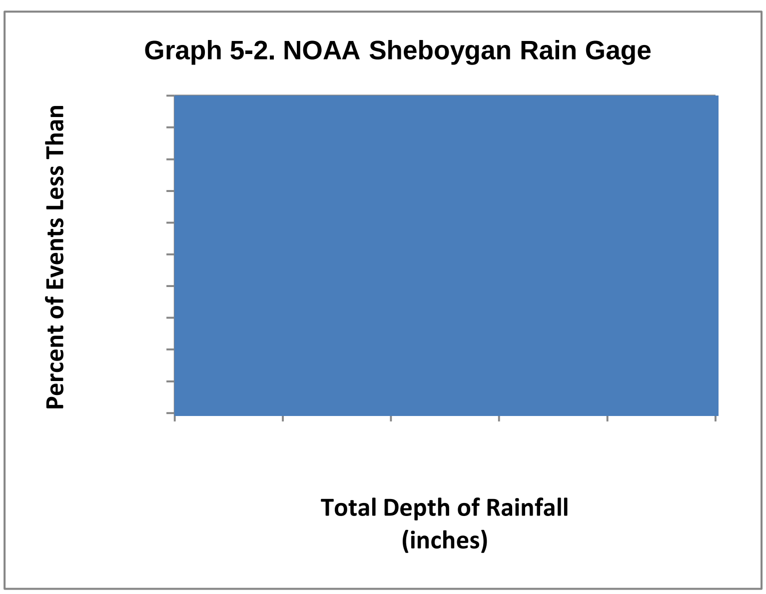
Coldwater species using this segment of stream require high levels of dissolved oxygen (>7.0 mg/l). Dissolved oxygen levels were highest downstream of Interstate I-43, with the highest level (8.4 mg/l) recorded at Greendale Road. High dissolved oxygen levels downstream of Interstate I-43 correlate to increased groundwater discharge along the lower segments of the watershed (Turyk, 2007).

5.4.4 Aquatic Habitat

Biological surveys completed in 2006/2007 observed reproducing trout and salmon in the segment of Willow Creek between Interstate I-43 and Greendale Road. Habitat assessments in this segment showed fair IBI scores, indicating fair fish community assemblages, and good HBI scores, indicating good water quality and macroinvertebrate assemblages. The substrate in this segment is predominantly sand to cobble size material with occasional boulders and an average channel sinuosity of 1.35 (Wiater, 2007). Fourteen fish species were observed in this segment, including brook trout, brown trout, and young of the year Coho salmon, Chinook salmon, and Steelhead (Masterson, 2006). Based on these findings Willow Creek was classified as a cold water Class II trout fishery by the WDNR in 2008. It is also the only known coldwater Wisconsin tributary to Lake Michigan that supports naturally reproducing anadromous salmonid populations, making Willow Creek a unique feature on the Lake Michigan coastline.

5.4.5 Precipitation

Understanding precipitation is important in agricultural and urban areas because of the impact of storm water runoff to aquatic habitat and stream morphology. Precipitation data was obtained from the National Ocean and Atmospheric Administration (NOAA) rain gage 477725, which is maintained by Sheboygan County. Graph 5-2 sorts and ranks each rainfall event for a 107 year period from January 1, 1900



through December 31, 2007 (Rain evens greater than 2.5 inches were not shown in the graph).

These rainfall records show that 48 percent of all rain events are less than 0.25 inches, 69 percent are less than 0.5 inches, 87 percent are less than 1.0 inches, and so on. Total annual rainfall for Sheboygan for the 107 years of record averages around 30 inches. About half of the total rainfall occurs in rain events less than 0.66 inches of rain. Events less than one inch of rainfall represent around 75 percent of the total rainfall, and almost all events are less than two inches. Therefore, recharge of the surficial aquifer that is providing baseflow to Willow Creek is made up primarily from rain events less than two inches. By targeting smaller, more frequent rain events, the designs of storm water infiltration systems are smaller and the concept/strategy of preserving or enhancing the recharge of the surficial groundwater supplies is more feasible and reasonable to implement.

Rainfall is often referred to in its probability of occurrence. The Illinois Water Survey completed an in-depth analysis of rainfall throughout the Midwest Region (Huff and Angel, 1992). Table 5-2 summarizes their estimate of rainfalls with varying rainfall durations (5 minutes to 10 day long rainfall events) with probability of reoccurrence that ranges from on average every two months to an average of 100 years. Table 5-2 reports only the total amount of rain and does not indicate if the rain fell in one hour or one day. For purposes of discussions in this analysis, the one-hour design storm is referenced, because it allows for the estimation of return frequency probability for storms of small volumes of rainfall that are most critical to the recharge of groundwater supplies for Willow Creek.

Table 5-2. Rainfall Frequency for the Sheboygan (Illinois State Water Survey Bulletin 71)

Duration	2-month	3-month	4-month	6-month	9-month	1-year	2-year	5-year	10-year	25-year	50-year	100-year
24-hr	1.42	1.66	1.84	2.1	2.38	2.59	3.11	3.93	4.65	5.57	6.46	7.45
1-hr	0.67	0.79	0.87	0.99	1.12	1.21	1.46	1.85	2.19	2.62	3.04	3.5
5-min	0.17	0.2	0.22	0.25	0.29	0.31	0.37	0.47	0.56	0.67	0.78	0.89

5.4.6 Drainage Basins

A digital representation of the Willow Creek watershed boundary was created in ArcInfo using the "Watershed" tool in the Spatial Analyst toolset. LiDAR-based, two-foot elevation contours provided by the Sheboygan County Planning and Resources Department were the basis for this analysis. Flow accumulation surfaces were also modeled in this process. This information was used to create a map outlining the stream thread of Willow Creek and the watershed boundary. Sub-basins within the watershed were also delineated using the "Watershed" tool in the Spatial Analyst toolset.

Willow Creek consists of approximately 30,450 linear feet (5.75 miles) of stream channel. The Willow Creek watershed is approximately 2,543 acres or four square miles. The watershed was divided into 14 drainage basins, or subwatersheds, representing breaks in the topography and key road crossings (Figure 4).

Drainage areas and the percent impervious cover are summarized in Table 5-3. With the exceptions of Basins 5, 6, 7, and 10 (Village of Kohler, Town of Sheboygan, City of Sheboygan), there is little development or impervious areas within the watershed. Future land use information for this region of Sheboygan County is being developed by BLRPC but is not yet available. Future land use plans can be used to estimate impervious cover and potential water quality impacts under projected conditions.

Table 5-3. Basin Land Area and Percent Impervious

Basin	Acreage (ac)	Existing Impervious
1	58	0.3%
2	94	3.4%
3	167	3.7%
4	138	7.0%
5	197	52.2%
6	253	28.0%
7	187	24.0%
8	252	12.8%
9	160	7.4%
10	184	40.6%
11	330	18.7%
12	140	0.9%
13	69	8.7%
14	314	10.3%
Total	**2543**	
Average Imperviousness		**29.7%**

5.4.7 Soil Conditions

Soils in the Willow Creek watershed differ in surface textures and underlying parent material. Most soils (76%) are well drained and 7% are poorly drained (Turyk, 2007). In general, soils east of Woodland Road tend to be more permeable loamy sands and silt loams overlying loams with sand and gravel and are well drained. West of Woodland the soils tend to be less permeable loams and silt loams overlying silty clay loams. The soil patterns correlate to the stream reach that supports the colder water fishery, which steadily improves to the east (downstream) near Greendale Road where the channel receives more baseflow from the underlying sand and gravel deposits. Figure 7 shows the soil units and mapped hydric soil units within the watershed. Attachment B presents a description of the soils mapped within the watershed from the Sheboygan County Soil Survey.

Permeability rates of mapped soils were used to evaluate the groundwater infiltration potential of soils within the watershed. Soils with permeability rates greater than 6.0 inches per hour were rated a high value for groundwater infiltration potential. Soils with permeability rates less than 0.6 inches per hour were rated a low value for groundwater infiltration potential. Figure 8 presents a map showing that more areas with the greatest groundwater infiltration potential are located east of Woodland Road. This map has been prepared for planning purposes and illustrates areas where groundwater infiltration could be considered for storm water management. Actual infiltration rates are dependent on site-specific soil information.

5.5 Invasive Plant Species Survey

Invasive terrestrial plant species are problematic within a watershed and can be easily spread along waterways and road corridors. Common reed grass (*Phragmites australis*) and common buckthorn (*Rhamnus cathartica*) were selected as target invasive species that could be controlled on public lands and within road right-of-ways (ROW). A windshield survey was completed to locate areas of common reed grass visible from existing ROWs. In general, there was a low percentage of common reed grass observed within or near the existing ROWs. Several areas of common reed grass were observed within approximately one-third of a mile of the I-43 and STH 23 interchange with the greatest density along STH 23, east of the interchange. The low occurrence of common reed grass within the watershed indicates populations are controllable using standard vegetation management techniques.

A field reconnaissance of public lands owned by the City of Sheboygan and Sheboygan County located at the Plank Road Trailhead, east of I-43, was completed to evaluate the prevalence of buckthorn and Phragmites. The Sheboygan County parcel, located on the south side of the trailhead, contains primarily natural habitats, including forested wetlands, forested uplands, emergent wetlands and some mowed grass. The City of Sheboygan parcel, located on the north side of the trailhead, includes mowed grass. Buckthorn was prevalent in the shrub layer on the Sheboygan County parcel and not prevalent on the City of Sheboygan parcel. The most common plants observed within the Sheboygan County parcel included green ash (*Fraxinus pennsylvanica*) in the tree canopy; willows (*Salix* sp.), non-native bush honeysuckle (*Lonicera* sp.), and common buckthorn in the shrub layer; and narrow-leaved cattail (*Typha angustifolia*) and reed canary grass (*Phalaris arundinacea*) in the herbaceous layer. Garlic mustard (*Alliaria offficinalis*), an invasive forb, was also observed in small areas. A list of plant species observed on the Sheboygan County parcel is presented in Table 5-4. Five of the eight common plant taxa observed on the Sheboygan County parcel are exotic invasive species, indicating the vegetative integrity at this parcel is low quality. Based on this survey, aggressive treatment of buckthorn, honeysuckle, and garlic mustard is needed to control these invasive plants on the Sheboygan County parcel.

Table 5-4. Sheboygan County Plank Road Trailhead Parcel Vegetation Survey Results

Species	Common Name	Life Form	Occurrence
Acer negundo	Box-elder	Tree	2
*Alliaria officinalis**	Garlic mustard	Forb	2
Alnus rugosa	Tag alder	Shrub	2
Aster lateriflorus	Panicled aster	Forb	2
Betula papyrifera	Paper birch	Tree	2
Cornus stolonifera	Red-osier dogwood	Shrub	2
Fraxinus pennsylvanica	Green ash	Tree	3
*Hesperis matronalis**	Dame's rocket	Forb	2
*Lonicera sp.**	Bush honeysuckle	Shrub	3
*Malus sp.**	Apple	Tree	1
*Phalaris arundinacea**	Reed canary grass	Grass	3
Physocarpus opulifolius	Nine bark	Shrub	1
Quercus macrocarpa	Bur oak	Tree	1
*Rhamnus cathartica**	Common buckthorn	Shrub	3
*Rhamnus frangula**	Glossy buckthorn	Shrub	2
Salix sp.	Willow	Shrub	3
*Typha angustifolia**	Narrow-leaved cattail	Grass	3

*Denotes non-native invasive species.
Occurrence Values: 1-rare within community; 2-few scattered individuals within community; 3-co-dominant within community; 4-lone dominant within community; 5-monoculture.

5.6 Fish Passage Inventory

A field survey of existing culverts along the mainstem of Willow Creek was completed to consider impairments to fish passage. The survey was conducted on November 16, 2010 by completing the Stream Crossing Data Sheet in accordance with the SRBP's Adopt-A-Stream Program Handbook and WDNR protocol. Fourteen culvert crossings and one ford were evaluated (Figure 9). Results of the fish passage evaluation at the culvert locations are summarized in Table 5-5. Seven, or 50 percent, of the stream crossings contained passage issues. The impaired culverts are; C-1, C-6, C-9, C-10, C-11, C-12, and C-12a. The most common passage impairments included culvert length and lack of natural substrate, perched outlets, debris accumulation, and shallow water in low flow conditions. Culverts C-9, C-10, C-11, C-12, and C-12a are located in the segment classified as a coldwater fishery and include an area starting at the confluence to the Sheboygan River upstream to the west side of I-43. These impairments likely cause seasonal fragmentation of stream segments, which may affect fish migration and spawning productivity. Field survey forms and photographs are presented in Attachment C.

Table 5-5. Fish Passage Inventory Summary

Culvert ID	Observation Date	Observer	Passage Issue Occurrence	Notes
C-1	11/16/2010	Nedland	NA	This culvert does not continue on the other side of Hwy 23. Appears to be drain tile or storm sewer outfall.
C-1a	11/16/2010	Nedland	Some Species/Life Stages at Most Flows	Passage issue due to culvert length. This is the headwater of Willow Creek
C-2	11/16/2010	Nedland	Passage Issues at High Flows	Slight passage issues due to structure constriction ratio.
C-3	11/16/2010	Nedland	None	Does not appear to be a fish passage issue. Stream was dry at time of evaluation.
C-4	11/16/2010	Nedland	Passage Issues at High Flows	Slight passage issues due to structure constriction ratio. Further evidence of slight passage issue provided by scour pool below structure.
C-5	11/16/2010	Nedland	Passage Issues at High Flows	Evidence of slight passage issue provided by scour pool below structure.
C-6	11/16/2010	Nedland	Most Species/Life Stages at Most Flows	Fish passage restriction due to perched outlet.
C-7	11/16/2010	Nedland	Passage Issues at High Flows	Slight passage issues due to structure constriction ratio.
C-8	11/16/2010	Nedland	None	Fish passage does not appear to be an issue. Fish were observed passing both up and downstream through the structure.
C-9	11/16/2010	Nedland	Some Species/Life Stages at Most Flows	Passage issue due to culvert length and shallow water depth within the structure.
C-10	11/16/2010	Nedland	Some Species/Life Stages at Most Flows	Passage issue due to culvert length and shallow water depth within the structure.
C-11	11/16/2010	Nedland	Some Species/Life Stages at Most Flows	Passage issue due to culvert length and debris accumulation. Large fish observed below outlet.
C-12	11/16/2010	Nedland	Some Species/Life Stages at Most Flows	Passage issue due to water main across outlet 12a.
C-12a	11/16/2010	Nedland	Most Species/Life Stages at Most Flows	Outlet is perched, and shallow water within structure.

5.7 Stream Condition Summary

The stream assessment results presented in this report and results from previous studies (Turyk, 2007) (Waiter, 2007) (Masterson, 2006) indicate the lower segments of the Willow Creek channel are higher quality than the upper segments. Factors influencing the habitat include channelization, riparian buffer, water quality, aquatic habitat, groundwater contribution, and fish passage impairments. To illustrate, stream segments were assigned a classification based on the existing habitat quality as follows:

- Poor (impaired by channelization and land use practices with low aquatic value)
- Fair (impacted by channelization and land uses with low-medium aquatic value)
- Good (not significantly impacted from channelization or land uses with medium aquatic value)
- Excellent (stream in natural condition, low impact from land uses, and high aquatic value)

Figure 10 shows the habitat quality based on existing conditions. This figure illustrates where existing habitat should be preserved and where improvements could be made within the watershed to expand areas of better quality to have the greatest habitat and water quality benefits. Suggested improvements include the following:

- Stream and wetland restoration
- Conservation easements to preserve riparian corridors
- Fish passage improvements
- Groundwater recharge enhancements

6.0 Hydrologic Analysis

A hydrologic analysis was completed for this watershed as a baseline inventory of current conditions and as a tool to evaluate storm water impacts from existing and future development. Understanding how the watershed functions hydrologically will assist in proper siting and design of storm water controls and prioritize areas for implementation of best management practices (BMPs).

6.1 Design Storms

A rainfall–runoff model was developed for each of the 14 drainage basins. Runoff volume and runoff rate were computed for 17 design rainfall events (Table 6-1). Twelve of the design storms were taken from Bulletin 71 (Huff and Angel, 1992) for the one hour duration storms. Five more one hour design storms were added to round out the range of the analysis and for which no return frequencies were assigned (0.25-, 0.5-, 4.0-, 5.0-, and 6.0-inches).

Table 6-1. One Hour Design Storms Used in Hydrologic Analysis

Return Frequency	Depth of Rainfall (in)		Return Frequency	Depth of Rainfall (in)		Return Frequency	Depth of Rainfall (in)
--	6.0		10-year	2.19		4-month	0.87
--	5.0		5-year	1.85		3-month	0.79
--	4.0		2-year	1.46		2-month	0.67
100-year	3.5		1-year	1.21		--	0.5
50-year	3.04		9-month	1.12		--	0.25
25-year	2.62		6-month	0.99		--	--

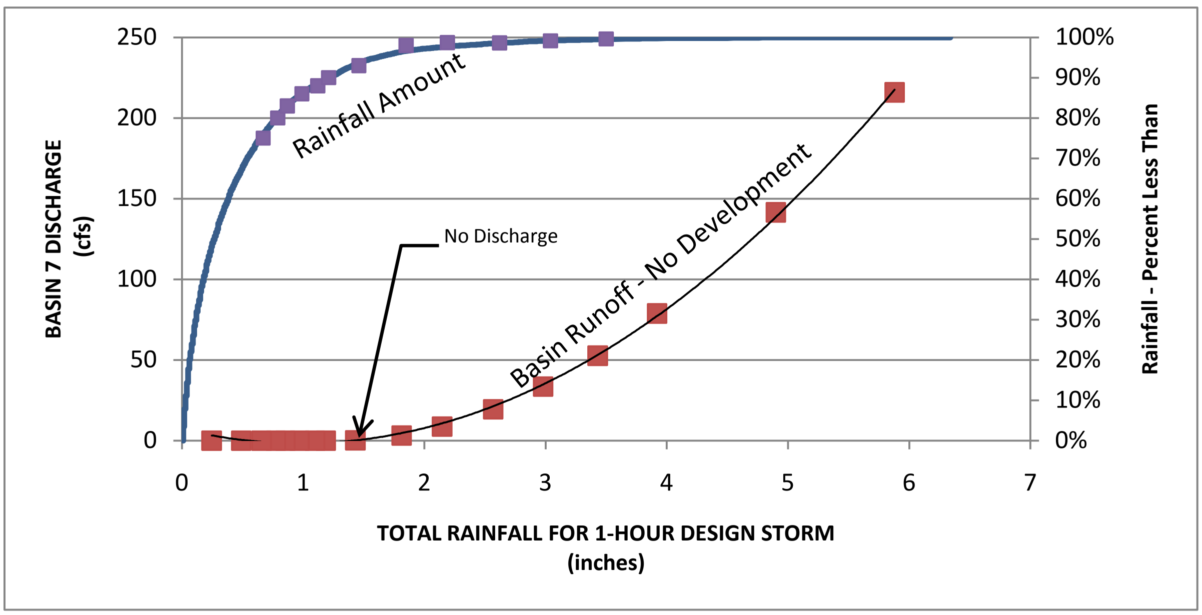
6.2 Rainfall Distribution

The distribution of rainfall over the one hour duration of the simulation was defined by the First Quartile rainfall distribution (Huff and Angel, 1992). The Huff distribution was chosen because it does not produce the extreme rainfall intensity that is characteristic of the Type II distribution.

6.3 Changes in Peak Runoff Rates

Basin 7 will be used to illustrate the results of the hydrologic analysis. Basin 7 includes the northeast area of the I-43 and STH 23 interchange. The basin is largely developed (24% impervious) with residential, highways, and local roads and represents average build-out conditions for the watershed. Assuming that there is no impervious area in the basin (before the basin was developed) runoff is not generated until rainfall exceeds about 1.4 inches (Graph 6-1). Runoff then increases to around 215 cfs given six inches of rainfall in an hour assuming no development in the drainage basin.

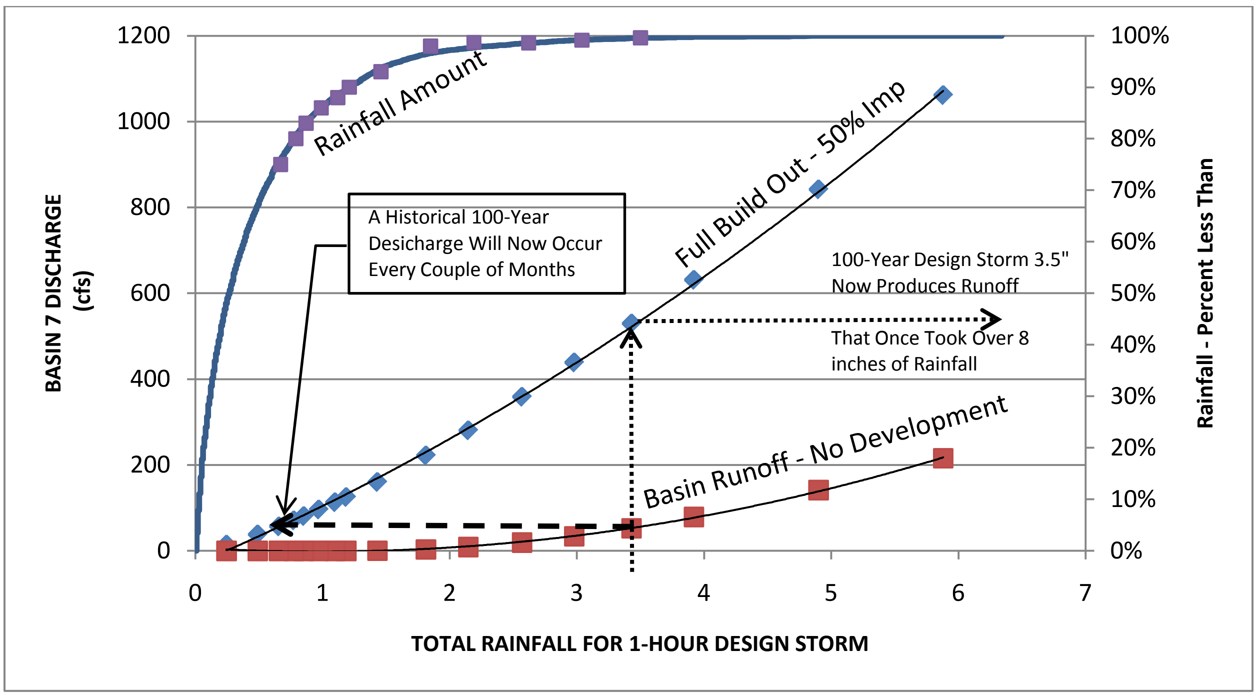
Graph 6-1. Runoff In Basin 7 With No Impervious Area



Based on existing development patterns in the Willow Creek watershed, 50 percent impervious area was assumed to be completed in build out conditions. Two dramatic changes occur with development. First is the increase in the runoff rate (cubic feet per second or cfs). The second is the increased frequency of rare flood events.

As a watershed develops, the volume and peak flows increase. With the 100-year design storm (3.5 inches of rainfall in one hour) and assuming no impervious cover in the basin, the peak runoff rate was estimated at 50 cfs. The peak runoff rate increases to an estimated 500 cfs once the percent of impervious cover reached 50 percent. Historically (no impervious area), a discharge of around 500 cfs would be an extremely rare occurrence (around 8.3 inches of rainfall with greater than 100-year return frequency) (Graph 6-2). In addition, the discharge that historically generated the discharge from a 100-year rainfall event (50 cfs) is, with 50 percent imperviousness, being generated by a design storm of only 0.66 inches of rainfall.

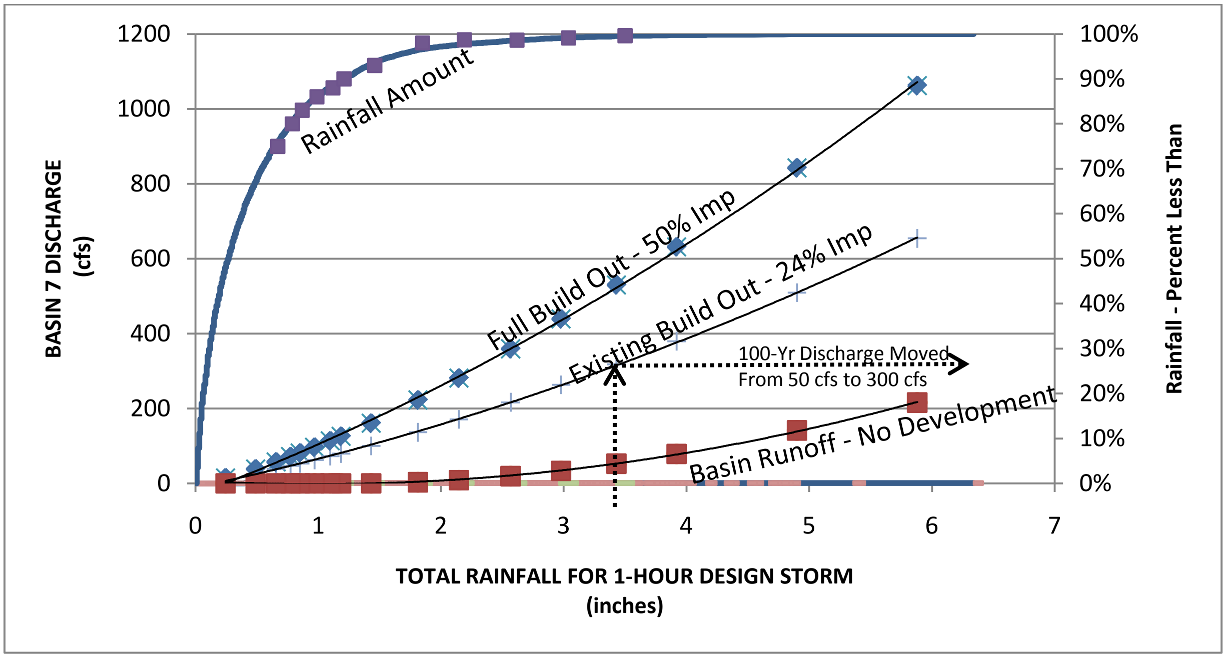
Graph 6-2. Increased Runoff Rate and Frequency of Flooding Caused by Development In Basin 7



More damaging to Willow Creek are the discharges from the small frequent rain events that begin to generate sufficient energy (flow, velocity and frequency) to define the shape of the stream channel. For Basin 7 these appear to be rain events of 1.5 to 3.0 inches of rainfall. These are storms that might occur two to three times a year under “natural” undeveloped conditions. However with 50 percent of the basin covered with impervious area similar runoff conditions will be created with as little as 0.5 inches of rainfall and can occur as many as 10 to 15 times a year. The increase in discharge to Willow Creek will change the stream’s morphology and cause conditions that will erode streambanks and impact the existing bank cover habitat, and create additional debris dams within the stream channel.

Currently, Basin 7 has about 24 percent of impervious area. The 100-year design storm is (around 3.5 inches of rainfall) is estimated to generate discharges of around 300 cfs. Historically, it once took between 6.0 and 6.5 inches of rainfall to generate the same amount of flow that is now generated with only 3.5 inches of rain (Graph 6-3).

Graph 6-3. Estimated Discharge from Basin 7 under Undeveloped, Existing Build Out, and Full Build Out Conditions



The outfall from Basin 7 enters Willow Creek through a 54-inch culvert about 760 feet north of the I-43 culvert crossing. The increased erosive energy of the discharges (greater frequency and magnitude) from Basin 7 resulting from the development within the drainage area has damaged over 75 feet of streambank. Repairs should include the reduction of the erosive force from this discharge by detaining and infiltrating runoff from the basin. Controlling discharge and repairing this unstable bank would reduce erosion and decrease sedimentation to Willow Creek. The following image shows the effect of streambank erosion from increased runoff.

Eroding streambank at Basin 7 outfall to Willow Creek

6.4 Other Channel Erosion Problems

The increase in the erosive forces from urbanization within the watershed has disrupted the stability of the channel in a number of locations, including the following:

- Bank instability downstream of the box culvert (Culvert C-9) located southwest of the I-43 and STH 23 interchange.
- Bank instability downstream of the two culverts (Culvert C-11) located at the Greendale Road crossing.
- Bank instability located on the north bank of Willow Creek approximately 500 feet downstream of the I-43 crossing (C-10) located on public land owned by Sheboygan County.

6.5 Decreasing Groundwater Recharge

The hydrologic analysis quantified the change in recharge to groundwater supplies (and to the base flow to Willow Creek) assuming no impervious area, existing level of impervious area and full build out (50 percent) impervious area. Already there has been about a 14 percent loss in groundwater and base flows to Willow Creek. Should the watershed become fully developed, groundwater contributions would be expected to decrease by as much as 50 percent. The four basins that contributed the most to groundwater under all three scenarios were Basins 6, 8, 11 and 14. Basin 14 is dominated by poor draining soils but ranks high because of its large land area. Under the no impervious area scenario, Basin 7 and 10 contributed almost 10 percent of the groundwater sources. But as development has occurred, Basins 4 and 5 now exceed them in the volume of groundwater contributions. The decrease in groundwater contributions in these two basins (7 and 10) account for a little more than half of the loss to groundwater sources for the entire watershed.

6.6 Role of Floodplain Storage

Soils west of Woodland Road are more poorly drained silt loams and silty clays, and as a result generate larger volumes of runoff than the basins with better draining soils east of Woodland Road. Willow Creek does not currently have a regulated floodplain. The importance of establishing a floodplain is to preserve flood storage between Woodland Road and STH 23. It was estimated that the approximate 80 to 90 acre floodplain in Basins 12 and 14 currently holds somewhere around 100 to 150 acre-feet of runoff. Without preservation of the floodplain storage, flooding downstream of Woodland Road will likely become severe as development occurs in the upper watershed. Figure 6 shows wetland restoration areas in Basins 12 and 14, upstream of Woodland Road that would improve floodplain storage.

7.0 Estimated Erosion Within the Willow Creek Watershed

The portion of the watershed west of Woodland Road is dominated by agricultural row crops, approximately 60 percent of the existing land use. For the majority of the first 7,400 feet of channel upstream of Woodland Road, the vegetated buffer measures around ten feet. South of STH 23 Willow Creek is only a grassed waterway through a farm field, not much more than 10 feet in width and approximately 1,000 feet in length. Soil loss from these agricultural fields was estimated using the Universal Soil Loss Equation (USLE). The estimated losses were selected to predict the soil losses during the worst year in the crop rotation. The objective would be to select BMPs to protect downstream fish habitats during those years that the land would be most susceptible to erosion. Therefore, it was assumed that all fields were planted with corn and that there were no conservation practices. The average erosion rate was estimated to be around 5 to 7 tons per acre per year (Table 7-1).

Table 7-1. Estimated Erosion Rates From Agricultural Fields in the Willow Creek Watershed

Basin No.	Total Basin Area ac	Area of Agriculture ac	Estimated Rate of Erosion ton/ac/yr	Lower Estimate of Annual Loads ton/yr	Upper Estimate of Annual Loads ton/yr
Basin 1	58	38	7 to 8	266	304
Basin 2	94	60	5 to 6	300	360
Basin 3	167	144	4 to 8	576	1,152
Basin 4	138	56	4 to 6	224	336
Basin 12	139	95	5 to 6	475	570
Basin 13	69	37	7 to 8	259	296
Basin 14	313	188	5 to 6	940	1,128
Total	**978**	**618**	**5 to 7**	**3,040**	**4,146**

The total sediment load from the entire urban area (using SLAMM) for the City of Sheboygan, Village of Kohler, City of Sheboygan Falls, Village of Howards Grove, Town of Sheboygan, and the Town of Wilson total around 2,400 tons per year (Table 7-2). It is realized that this is a comparison of two completely different algorithms. The purpose here is only to establish a relative comparison to point out that erosion from agricultural fields is a significant source of sediments that are contributing to the impairment of the water quality in Willow Creek. It is further pointed out that only a portion of each community is actually in the Willow Creek watershed so that the total sediment load to Willow Creek is actually less than the 2,400 tons per year that was reported to WDNR for the entirety of each community. This highlights the priority that should be placed on establishing better conservation practices on the agricultural lands upstream of Woodland Road.

Table 7-2. Willow Creek Watershed MS4 TSS Estimated TSS Reduction

MS4 Name Sheboygan County	**Reported Base "no controls" Load (TSS tons/yr)**	**Reported "with controls" Load (TSS tons/yr)**	**Calculated % TSS Reduction**	**Additional TSS Reduction (%)**	**Additional TSS Reduction (TSS tons/yr)**
Sheboygan City	1,081	866	19.9%	20.1%	217.4
Kohler Village	187	137	26.7%	13.3%	24.8
Sheboygan Falls City	580	310	46.6%	0.0%	0
Howards Grove, village	90	71	21.1%	18.9%	17
Sheboygan Town	309	275	11.0%	29.0%	89.6
Wilson Town	154	34	77.9%	0.0%	0
Sheboygan Urbanized Area Totals	**2,401**	**1,693**	**29.5%**		**348.8**
Target Load		**1,441**			

Soils in the watershed are dominated by sandy silt loams. Table 7-3 summarizes the sieve analysis reported by the NRCS in the Sheboygan County Soil Survey for the Waymor series. The Waymor is one of the dominant soils in this part of the watershed; others include the Poygan, Kewaunee, and Manawa series. All are reported to have 30 to 40 percent sand and 60 to 70 percent silt and clay.

Table 7-3. Waymor Series Sieve Analysis

Soil Particle Size um	Aggregate Name	Cumulative Percentage Greater Than
0	--	100%
60	Silt/Clay	40%
75	Very Fine Sand	25%
420	Medium Sand	15%
2,000	Very Fine Gravel	5%
4,700	Fine Gravel	0%

Though the USLE estimates soil that is dislodged on a field, it does not predict how much actually reaches the stream or is transported downstream. However, since fields are plowed to within 10 feet of the stream, there is very little protection to prevent sediments being carried into the stream. The eroded sand covers the channel bottom of Willow Creek between CTH Y and I-43. The channel bottom in the lowest reaches of the stream channel near the confluence with the Sheboygan River contains higher quantities of the silts and clays that are being washed off the farm fields.

Vegetated filter strips are often installed to cause soil particles to drop out and would be effective in trapping the sand component of the soil. However, larger sand particles make up less than half of the soil being washed off agricultural fields. It appears that more aggressive use of agricultural BMPs would be necessary to reach a higher, more desirable reduction in the sediment loads from farm fields. These would include practices such as wider use of grassed waterways, wider vegetated buffers, and restoration of the floodplain to act as a more effective sediment trap.

8.0 Meeting Requirements of NR 216 and NR 151 at Lower Cost

Input received from the Stakeholder Group meetings suggested concerns about the costs associated with implementing stormwater management practices above regulatory requirements. This section introduces innovative concepts to cost-effectively manage stormwater within the Willow Creek watershed while maintaining regulatory compliance.

8. 1 Stormwater Management Collaboration Concepts

The provisions of NR 151 require communities (MS4) to reduce the average annual loading of Total Suspended Solids (TSS) by 40 percent by the year 2013. Table 7-1 summarizes the estimated TSS reduction that each community has reported to the WDNR. Communities will be updating this information and WDNR will provide comments to these reported numbers which may result in a change in the TSS reductions reported at this time.

Only the Town of Wilson and the City of Sheboygan Falls report TSS reductions that achieve the requirements of NR 151 of a 40 percent reduction. The remainder of the communities need to achieve additional reductions of between 13 to 29 percent. A new storm water facility that will be constructed by the Village of Kohler near I-43 and south of the Plank Road trail is anticipated to allow the Village to exceed their 40 percent TSS reduction threshold.

8. 2 A Watershed Approach to Willow Creek Stormwater Management

The WDNR is now encouraging MS4s to collaborate in meeting the 40 percent reduction goals of NR 151. Permits are being written with language similar to that presented below from the Menomonee River Groups Permit, which references the first threshold of 20 percent TSS reduction by 2008.

> **F. STORM WATER QUALITY MANAGEMENT:** Each municipality shall develop and implement a municipal storm water management program. The storm water management program shall achieve compliance with the developed urban area performance standards of s. NR 51.13(2), Wis. Adm. Code, for those areas of the municipality that were not subject to the post-construction performance standards of s. NR 151.12 or 151.24, Wis. Adm. Code. (Note: projects prior to Oct. 1, 2004). The program shall include:
>
> 1. To the maximum extent practicable, implementation of storm water management practices necessary to achieve a 20% reduction in the annual average mass of total suspended solids discharging from the MS4 to waters of the state as compared to no controls, by March 10, 2008. (Note: reconstruction or redevelopment projects should be targeted to incorporate storm water management practices to help attain 20% and 40% total suspended solids reduction requirements). **The municipality may elect to meet the 20% total suspended solids standard on a watershed or regional basis by working with other permittee(s) to provide regional treatment or other measures that collectively meets the standard.**

All that is required is an intergovernmental agreement that spells out how the TSS reductions of a BMP are to be shared among participants. DNR does not need to know how the cost share agreement breaks down nor any of the details of the intergovernmental agreement that would accompany such a project.

8. 3 Illustration of a Cooperative Watershed Approach

The base conditions reported by the MS4s total 2,401 tons of TSS per year (Table 7-1). With the current BMPs the MS4s can reduce that number down to 1,693 tons per year. This leaves an additional 348.8 tons that need to be removed by new stormwater facilities. However, taken as a group, municipalities need only to reduce the aggregated loadings to 1,441 tons per year, or a reduction of 252.4 tons (instead of 348.8 tons). At an average cost of around $50,000 per ton for stormwater BMPs, this should translate in a reduction in overall cost to the region of $4 to $5 million.

If the 252 tons were to be distributed evenly among the six communities, stormwater BMPs would be constructed to remove an additional 42 tons per year from each jurisdiction (Table 8-1). Assuming typical TSS loads from residential, commercial and industrial development, the acreage that would have to be tributary to the BMPs would be around 1,153, 763, and 600 acres respectively. This is about 27 percent less area than would have to be treated if each community built the projects as they needed to meet their reductions on their own. Less land area requiring treatment should translate into an overall reduction in the cost to the communities to comply with the requirements of NR 151.

Table 8-1. Reduction in Land Required To Be Treated Using a Watershed Approach

MS4 Name	Reported Base "no controls" Load (TSS tons/yr)	Reported "with controls" Load (TSS tons/yr)	Calculated % TSS Reduction	Additional TSS Reduction (%)	Uniform Allocation of TSS Reduction (tons/yr)	Residential Development Required Treatment Area Typical Annual Loads (0.3 tons/ac/yr) (ac)	Commercial Development Required Treatment Area Typical Annual Loads (0.4 tons/ac/yr) (ac)	Industrial Development Required Treatment Area Typical Annual Loads (0.5 tons/ac/yr) (ac)
Sheboygan County								
Sheboygan City	1,081	866	19.9%	20.1%	42	192	127	100
Kohler village	187	137	26.7%	13.3%	42	192	127	100
Sheboygan Falls City	580	310	46.6%	0.0%	42	192	127	100
Howards Grove, village	90	71	21.1%	18.9%	42	192	127	100
Sheboygan town	309	275	11.0%	29.0%	42	192	127	100
Wilson town	154	34	77.9%	0.0%	42	192	127	100
Sheboygan Urbanized Area Totals	2,401	1,693	29.5%		252	1,153	763	600
Target Load		1,441						
Remaining TSS Reduction		252						

By MS4 – 27% greater area

	0	0	0
.8	1,594	1,055	829

8.4 Pollutant Banking

Another option for communities would be to "sell" their "excess" pollutant reductions. The concept of pollutant banking should be possible under WDNR's current policy of encouraging communities to cooperate on a regional basis to achieve watershed objectives through intergovernmental agreements. However, the simple outright sale of pollutant "credits" without regional cooperative agreements may be considered inconsistent with this policy and may require pre-approval by WDNR.

Assuming the numbers reported to WDNR are accurate, the Town of Wilson has around 58 tons of surplus reduction capacity and the City of Sheboygan Falls has roughly 38 tons of surplus reduction capacity, for a total of 96 tons. That is enough capacity for the Town of Sheboygan to meet its TSS reduction goals, or the Villages of both Kohler and Howards Grove to meet their reduction targets, or the City of Sheboygan to meet over 40 percent of its remaining reduction requirements.

From previous estimates of costs for stormwater BMPs, the range is anywhere from $13,000 to over $100,000 per ton, with an average around $50,000 per ton. If we assume that the value of the surplus reduction capacity is between $13,000 to $50,000, the cost to the Village of Kohler, the Village of Howards Grove, the Town of Sheboygan and the City of Sheboygan should be around $1.2 to $4.8 million. This breaks down to $500,000 to $1,900,000 of revenue for Sheboygan Falls and $750,000 to $2,900,000 of revenue to the Town of Wilson.

9.0 Watershed Management Alternatives

The following watershed management alternatives have been developed based on the findings of this study and stakeholder input.

9.1 Low Impact Development

1. Promote low impact development principles (i.e. conservation subdivisions, greenspace preservation, cluster housing) into new land development projects. The attached link http://www.swmpc.org/mi_lid_manual.asp provides conservation principles from a Low Impact Development Manual developed in Michigan.

9.2 Floodplain Storage

1. Complete a detailed hydrologic and hydraulic floodplain analysis to establish a flood storage area upstream and downstream of Woodland Road to control stream flows and prevent encroachment of the floodplain and loss of flood storage.

9.3 Infiltration

1. Retrofit developed basins with infiltration practices. Similar analysis of highly urbanized basins in Chicago and Appleton has demonstrated that aggressive installation of infiltration practices could reduce runoff by as much as 30 percent. Targeted in the Willow Creek Watershed are Basins 5, 6, 7, 8, and 10.
2. Coordinate with WisDOT to construct a regional infiltration facility within the Interstate I-43/STH 23 interchange to mitigate the loss of groundwater recharge in these basins from past development.
3. Implement an infiltration initiative within Basins 6 and 9 which serves as a critical source area for infiltration contributing to the baseflow of Willow Creek.
4. Protect existing seep areas adjacent to Willow Creek in Basins 10 and 11 which also provide groundwater discharge and contribute to the baseflow of Willow Creek.
5. Incorporate green infrastructure practices into the design of development plans for this Basin. Attachment D presents examples of sustainable/green infiltration practices.

9.4 Water Quality Improvements

1. Implement an annual water quality and aquatic habitat volunteer monitoring program using previous baseline sampling protocol for future comparison.
2. Restore drained wetlands (PRW areas) to improve water quality, control floodwater, improve stream baseflow conditions through groundwater infiltration, and enhance riparian buffer habitat.
3. Develop conservation practices with agricultural based landowners upstream of Woodland Road to reduce the sediment loads that are passed downstream to the coldwater fishery.
4. Promote rain garden installation and bioretention basin use within the watershed to improve storm water runoff.
5. Stabilize areas of bank erosion downstream of Greendale Road (C-11), I-43 (C-10), and I-43/STH 23 (C-9).
6. Control the discharge of storm water and stabilize bank at the 54-inch outfall to Willow Creek in Basin 7.

9.5 Habitat Restoration/Enhancements

1. Remove invasive plant species including Phragmites and buckthorn from public and private lands in the watershed.
2. Remove debris dams annually (fall season) downstream of CTH Y.

3. Improve fish passage at culverts located at Greendale Road (C-11), I-43 (C-10), I-43/STH 23 (C-9), and Woodland Road (C-6).
4. Complete a stream habitat improvement assessment downstream of CTH Y to identify and prioritize in-stream aquatic habitat improvements.
5. Preserve a riparian corridor along Willow Creek downstream of CTH Y.

9.6 Regional Education Initiative

1. Install informational signage along the Plank Road Trail educating the public about Willow Creek.
2. Educate the public regarding the benefits of rain gardens, rain barrels and storm water infiltration.

9.7 Municipal Stormwater Performance Standards

1. Promote infiltration of storm water by following NR 151.24 guidelines.
2. Develop land development standards or an ordinance for development within the Willow Creek Watershed that targets sustainable low impact development principles and storm water infiltration practices over the more conventional subdivision and detention basin storm water management approach.

9.8 Meeting Requirements of NR 216 and NR 151 at Lower Cost

1. Develop a watershed approach to stormwater management that encourages multi-jurisdictional cooperation and lower overall implementation costs.
2. Encourage the concept of “Pollution Banking” to allow communities to bank surplus pollution reduction “credits” and “sell” those “credits” to communities who are not able to meet their stormwater requirements.

10.0 Recommended Alternatives

The watershed management alternatives developed for this project represent a wide range of opportunities to improve the quality of Willow Creek. Table 10-1 prioritizes projects based on watershed need, complexity, and ability to obtain funding. Implementation of these alternatives will be dependent on funding and future local land use decisions and public involvement. The stakeholders expressed concern about local taxpayer and elected official support for initiating projects that are not required by regulation or would increase local taxes.

The estimated costs of alternatives represent a range of costs to implement. Actual costs are highly variable at this conceptual stage and are dependent on actual site conditions, design objectives, and volunteer support.

Table 10-1. Priority Ranking of Management Alternatives

Alternative	Priority	Total Estimated Cost (Costs represent multiple projects)
9.8 Meeting Requirements of NR 216 and NR 151 at Lower Cost	1	$0
9.7 Municipal Stormwater Standards Requiring Maximum Use of Infiltration Practices	2	$5,000 - $10,000
9.5 Habitat Restoration/Enhancements (3 habitat/4 culvert projects)	3	Habitat 80,000 - $100,000/Culvert Removal $100,000 - $1,500,000
9.6 Regional Education Initiative	4	$10,000 -$15,000
9.3 Infiltration (4 in WisDOT interchange)	5	$300,000 - $450,000
9.4 Water Quality Improvements (Annual monitoring/4 projects)	6	Monitoring $5,000 - $15,000/Projects $200,000 - $250,000
9.1 Low Impact Development (Demonstration Project)	7	$20,000 - $25,000
9.2 Floodplain Storage (Floodplain Mapping)	8	$75,000 - $100,000

11.0 REFERENCES

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