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Storm Water Quality Management Plan Update / TMDL Preparedness Assessment

Final Report

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Wisconsin Department of Natural Resources: http://dnr.wi.gov/org/water/wm/wqs/303d/TMDL.html

Executive Summary

The City of Racine's MS4 system is currently regulated under the Wisconsin Pollution Discharge Elimination System (WPDES) permit. The City is in compliance with the requirements of this permit, including the requirement to reduce the amount of Total Suspended Solids (TSS) discharged into receiving waters by 20-percent. The next stage in storm water management regulations the will impact the City of Racine are Total Maximum Daily Loads (TMDLs) that will be developed for the Root River and Pike River. There are currently no TMDLs in place for these waterbodies, however, they will be developed in the future. A TMDL will contain additional pollution control requirements for storm water discharges to the Root River and Pike River.

This study explains the current state of storm water quality management in the City of Racine, with a focus on the Root River and Pike River watersheds. The study discussed the potential impact of future TMDLs on the City and potential best management practices (BMPs) that may be applicable to further improve water quality. The study identified thirteen specific locations for wet detention basins that may be implemented to assist in meeting TMDLs. In addition, street sweeping, bioretention, underground detention, catch basins, and hydrodynamic separation devices were discussed for potential implementation.

It is recommended that the City of Racine further explore the implementation of BMPs to improve water quality on a city-wide basis, but with a focus of the Root River and Pike River watersheds in order to prepare for the development of future TMDLs. This study identifies that wet detention ponds are likely the most cost-effective means of provided storm water pollution reduction. However, site specific factors may prevent some wet detention ponds from being implemented, or cause other BMPs to be more suitable.

As part of the next steps it is recommended that the City conduct a preliminary engineering analysis of BMPs to further review the feasibility, cost, and prioritization of projects for implementation. The preliminary engineering analysis should identify more detailed project costs to allow for budgeting, along with identifying potential grants which may assist in project funding. Identified projects should be added to the storm water utility budget and implemented as in a systematic manner.

1.0 Introduction

In recent years, storm water pollution management for urban areas in the State of Wisconsin, such as the City of Racine, focused on meeting the requirements contained in the Wisconsin Pollution Discharge Elimination System (WPDES) permit. In 2004, the City of Racine was issued WPDES Permit No. WI-S050059-1 as part of the Root River Watershed Group. State of Wisconsin regulations by the Department of Natural Resources (WDNR) Chapter NR 151 Runoff Management and NR 216 Storm Water Discharge Permits are the driving force behind the storm water permit. Implementation of the permit is also guided by a number of storm water technical standards (http://dnr.wi.gov/topic/stormwater/standards/). A prominent condition of this permit requires the reduction of total suspended solids (TSS) from existing urban areas. The TSS requirements were based on state-wide water quality studies and are the same for all permitted municipalities.

The City of Racine conducted initial storm water management planning efforts to prepare for the storm water permit in phases over a number of years, culminating in a summary report entitled "Comprehensive Storm Water Management Plan (AECOM, formerly Earth Tech, 2002). Follow-up studies included the "Assessment of Compliance with s NR 151.13(2)" (AECOM October 19, 2007) and the "City of Racine Updated WinSLAMM Assessment of Compliance" (September 1, 2011) memoranda. These studies were conducted to assess storm water pollution on a city-wide basis in compliance with the permit and to assist the City in further storm water management planning. The City has always remained in compliance with the storm water permit requirements.

Storm water pollution management within Wisconsin is currently evolving to include establishing and complying with a Total Maximum Daily Load (TMDL) for impaired waterbodies. A TMDL establishes a pollution loading that a specific waterbody or waterbody segment/reach can receive and still meet water quality standards. A TMDL is established for each pollutant which causes the impairment of a waterbody. As part of the TMDL, sources of pollution such as an individual City's municipal separate storm sewer system (MS4) are assigned a pollution load which they are allowed to discharge into the waterbody. The pollution loads assigned to MS4s as part of a TMDL are generally more restrictive than the requirements contained in current regulations.

In the future each impaired waterbody within the State of Wisconsin will have a TMDL developed. The City of Racine currently discharges storm water runoff into three impaired waters, the Root River, the North Branch of the Pike River, and the Pike River. The City will need to meet separate pollution loading requirements for the areas of the City that discharge to each of these waterbodies.

Knowing that TMDLs will be developed for the Root River and Pike River which will likely require additional storm water management efforts in these areas, the City of Racine has recognized the need to evaluate and begin to plan for the impacts of future TMDLs. To this end, the City of Racine requested and received a grant from the WDNRs Non-point Source Grant Program. The initial grant request was a general update to the City's existing storm water management plan but was modified with the support of the WDNR to focus more specifically on waterbodies that are currently targeted for future TMDLs. At this time, no specific metrics or limitations are currently in place as no TMDLs exist that impact the City of Racine. The purpose of this analysis is to provide general guidance for the City of Racine in meeting future TMDL requirements for the Root River, the North Branch of the Pike River, and the Pike River.

2.0 Project Setting

2.1 Overview

Storm water runoff generated within the City of Racine is tributary to three main waterbodies; Lake Michigan, the Root River, and the Pike River and its tributaries. Two of those waterbodies, the Root River and Pike River, are considered "impaired waters" and will be the subject of future TMDLs. The focus of this analysis is to evaluate the impacts of future TMDLs on the Root River and the Pike River and its tributaries. Figure 2-1, Regional Watershed Map, displays the position of the City of Racine within the context of the watershed areas and impaired waterbodies (segments) of the Root and Pike River and their tributaries. This Figure is based on information from the WDNR website. Figure 2-2, City Drainage Areas, shows a more detailed watershed map based on City of Racine storm water basins in comparison to the WDNR watershed information. Differences between the two datasets are present and should be taken into account when future water quality analyses are conducted for TMDL development. Figure 2-3, City Watersheds Map, shows the level of detail that was used for this and prior City water quality analyses and is based on individual drainage basins within each watershed. Areas both inside and outside of the City of Racine municipal boundary are included in some areas. This is because the effectiveness of best management practices (BMPs) within a drainage boundary are influenced by the entire area tributary to it and in some cases, the City has worked with neighboring municipalities to develop shared BMPs to the mutual benefit of both municipalities and receiving waters.

2.2 Impaired Waters

The Clean Water Act Section 303(d) requires states to identify impaired waters. The EPA identifies impaired waters as, "waters that are too polluted or otherwise degraded to meet the water quality standard," (EPA, 2013 reference: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/index.cfm). As required by the Clean Water Act, water quality standards are set by the WDNR to protect waters from pollution. To identify impaired waters, the DNR monitors waterways and compares the results to the water quality standards. A water is considered impaired if it "does not support full use by humans, wildlife, fish and other aquatic life and it is shown that one or more of the pollutant criteria are not met" (WDNR, 2013 reference: http://dnr.wi.gov/topic/impairedwaters/impairments.html).

2.2.1 Impairments

An impairment is the reason a waterbody is considered to be degraded. Impairments indicate which aspects of the waterbody are not meeting their designated use. The impairments for waterbodies receiving runoff from the City of Racine are listed on Table 2-1 Impaired Waters.

Table 2-1 Impaired Waters City of Racine TMDL Analysis			
Waterbody	**Location**	**Impairment**	**Pollutant**
Root River	Lake Michigan to Horlick Dam	Water Quality Use Restrictions	Total Phosphorus
		Contaminated Fish Tissue	PCBs
	Upstream of Horlick Dam[1]	Degraded Biological Community[1]	Total Phosphorus[1]
North Branch of the Pike River	STH 20 to Pike River (CTH A)	Chronic Aquatic Toxicity	Unknown Pollutant
		Degraded Habitat	Sediment / Total Suspended Solids
Pike River	Entire Length (Lake Michigan to Kenosha CTH A)[1]	Degraded Biological Community[1]	Total Phosphorus[1]
[1]Proposed to be added to Impaired Waters List			

2.2.2 Pollutants of Concern

For each impairment identified for a waterbody, one or more pollutants, were identified as contributing to the impairment. Three specific pollutants, along with an unknown pollutant, were identified as contributing factors to impairments in the City of Racine receiving waters. The specific pollutants identified are;

- Total Phosphorus (TP),
- Sediment / Total Suspended Solids (TSS), and
- PCBs.

To mitigate for the pollutants that are causing the impaired waters, TMDLs will be developed in the future for each pollutant of concern. TMDLs will be developed based on water quality sampling data that is used in various computer models to evaluate loads from various land use areas, fate and transport of pollutants, and reductions needed from drainage areas to meet the desired water quality levels.

This study will focus on the amount of TP and TSS generated by the City of Racine and discharged into the impaired waters. For each impaired water both TP and TSS loadings were calculated. In some cases TSS is not considered an impairment to a waterbody. However, existing water quality regulations in Wisconsin require the reduction of TSS from all existing urban areas.

Contaminated fish tissues were observed in the Root River that indicate the presence of PCBs. Past industrial related discharges are suspected to be responsible for the presence of PCBs in the sediment and aquatic life in this area. Storm water runoff does not contain PCBs (at least in this day and age) and thus were not included as part of the analysis.

Chronic aquatic toxicity is present in the North Branch of the Pike River, and is caused by an unknown pollutant. A variety of pollutants may be causing this impairment and in the future one or more pollutants of concern may be identified. For the purpose of this study TSS will be used as an "indicator" pollutant for the North Branch of the Pike River. It is common to use TSS as an indicator pollutant in storm water pollution analysis. In urban storm water runoff metals, nutrients, and other pollutants can be attached to suspended solids. Typically, if treatment of TSS is provided, a relative level of treatment for other pollutants is achieved.

2.3 Root River

The Root River drains through the center of the City and discharges into Lake Michigan near the City's downtown area. The Root River watershed is shown on Figure 2-1. The Root River originates to the northeast of the City and collects runoff from a 198 square mile watershed that includes portions of the Cities of Franklin, Greenfield, Milwaukee, Muskego, New Berlin, Oak Creek, West Allis, and Racine, the Towns of Dover, Norway, Paris, Raymond, and Yorkville, and the Villages of Caledonia, Greendale, Hales Corners, Mount Pleasant, Sturtevant, and Union Grove. The watershed is a mix of urban and agricultural land uses. Approximately 4,400 acres from the City of Racine drain into the Root River. Within the City the land draining to the Root River are nearly completed developed. They include a mix of residential, commercial, and industrial land use areas. A portion of the lands directly adjacent to the Root River are owned by the City and are generally parkland.

2.4 Pike River

The Pike River discharges to Lake Michigan in the City of Kenosha. The City of Racine, and the Village of Mount Pleasant immediately west of the City, represents the northern boundary of the Pike River watershed. Runoff from the southern, and southwestern, edges of the City is tributary to the Pike River watershed. The entire Pike River watershed is about 52 square miles, of which, 660 acres is from the City of Racine. Figure 2-1 also shows the Pike River watershed. Other communities within the Pike River watershed include the City of Kenosha, the Town of Somers, and the Villages of Mount Pleasant, Pleasant Prairie, and Sturtevant.

Areas on the southern edge of the City discharge into Sorenson Creek, which travels south into the main-stem of the Pike River. Sorenson Creek originates near the intersection of Taylor Avenue (CTH X) and Meachem Road (CTH Y). South of the city, Sorenson Creek travels through Mount Pleasant before joining the Pike River in the Town of Somers near the intersection of 7^{th} Street and 13^{th} Avenue. Approximately 230 acres of land from the City of Racine are tributary to Sorenson Creek. This area is primarily residential in land use.

The North Branch of the Pike River primarily runs north-south and flows from CTH C in the Village of Mount Pleasant to the south into the Town of Somers, near the intersection of STH 31 and CTH A, where it joins the South Branch of the Pike River to form the Pike River. Storm water runoff from along the southwestern edge of the City of Racine discharges into the North Branch of the Pike River. Approximately 430 acres from the City are directly tributary to the North Branch. In addition the City has taken responsibility for storm water pollution runoff from 175 acres in the Town of Mount Pleasant that discharge to the North Branch. The area from Mount Pleasant is tributary to the Stewart-McBride Pond. The portions of the City that are tributary to the North Branch of the Pike River are a mix of land uses including residential, commercial, and industrial.

3.0 Water Quality Regulations and TMDLs

3.1 Regulatory Environment

There are two main regulatory components for urban storm water pollution for municipalities in Wisconsin; WPDES permits, and TMDLs. The WPDES permit includes requirements for municipalities to provide public education and outreach, public involvement and participation, illicit discharge detection and elimination, construction site pollutant control, and pollution prevention practices for municipally owned facilities. Also, the WPDES permit requires that the permittee reduce TSS loads from existing urban areas by 20 percent. The required TSS reduction was previously 40 percent, however, the State of Wisconsin recently enacted legislation to remove the compliance date for the 40 percent reduction.

In addition to the requirements of the WPDES permit, TMDLs are being developed for impaired waterbodies throughout the State of Wisconsin. A TMDL places a limit on the amount of pollution that can be discharged into an impaired waterbody. The WDNR is responsible for the development and implementation of TMDLs within the State of Wisconsin. However, it is possible for other agencies to develop a TMDL. The Milwaukee Metropolitan Sewerage District (MMSD) is currently in the process of developing TMDLs for waterbodies within its service area. The targets listed in the TMDL will ultimately be incorporated into the WPDES permit for those areas impacted by the study (which does not include the City of Racine).

3.2 TMDL Background

A TMDL is defined by the WDNR, as “an analysis used to calculate a pollutant budget: sources of pollutants are identified and then reductions are given to various sources in order to meet water quality standards,” (source: WDNR Wisconsin Total Maximum Daily Loads). An alternative way of stating this is, “A TMDL is the amount of a pollutant a waterbody can receive and still meet water quality standard,” (source: WNDR, 2012 reference: http://dnr.wi.gov/topic/TMDLs/index.html). The Clean Water Act requires that the WDNR develop TMDLs for impaired waters. The first TMDL in Wisconsin was developed in 2000, and as of the date of this study, 30 TMDLs have been developed and approved in Wisconsin (source: http://dnr.wi.gov/topic/tmdls/tmdlreports.html). The development process is ongoing in several waterbodies. However, currently there is no schedule for the development of TMDLs for the Pike River, Root River, or any of their tributaries.

A TMDL fact sheet which was prepared by the WDNR with additional background and information on TMDLs is included in Appendix A.

3.2.1 TMDL Development Process

The development of a TMDL begins with a data collection period, during which, the waterbody is monitored to identify the current pollution loadings and water flow, along with other pertinent data. Using the monitoring data a computer model is used simulate the processes in the waterbody and determine the existing pollution loads and to calculate the load reductions needed to meet the water quality standards for the waterbody.

From this point the TMDL can be broken into allocations of pollutants that are assigned to pollutant generators. This process is often expressed as a formula:

TMDL = Wasteload Allocation (WLA) + Load Allocation (LA) + Margin of Safety (MOS)

The WLA is the total allowable pollutant load from point sources, such as waste-water treatment plants, industrial facilities, confined animals feeding operations, and MS4s. The LA is the total allowable pollutant load from non-point sources, such as agricultural runoff and non-regulated urban areas. A margin of safety is also included in the TMDL. Within the total WLA, individual contributors (such as the City of Racine MS4) are assigned a specific allocation.

As part of a TMDL a waterbody may also be broken into segments, or reaches. Each reach is assigned its own wasteload and load allocations.

3.2.2 TMDL Implementation

The implementation process begins following the development of a TMDL. There is some uncertainty surrounding the implementation of TMDLs. Watersheds, such as the Pike River and Root River, include a number of stakeholders that will be subject to a TMDL. These stakeholders include agricultural landowners, public point sources (MS4s and waste-water treatment plants), private point sources (such as a manufacturing facility), and Department of Transportation lands (highways). The implementation process and requirements for each stakeholder are uncertain at this time as the program is still evolving.

The WDNR is currently developing guidance documents for the implementation of TMDLs within MS4s. The document will provide general guidance for MS4s regarding steps to be taken for planning, implementing, and storm water pollution modeling related to TMDLs. Based on a review of the draft guidance document (included in Appendix A), the implementation of TMDLs will include the following requirements:

- The pollution reduction requirements included in a TMDL for the City of Racine MS4 will be incorporated into the City's WPDES permit.
- The first WPDES permit issued following the approval of a TMDL will include a requirement to prepare a storm water management plan for how the TMDL will be met. This report will form the starting point for such an analysis and will be modified as needed in the future. The storm water management plan will include a schedule for meeting TMDL requirements and a schedule of interim benchmarks.
- The schedule for meeting TMDL requirements will be flexible and it is anticipated that at least 15-years will be allowed for compliance with a TMDL. During this time continual progress towards meeting the TMDL is expected. The City will need to track this progress and provide periodic submittals to the WDNR, most likely through the current annual reporting process.

The ultimate goal of implementing a TMDL is to improve water quality so that the waterbody meets the applicable water quality standards. This is determined by on-going monitoring and assessment of the waterbody. If a TMDL is implemented and water quality standards are not met additional evaluation will be needed, and further pollutant reductions may be required.

4.0 Storm Water Pollution Analysis

4.1 Previous City-wide Analyses

The City of Racine began city-wide storm water management planning in 1995 through a series of phases. Phase I was a needs assessment that was completed in 1996. Phase II was a detailed storm water investigation that covered three areas of the City with Phase IIA, IIB, and IIC completed in 1997, 1999, and 2002 respectively. These phases were summarized in the Comprehensive Storm Water Management Plan in 2002 (AECOM, formerly Earth Tech). The planning process had a water quality emphasis but also identified some flood management needs. The recommendations identified non-structural and structural BMPs covering 23 sites. Virtually all of those sites had subsequent analysis to evaluate feasibility of implementation and many were constructed.

A follow-up memorandum dated October 2007 titled “Assessment of Compliance with s. NR 151.13(2)” (AECOM) provided a water quality update and status on the City’s compliance with the current storm water regulations which required TSS reductions of 20 percent and 40 percent by March 10, 2008 and March 10, 2013, respectively. The study evaluated both non-structural and structural BMPs using WinSLAMM v 8.4. Many of the sites identified in the previous plan were referred to by name and evaluated in the study as reported in the memorandum. The conclusion of the memorandum was that the City would be in compliance with the 20 percent reduction requirement.

In 2011, the City conducted another updated analysis to assess the current level of pollution control, and compliance with NR 151. The analysis was conducted in compliance with WDNR guidance for city-wide storm water pollution modeling using current approved models (WinSLAMM). The results of that study were summarized in a document titled, “City of Racine Updated WinSLAMM Assessment of Compliance”, (AECOM, September 2011). Analyzed using WinSLAMM v 9.4, the assessment indicated that the City has a baseline TSS load of 1,349 tons/year (TSS without BMPs). The TSS load under existing conditions (with BMPs) for the City is 1,072 tons/year. This level represents a reduction in baseline TSS load from existing BMPs of 277 tons/year, for a reduction of 20.5% from the baseline load, showing that the City met the 20 percent TSS requirement included in NR 151. Loading results include areas where the City has accepted base loads from Mount Pleasant under agreement with that municipality.

The 2011 analysis also calculated the total phosphorus load of 8,214 lbs/year in the baseline condition and 7,007 lbs/year when evaluating the effectiveness of BMPs, resulting in a 14.7% reduction from the baseline load.

4.2 TMDL Analysis

The purpose of this analysis is to provide guidance for the City of Racine in meeting future TMDL requirements. Previous analyses focused of reducing storm water pollution on a city-wide basis. In this analysis, the focus is on evaluating the pollution loads discharging to impaired waters in the Root and Pike Rivers.

To evaluate the potential impacts of future TMDLs, storm water pollution loads were calculated to each impaired waterbody that receives storm water runoff from the City of Racine. The majority of the analysis was consistent with the methodology of previous city-wide studies. Modifications to the methodology were made to follow WDNR guidance titled, "(Draft) TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance," and provided in Appendix A. Final guidance was not yet available as of the completion of this project.

The methodology utilized for this study represents the best practices for calculating storm water pollution loads from urban areas for compliance with TMDLs. Experience with TMDLs that are already developed demonstrates that differences (sometimes large) exist between city-wide storm water pollution analyses and the methodology which is utilized to create TMDLs. The implementation of TMDLs within the State of Wisconsin is in its early stages, and it is reasonable to expect that changes will occur in how TMDLs are developed and implemented in the future. These changes will need to be reviewed to determine how they differ from this analysis, and how they may impact the City of Racine.

4.2.1 Methodology

To analyze storm water pollution loads, the 2011 WinSLAMM model data (version 9.4) was used. Storm water pollution loads discharging to each impaired waterbody were calculated. Support files, such as standard land use files and parameter files, for the WinSLAMM model were consistent with previous city-wide analyses.

To provide input data for the WinSLAMM model the Geographic Information System (GIS) created as part of the 2011 City-wide Analysis was utilized. The GIS was reviewed and updated in order to allow the analysis to comply with the current draft WDNR guidance for modeling urban areas for TMDL compliance. The following modifications were made to the GIS.

1. Drainage Basins: The detailed drainage basin mapping within the City of Racine was reviewed and updated as appropriate. (Note that some changes were made to modify basins tributary to the Pike River and South Lake Michigan drainage basins during the course of this study which will be corrected in the City GIS mapping.) Previous studies were conducted on a city-wide basis. The drainage basins were updated to identify the whether they drain to an impaired water.
2. Excluded Areas: The following areas were excluded from the analysis:
    a. Agricultural lands,
    b. County Owned right of way,
    c. Riparian lands which drain directly to receiving waters and do not flow through the City MS4, and
    d. Permitted Industrial Facilities.

   The exclusion of these areas is consistent with WDNR TMDL modeling guidance. It is also similar to the areas which were excluded from previous studies. Based on the WNDR TMDL guidance riparian, agricultural, and permitted industrial land is optional for inclusion. There are reasons that they City may want to include or exclude any of these areas from future TMDL compliance modeling. These areas should be further reviewed during TMDL implementation.

Also included within the analysis is an area from the Village of Mount Pleasant which drains to the Stewart McBride Pond. As part of the implementation of this pond the City of Racine agreed to become responsible for the pollution loading in the area tributary to the pond. As part of the agreement the City is also able to benefit from the pollution control that the Stewart McBride Pond achieves. Other areas draining into the City from Mount Pleasant were included when analyzing future potential BMPs as they can impact the TSS reduction efficiency of the device and may present an opportunity for the City of Racine to enter into additional agreements with the Village.

Pollution loads were calculated for all areas tributary to impaired waterbodies within the City of Racine. The pollutants analyzed for the project were TSS and TP.

4.2.2 Results: Base Condition

To determine a starting point for compliance with a TMDL a "Base Condition" is calculated. In the development of other TMDLs, the base conditions have included the requirements of any current pollution reduction standards (i.e. the 20 percent TSS reduction required by NR 151). The Base Condition used in this study is similar to that of previous city-wide studies used to evaluate compliance with WPDES permit requirements. This base condition represents the pollution loading from the City without any BMPs implemented at the time of this study. This difference should be noted and any future TMDLs should be reviewed to gather a definition of the base condition and determine how it compares to this analysis.

The City's base loads calculated for this study to the impaired waterbodies are summarized in Table 4-1.

Table 4-1
Base Condition Results
City of Racine TMDL Analysis

Watershed	Total Area in City of Racine	Area Included in Analysis	Area Excluded from Analysis	Runoff Volume	Total Suspended Solids Load	Total Phosphorus Load
	(acres)	(acres)	(acres)	(acre-feet)	(tons/year)	(lbs/year)
Root River	4,397	3,812	585	2,710	542	3,463
North Branch of the Pike River	600	443	157	426	88	388
Pike River	229	217	12	131	26	191

4.2.3 Results: Existing Condition

Following the establishment of the base condition the City's existing BMPs were evaluated. Existing practices include street cleaning, swales (which are minimal in the City), and structural BMPs. Figure 4-1, Existing Best Management Practices, displays the existing structural BMPs included in the analysis, and the drainage areas to the BMPs. The evaluation of the existing BMPs utilized the treatment efficiencies that were calculated as part of the 2011 Study.

Table 4-2 includes a summary of the existing management condition compared to the base condition. Figure 4-2, Existing TSS Loadings, displays the existing conditions TSS loadings from the City of Racine within the study area. Appendix B includes tables with base and existing condition pollutant loading broken down by watershed.

Table 4-2 Existing Condition Results City of Racine TMDL Analysis						
Root River Watershed						
Scenario	Total Area	Area Included in Analysis	Area Excluded from Analysis	Runoff	Total Suspended Solids	Total Phosphorus
	(ac)	(ac)	(ac)	(ac-ft)	(tons/yr)	(lbs/yr)
Base Condition	4,397	3,812	585	2,710	542	3,463
Existing Condition				2,651	465	3,060
				Percent Reduction (%)	**14.4%**	**11.6%**
North Branch of the Pike River Watershed						
Scenario	Total Area	Area Included in Analysis	Area Excluded from Analysis	Runoff	Total Suspended Solids	Total Phosphorus
	(ac)	(ac)	(ac)	(ac-ft)	(tons/yr)	(lbs/yr)
Base Condition						
Racine	426	276	150	315	68	257
Mount Pleasant	173	167	6	111	20	131
Total	600	443	157	426	88	388
Existing Condition						
Racine	426	276	150	315	48	193
Mount Pleasant	173	167	6	110	5	57
Total	600	443	157	425	53	250
				Percent Reduction (%)	**40.0%**	**35.6%**
Pike River Watershed						
Scenario	Total Area	Area Included in Analysis	Area Excluded from Analysis	Runoff	Total Suspended Solids	Total Phosphorus
	(ac)	(ac)	(ac)	(ac-ft)	(tons/yr)	(lbs/yr)
Base Condition	229	217	12	131	26	191
Existing Condition				122	19	149
				Percent Reduction (%)	**28.6%**	**21.9%**

4.3 Comparison to TMDL Pollution Calculations

As part of a TMDL the City of Racine will receive pollution control requirements as a waste load allocation (WLA) for the areas of the City draining to impaired waterbodies. The WLA from a TMDL will differ from calculations in this report. The base and existing conditions pollutant loadings calculated for the Pike River and Root River watersheds in the City of Racine are based on detailed input data. A TMDL is calculated on a large-scale watershed basis. This process limits the detail that can be incorporated into the development of TMDLs. One example of this is that the urban pollution loadings calculated in previous TMDLs are based on a unit load, meaning that the same pollution load is applied to every acre of urban area within a TMDL. Also, watersheds delineations for TMDLs are based on large-scale data-sets. The watersheds delineated for TMDLs do not typically incorporate the detailed information about storm sewer networks and urban drainage patterns that are available to cities. The difference in the level of detail of the input data can result in significant differences of the watershed areas and pollutant loads calculated by TMDLs and those calculated by a city-wide storm water management plan, such as this analysis. This report and associated data will be provided to the WDNR for reference when developing TMDLs in the future in the hope of minimizing these differences.

Due to the differences in pollution loadings (the tons or pounds of a pollutant) calculated by TMDLs and detailed analyses conducted by cities the WDNR guidance suggests that a percent reduction approach is used to plan for, and meet TMDLs. The percent reduction approach means that the percent reduction in pollution required by a TMDL is set as the goal for compliance with a TMDL. This can then be compared to the percent reduction calculated from a detailed city-wide analysis.

Previous TMDLs in Wisconsin have required a range of pollution reductions from urban areas. The range in pollution reductions required by the Lower Fox River and the Rock River TMDLs are shown in Table 4-3. These TMDLs are approved and in the implementation process and include numerous urban areas. The pollution reduction requirements listed in Table 4-3 are only examples of what reductions are required in other areas of the state to show the variability. Future TMDLs for the Root River and Pike River will calculate specific pollutant reduction requirements for those waters. Based on the percent reductions required to meet TMDLs in other areas of the state it is reasonable to expect pollutant reductions in excess of current requirements (20 percent reduction in TSS) will be included in TMDLs. However, conclusions about what level of pollution reduction will be required by a Root River of Pike River TMDL should not be drawn from the TMDLs for other watersheds. This is due to the unique nature of each watershed.

Table 4-3
Example of Previous TMDL Pollution Reduction Requirements
City of Racine TMDL Analysis

TMDL	TSS Reduction Range	Phosphorus Reduction Range
Lower Fox River	28% - 65%	30% - 63%
Rock River	40% - 73%	27% - 87%

5.0 Urban BMP Analysis

A variety of best management practices (BMPs) are available that can reduce storm water runoff pollutants and improve water quality. The following section provides a brief discussion on some of the many various types of BMPs that could be implemented to assist in meeting future TMDL water quality requirements. The City of Racine is already implementing many of these BMPs and additional BMPs were analyzed as a part of this study. Pollutant removals and other characteristics associated with potential new BMPs are included in this section where applicable.

5.1 Street Cleaning (Sweeping)

Street sweeping is a widely recognized and practiced BMP, which the City of Racine currently conducts on a city-wide, weekly basis, with conventional, mechanical broom type sweepers. From the 2013 City of Racine Budget, 5 staff are allocated to the street sweeping program at 2/3 time or 3.3 full time employees (FTEs). This is considered a non-structural BMP because it does not involve the installation of a structural facility.

Street sweeping is highly visible and is useful as an informational and educational tool in promoting awareness of storm water pollution. The mechanical broom sweepers currently being utilized by the City of Racine effectively remove large particles (sand size or larger) and litter; however these types of sweepers remove very little of the fine particles (which contain most of the storm water pollutants) that must be removed to meet reduction goals in a TMDL. Other factors that impact the effectiveness of a street sweeping program include street dirt particle size and loading, street texture, moisture, parked car locations, frequency of schedule and equipment operating conditions. Other benefits of a street sweeping program including leaf removal, keeping inlets clear and general aesthetics easily justify maintaining a street sweeping schedule.

Street cleaners that employ a high efficiency vacuum system have been shown to be more effective at removing finer street dirt particles than traditional street sweepers. Various manufacturers claim sediment removal efficiencies of 30-50% and while the total tonnage of sweeping materials collected by municipal sweepers is significant, the portion attributed to TSS as defined by the Wisconsin Department of Natural Resources (WDNR) is only the smallest portion of the sediment particle distribution. Studies, analysis and modeling based on data collected by the WDNR and United States Geological Survey estimate a range of street sweeping TSS removal effectiveness for high efficiency street sweepers from less that 5% to greater than 20% depending on land use, parking density, and other factors. City-wide programs therefore logically land somewhere in between.

Two potential scenarios were considered for modifying the City’s current street sweeping program to a high efficiency model. Overall TSS and phosphorous reductions for the three basins of interest for both scenarios are shown on Table 5-1.

The first high efficiency street sweeping scenario investigated was converting the existing weekly street cleaning program to include the use of high efficiency street cleaners. Under this scenario, the increased TSS reductions from the change in sweepers ranged from 1.5% in the Pike River watershed to 8.2% for the Root River watershed. The difference in treatment efficiency is based on the amount of tributary area treated by other existing BMPs, such as the wet ponds. These other BMPs provide a higher level of treatment than street cleaning, and thus increased street cleaning does not provide significant storm water pollution reduction benefits. The Root River watershed has fewer structural BMPS, so the impact of high efficiency street cleaning is greater in this watershed.

Table 5-1
High Efficiency Street Cleaning Evaluation
City of Racine TMDL Analysis

Watershed	Added TSS Reduction (tons/yr)	Added % TSS Reduction	Added TP Reduction (lbs/yr)	Added % TP Reduction
Conversion to High Efficiency Street Cleaning (Once per Week) Added Pollution Reduction				
Root River	44	8.2%	186	5.4%
North Branch of the Pike River	2	3.4%	5	2.1%
Pike River	0.4	1.5%	2	1.0%
Conversion to Intensive Spring Street Cleaning Added Pollution Reduction				
Watershed	Added TSS Reduction (tons/yr)	Added % TSS Reduction	Added TP Reduction (lbs/yr)	Added % TP Reduction
Root River	22	4.1%	94	2.7%
North Branch of the Pike River	1	1.5%	2	0.9%
Pike River	0.2	0.8%	1	0.5%

*Once per Week in Spring, Once per Month Remainder of Year

The cost for a high efficiency program of this type is highly variable and not without impact. High efficiency street sweepers cost more than a conventional sweeper to purchase and the City would likely need to phase in this program over several years as new sweepers are purchased at an incrementally higher price than conventional sweepers. Additionally, high efficiency street sweepers must be operated at a slower speed (typically 3-6 mph) than conventional sweepers (typically 6-12 mph) requiring more sweepers than are currently running and additional labor to run them. Also, mechanical street sweepers function better at collecting and removing larger sediment and garbage. Experience has shown that municipalities still need to maintain at least one mechanical street sweeper in order perform street sweeping during times of heavy debris loads, such as after winter or a street festival. If a new high efficiency street sweeper averages $200,000 and a conventional sweeper is $100,000, the estimated increment on a street sweeper purchase is $100,000. If one assumes that the high efficiency sweeper runs at half the speed of the conventional sweepers, the labor force assigned to street cleaning would need to double as would the number of available sweepers.

If the City were to implement a high efficiency street sweeping program on a city-wide basis, adding or shifting 3.3 FTE staff assignments to this program would be required and cost $165,000 annually assuming a cost of $50,000 per FTE. Capital cost would be $1,500,000 total for 10 new sweepers (assuming 5 are replacements and only incur the incremental cost.) This is looking at the City as a whole as well, if increased sweeping was only implemented on specific watershed areas and not city-wide, the total cost would be reduced. Additional maintenance and disposal costs would also apply and are not currently estimated.

However, if we assume that the Pike and Root River watersheds consist of approximately 5,226 acres of the entire 10,162 acre City drainage area (just over 51% of the total area of the City) and that the sweeping efforts are evenly distributed throughout the City, the incremental cost can also be assumed to be roughly prorated to 50% of the cost. Assume an increase in staffing cost of $82,500 annually

(50% of $165,000) and $75,000 for equipment (50% of $1,500,000 annualized for a 10-year sweeper life) results in a total annual cost of $1,575,000 to remove approximately 46 tons annually results in a cost of $3,424 per ton of TSS removed. Caution should be taken when comparing this cost to the cost of other BMPs since this is an annualized cost and not directly comparable to the cost per ton of TSS which is typically provided as a one-time value. For instance, costs over a 10-year period will exceed $50,000 per ton of TSS removed annually not taking into account inflation and other annual costs such as disposal and materials. All BMPs must be normalized to a present worth value to be more directly comparable.

The second scenario investigated the conversion to an intensive spring street cleaning program. This program sweeps streets weekly in spring and once per month the rest of the year with high efficiency sweepers. Under this scenario, the City would sweep with conventional sweepers the other available weeks of the year to keep streets clean of debris for aesthetic and pollution control reason. As would be expected, the increase in TSS reduction is smaller under all scenarios dropping to only 0.8% in the Pike River and 4.1% in the Root River. Capital costs would be the same as that described previously because the sweepers need to be available for weekly city-wide sweeping in spring. Staff costs would be somewhat reduced as the intensive weekly high efficiency sweeping program is shorter than the annual sweeping effort. Again, total cost could be reduced by implementing on priority watersheds only and while they would be somewhat less than the previous scenario, the cost per ton would be higher because the same amount of equipment would be needed to carry out the most intensive periods of sweeping and is a significant cost component.

5.2 Catch Basins

A common basic structural BMP employed in urban areas is the installation and associated cleaning of catch basins. Catch basins are inlets or other similar devices with sumps extended below the elevation of the outlet pipe to trap and settle sediment. They are typically the first line of treatment after street sweeping, operating to partially remove sediment left over after street sweeping and in the event that it rains between street sweeping intervals. The majority of material captured by catch basins is coarse material that is larger than TSS. The analysis of catch basins in conjunction with street sweeping requires the use of a model capable of handling BMPs in series, such as WinSLAMM version 10. It may be beneficial in the future to analyze the impacts of street sweeping and catch basins in series. In order to conduct this analysis information regarding the number of catch basins, their size and depth, and the drainage area to catch basins is needed.

The City performs year round inspection of catch basins and cleans basin during the summer as needed. Because catch basins are relatively small compared to the overall drainage system, TSS removals are relatively low and generally capture the same general range of particles as street sweeping. Catch basin cleaning is not currently estimated in this report from a TSS reduction standpoint. The City tracks costs and estimates budget needs annually in the Storm Water Utility budget and rate setting process. Labor and equipment/vehicle costs are estimated at approximately $160,500 for 2014.

5.3 Wet Detention Ponds

Wet detention ponds are a commonly used best management practice for storm water control in urban areas. A wet detention pond consists of a permanent pool of water that receives water from the surrounding drainage basin. A typical wet detention pond has a permanent pool of water with a depth between three and seven feet in the permanent pool. Above the permanent pool is several feet of storage area that will hold water during and after storm events. An outlet structure is installed to control the outflow of water from the pond. While storm water is held in the pond, particles and pollutants are allowed to settle out of the water before it is discharged.

Wet detention ponds are a very effective BMP, especially for large drainage basins, with studies showing ponds can remove up to 80 percent or more of suspended solids on an average annual basis. Along with the sediment, other particulate pollutants, such as heavy metals and bacteria can be controlled. Another positive impact of wet detention ponds are that they can be an attractive community asset for wildlife and humans if designed properly. Potential negative impacts of wet detention ponds include the potential for downstream warming from thermal discharges, attraction of nuisance wildlife (such as geese), and the land requirements necessary for the implementation of the practice. In addition, there are also maintenance requirements associated with the pond such as lawn care, litter control, outlet structure clearing and the need to periodically remove the accumulated sediment.

The costs associated with the construction of a wet detention pond include land acquisition (if necessary), construction and maintenance costs. Construction costs include excavation of the pond basin, installation of a clay liner in some instances, restoration and landscaping costs. Maintenance costs include the annual cost to perform the maintenance items indicated previously, as well as the pro-rated amount for the occasional dredging (typically on a period of greater than 15 years) that is required. In general wet detention ponds are a cost effective treatment option, especially for larger (greater than 5 acre) watersheds.

The City of Racine currently relies on several wet detention ponds that were analyzed in this and past water quality studies, most of which are publically owned and maintained. These include Steward McBride, Reservoir, Pritchard, Foxwood, Mallard Shores, Mound Cemetery, Graceland Cemetery, Zoo, and St. Mary’s Hospital ponds and are shown geographically on Figure 4-2. The Stewart McBride and Mallard Shores ponds are in the Pike River watershed area. The Graceland Cemetery, Mound Cemetery, and St. Mary’s Hospital ponds are in the Root River watershed area. All others are in Lake Michigan drainage areas.

While wet detention ponds are an older form of water quality BMP, new advancements in this area, such as the addition of iron filings to facility the removal of phosphorous, continue to improve this reliable treatment practice.

An additional 13 wet detention ponds were considered in this study and evaluated for both their effectiveness and cost in helping the City of Racine meet future TMDL requirements. Some of these ponds are within the upstream drainage area of other potential new ponds presented for consideration and may not be necessary assuming the downstream facility was feasible and able to be sized to the degree that the upstream pond would not add significant additional water quality benefits. These potential new ponds are all tributary to the Root River and are shown on Figure 5-1, Potential Best Management Practices. The details of these ponds are described further in the following paragraphs and summarized in Table 5-2 which includes information on drainage areas (both inside and outside of the City limits), identifies if they are on publically available land or private property, potential land area available and needed permanent pool area at differing levels of estimated TSS control, TSS removal potential, and estimated construction and maintenance costs. The cost for ponds is also variable and impacted by many factors such as land acquisition (if needed) and storm sewer modifications. The cost per ton of TSS removed is less than $100,000 and ~$50,000 on average.

The analysis was based on planning level subbasin delineation, using the city’s topographic maps. The sites listed below were determined by looking at subbasins where annual pollutant loading rates

Table 5-2
Potential Wet Ponds
City of Racine TMDL Analysis

Site Name	Source Areas: Total Drainage Area (acres)	Source Areas: Area from City of Racine (acres)	Source Areas: Area from Outside City (acres)	BMP Location Information: Inside/Outside City of Racine	BMP Location Information: Public/Private Land	Estimated Pond Permanent Pool Area Sizing: Estimated Open Space Available (acres)	To Achieve 60% TSS Reduction (acres)	To Achieve 80% TSS Reduction (acres)	Net Pollution Removal - City Only [1]: Pond Pool Size Utilized [3] (acres)	TSS Removal Efficiency Achieved	TSS Removed (tons/year)	TP Removed[2] (lbs/year)	Costs: Construction Cost (Including Land)	Annual Maintenance Cost	Cost per Unit of TSS Control ($/ton)	Notes
Case Equipment	44.6	44.6	0.0	Inside	Private	1.4	0.3	0.9	0.7	74%	6.0	16	$358,000	$3,400	$60,000	Land Costs Associated with Site. Site is located on private property and would require coordination with landowner to acquire property and locate pond on the site.
Colonial Park	63.0	63.0	0.0	Inside	Public	1.8	0.2	0.7	0.7	80%	6.1	23	$213,000	$3,500	$35,000	Located in Colonial Park, need to be sensitive to floodplain location.
Country Club/Quarry	128.8	128.8	0.0	Outside	Private	1.5	0.6	1.9	0.8	63%	12.4	39	$240,000	$3,500	$19,000	Land Costs Associated with Site. Site is located on private property and would require coordination with landowner to acquire property and locate pond on the site.
Graceland Cemetary	593.0	282.3	310.8	Inside	Public	1.5	1.8	5.1	0.8	41%	2.1	3	$201,000	$3,500	$95,000	Located upstream of Spring Street & downstream of Lockwood Park sites. Limited space available to expand existing pond due to surrounding cemetary. Cost per ton can be lowered if including Mt. Pleasant treatment.
Hantschel Park	69.6	42.2	27.4	Inside	Public	5.4	0.2	0.7	0.7	80%	4.2	17	$105,000	$3,400	$25,000	Located upstream of Washington Park site, Project would retrofit existing dry pond to convert to wet pond
Humble Park	142.3	142.3	0.0	Inside	Public	3.0	0.6	2.3	1.5	71%	14.2	47	$560,000	$5,700	$40,000	Located upstream of Washington Park site. Adjacent storm sewer is >15 ft deep.
Lockwood Park West	435.7	223.7	212.0	Inside	Public	10.0	1.6	4.5	4.5	80%	12.6	46	$645,000	$14,700	$51,000	Project would retrofit existing dry pond to convert to wet pond. Possible contaminated soil at site - costs for any environmental remediation not included.
Lockwood Park North	572.8	270.0	302.9	Inside	Public	3.0	1.8	5.0	1.5	51%	5.5	13	$404,000	$5,700	$73,000	Located upstream of Spring Street & Graceland Cemetary sites
Lockwood Park South	137.2	46.3	90.9	Inside	Public	1.8	0.1	0.4	0.4	80%	2.8	10	$230,000	$5,700	$83,000	Located upstream of Spring Street & Graceland Cemetary sites
Memorial Dr Brownfield	97.4	97.4	0.0	Inside	Public	9.6	0.5	1.6	1.6	80%	13.2	39	$568,000	$6,200	$43,000	Site owned by RDA. RDA is currently working on remediation plan for site. Long-term plan calls for industrial redevelopment at site. Potential to integrate storm water BMP into new site.
Michigan Blvd Brownfield	159.7	159.7	0.0	Inside	Public	5.5	0.6	2.1	2.1	80%	18.2	67	$553,000	$7,500	$30,000	City owns the site. Site has high value for redevelopment. Potential to combine with private BMPs which would be needed at site. Adjacent sanitary sewer needs to be reviewed for potential conflicts.
Spring Street	836.9	513.0	323.9	Inside	Public	1.7	2.6	7.3	0.9	20%	3.0	14	$202,000	$3,800	$68,000	Potential willing seller on adjacent private property may expand available area. Located downstream of Graceland Cemetary and Lockwood Park site.
Starbuck Jr High School	190.7	119.4	71.4	Inside	Public	7.0	0.9	2.8	2.8	80%	15.2	49	$1,220,000	$9,700	$80,000	Located upstream of Washington Park site - Land Costs Associated with Site [4.] Site currently owned by school district.
Washington Park	1397.8	1294.8	103.0	Inside	Public	3.0	5.1	16.6	1.5	18%	15.5	56	$365,000	$5,700	$24,000	Located downstream of Starbuck Jr High School, Hantschel Park, & Humble Park sites

[1]Areas are currently treated with BMPs (street cleaning, swales, etc). Load represents the additional pollution control from potential BMP.
[2]Estimated total phosphorus removal to be 40% less than TSS removal rate
3 Pond size is either size required for 80% removal efficiency or maximum available open space, whichever is greater

were the highest, and were land may potentially be available. No discussions have been held with landowners or others who have a stake in the use of the proposed locations about the use of the property for a wet detention pond. Therefore the potential locations listed below should be considered purely conceptual.

Case Equipment

The proposed wet detention pond BMP could be located on the Case equipment property serves a 44.6 acre developed watershed. The drainage basin is located primarily west of the site along State Street (Highway 38), and the drainage basin does not contain any other wet pond BMPs. The proposed wet pond would have a surface area of approximately 0.9 acres, and would utilize available open space on the north side of the property. Due to the location of the Case equipment property on a bend in the Root River, stormwater overflow from the pond would discharge directly into the Root River. This pond would be located on private land, owned by the Case Equipment Corporation.

Colonial Park

A wet detention pond BMP could be situated in Colonial Park on the west-central side of the City of Racine. The pond can capture water from the existing storm sewer which drains a 63 acre primarily residential watershed located to the east of the park. The ideal wet pond surface area to provide maximum pollution reduction and flood control is 0.7 acres, out of the 1.8 acres available in the park. The pond would be located adjacent to West High Street in an area that is currently wooded. This location offers the benefits of being adjacent to the existing storm sewer under High Street and being able to easily discharge to the Root River.

Country Club/Quarry

Country Club/Quarry wet detention pond would be located just outside the City of Racine limits between the Racine Country Club and Quarry Lake Park on the northwest side. The pond would serve a 128 acre watershed which currently drains through the Country Club to the River untreated. By treating this developed watershed prior to discharging into the river it would improve the storm water quality discharge. The available open space between the parking lot for the lake and golf course is approximately 1.5 acres, and the pond would ideally utilize as much of that open space as possible. This proposed pond would be at least partially on private land, owned by the Racine Country Club.

Graceland Cemetery

An expansion is proposed for the Graceland Cemetery pond located on the west side of Racine to improve water quality on the 593 acre watershed. The existing wet pond in the cemetery is significantly in need of dredging and expanding the pond at the same time would increase the cost effectiveness of the project. This pond is located downstream of a very large watershed with an existing dry detention area in Lockwood Park that is proposed for additional potential wet ponds. The cemetery is publicly owned, but there are numerous challenges anticipated with this site include the difficulties associated with working in a cemetery, as well as the general lack of open space and would require significant stakeholder participation as would most of the BMPs discussed in this section. To achieve maximum water quality benefits the pond would have to be expanded to a wet pool area of 5.1 acres. Given that there is only 1.5 acres of available open space within the confines of the path system in the area, this pond would need to be supported by other potential nearby detention (Lockwood Park North and Lockwood Park South) to achieve higher water quality (ideally approaching 80 percent TSS reduction). Overflow from the proposed pond would be discharged back into the storm sewer to continue downstream towards the Root River.

Lockwood Park North

The proposed wet detention pond in Lockwood Park would be located just upstream of the existing pond in Graceland Cemetery, and just downstream of the existing Lockwood Park dry detention area. The pond is located in the same general watershed as Graceland cemetery, and would be located on undeveloped land on the north side of Lockwood Park. There is approximately 3 acres of available space along the north side of Lockwood Park, and ideally all 3 acres would be utilized for stormwater management. The existing storm sewer would have to be rerouted to reach the pond area, and the overflow would discharge back into the storm sewer and continue downstream to Graceland Cemetery.

Lockwood Park South

The proposed wet detention pond in the south portion of Lockwood Park would act in conjunction with the proposed and existing Lockwood and Graceland Cemetery ponds. The south pond would serve a 137 acre watershed, which is a sub-watershed of the larger watershed served by Lockwood north and Graceland Cemetery. The pond would be located between the existing tennis courts and Graceland Blvd., and would utilize 0.4 acre of the 1.8 acres of available open space for maximum water quality benefits. The existing storm sewer would have to be rerouted slightly to reach the pond area, and the overflow would discharge back into the storm sewer.

Lockwood Park West

Conversion of the existing dry detention facility to a wet detention pond should be considered. The past history of the park as a fill site and any restrictions to utilizing the park area as a wet detention pond must be explored. The combination of facilities in this area must be explored further through a future planning and preliminary engineering effort to fully evaluate the opportunity to implement each facility and the combined impact and operation of the group of facilities.

Hantschel Park

A proposed wet pond could be located in Hantschel Park to serve a 69.6 acre developed watershed on the far southwest side of the City of Racine. The proposed location of the pond is at the northwest corner of the park, which is an undeveloped depression/dry detention area adjacent to the existing storm sewer system. There is 5.4 acres of available open space, and ideally the pond would have a permanent pool area of 0.7 acres. The construction of a wet pond at this location would likely be relatively straightforward, but it also serves a small watershed area which minimizes its overall benefit. Overflow from the proposed pond would be discharged back into the storm sewer.

Humble Park

A wet detention pond BMP is proposed to be constructed in Humble Park on the south side of the City of Racine. The pond would be part of a 142 acre primarily residential watershed that does not contain any existing wet ponds. The ideal wet pond surface area to provide maximum pollution reduction and flood control is 2.3 acres, based on the drainage area. There is approximately 3 acres of available open space in the northwest corner of the park, which would also provide easy access to the existing storm sewer system. Overflow from the proposed pond would be discharged back into the storm sewer.

Memorial Drive Brownfield

There is a wet pond proposed for the Memorial Drive brownfield site, also known as the former Racine Steel Casting site. This land is currently owned by and being remediated by the City of Racine, with the intent being to turn it over to a developer at some point in the future. There are a number of benefits to developing a wet pond at this location. As the land is currently undeveloped, the pond could be sited and sized to provide maximum water quality benefit while also maximizing open space for future development and making connections to the storm sewer system as easy as possible. The pond could be designed to provide water quality benefits not only to the 97 acre watershed, but also to the redevelopment site itself. This would make it more attractive for future developers to not have to do additional stormwater management on site. Ideally the pond would have a surface area of 1.6 acres for maximum water quality benefits but this would need to be reviewed and evaluated with the redevelopment authority to create a site that has high redevelopment appeal.

Michigan Boulevard Brownfield

A wet detention pond BMP is also proposed for consideration on an old brownfield site at Michigan Boulevard, also known as the former Walker Manufacturing site. The rationale for putting a wet pond on this site is very similar to reasons behind the Memorial Drive brownfield site. The land is currently owned and remediated by the City of Racine, and there are a number of long term benefits to locating a pond on the site. The Michigan Blvd site would ideally have a surface area of 2.1 acres for maximum water quality benefits, and serves a 160 acre urban watershed in the City of Racine.

Spring Street

The proposed Spring Street wet pond is located between Spring Street and the Root River on the west side of the City of Racine. The parcel is land owned by the City of Racine, and has an area of approximately 1.7 acres, which ideally would all be utilized to provide maximum water quality benefits for the 837 acre watershed. There is an existing storm sewer outfall located just upstream of the property, so the storm sewer routing would have to be modified slightly to reach the proposed pond, and the overflow would discharge directly into the Root River. Floodplain impacts would need to be evaluated. Expansion to nearby lots if owners were willing to be purchased would increase the effectiveness of a BMP in this location.

Starbuck Junior High School

A wet detention pond BMP is proposed to be located at Starbuck Junior High School on the southwest side of the City of Racine. The proposed pond would ideally utilize 2.8 acres out of 7 acres of available open space, and would be located on the northeast side of the property, just north of the existing parking lot and south of Wright Ave. The pond would serve a 191 acre watershed located primarily to the southwest of the pond. The storm sewer cuts across the school property, and would require slight modification to reach the proposed pond area. While the school property is publicly owned, locating wet detention ponds on school property can be a sensitive issue and negotiations would need to occur with the school board to get permission to locate a pond on the property.

Washington Park

The proposed wet detention pond in Washington Park would serve the 1,398 acre watershed and be located in a triangular shaped piece of land between 12th Street, Horlick Park Drive and the Root River. The available land in this triangle is approximately 3 acres and would need to be incorporated into the existing golf course. The available land is much less than would be needed to treat this very large watershed at the desired level but it does provide an opportunity to treat the basin to some level. Currently three storm sewer outfalls are located in the proposed pond area, so the existing sewer would be modified to discharge to the pond and then into the Root River.

5.4 Bioretention

Bioretention basins consist of open depressions with a layer of engineered soil media and vegetation along the bottom designed to promote filtration of pollutants and infiltration of storm water into the native soil. Bioretention basins are usually designed to store runoff for no more than 24 hours after a storm event, and are not designed to have a permanent pond. Bioretention basins can be highly effective in pollutant removal, and help mitigate the thermal effects of storm water discharges. Approximately 80 percent of TSS is typically removed from runoff that travels through the engineered soil media of a bioretention area assuming it has the required hydraulic capacity needed. In addition to pollution removal, they are used to promote infiltration into the groundwater and control the peak flow runoff rates from storm events.

The City installed a bioretention basin at the Southside Industrial Park during the redevelopment of that site to serve future industrial development. A similar device (using sand instead of an engineered media) is in place in the City associated with the English Street outfall. Monitoring of this facility by the City of Racine health department in conjunction with the beach near shore water sampling has demonstrated this facility to have a very positive impact on water quality. Smaller scale rain gardens and inlet filters were installed on the 6th Street reconstruction project. Additionally, the City has designed a bioretention facility at the boat launch for that reconstruction project.

Bioretention is generally most effective with smaller tributary areas, of 2 acres or less (although the English Street facility serves a significantly larger area). Bioretention can also be fairly maintenance intensive, requiring constant care to keep the vegetation healthy and prevent clogging of the filter media, particularly in high profile areas. They also have a limited lifespan, as the filter media needs to be replaced if it becomes clogged. Bioretention performs best with pretreatment before the storm water enters the infiltration area to prevent clogging. While infiltration of runoff is generally considered a positive outcome, it could raise the groundwater table, which presents potential problems in areas with a high water table. Care must also be taken when locating this BMP so that groundwater contamination does not occur or in areas with contaminated soils. In these scenarios a liner can be included to mitigate potential impacts.

Table 5-3 provides estimates for the pollution control abilities and costs of some example bioretention scenarios. The City is currently considering adding bioretention along Pershing Drive. Retrofitting greenspace and drainage along roadways, especially in park or other areas with larger terrace or adjoining lands can provide can be ideal locations.

The cost of bioretention basins typically is higher than that of other control practices such as wet detention. Examples have shown that the cost per ton of pollution removed for a bioretention basin can be almost twice that of a wet detention pond. While bioretention is highly effective for small sites, the fact that it is not as effective on larger sites means that more bioretention basins are required. To provide a significant level of pollution control towards meeting a TMDL a large number of bioretention basins would need to be created. Bioretention can be used to target parking lots, which generate a high rate of pollution. Because parking lots are highly visible locations, these bioretention facilities can also serve as a public education tool.

Table 5-3
Bioretention Treatment Cost Example
City of Racine TMDL Analysis

					Industrial Parking Lot		Other Parking Lots	
					TSS Load = (tns/ac/yr)	0.6	TSS Load = (tns/ac/yr)	0.3
	Size (sq ft)	Estimated Cost [1]	TSS Removal Rate	TP Removal Rate	TSS Removed (tns/ac/yr)	Cost / ton Removed	TSS Removed (tns/ac/yr)	Cost / ton Removed
Biofilter	350	$ 7,000	50%	46%	0.3	$ 24,100	0.2	$ 46,700
	1250	$ 17,000	80%	70%	0.5	$ 36,600	0.2	$ 70,800

Biofilter Specifications:
Engineered Soil Depth = 3 ft
Rock Storage Layer Depth = 1 ft
Standpipe Outlet 0.75 ft above Top of Soil
Assumed 80% TSS Removal by Engineered Soil
Assumed 0.13 in/hr Native Soil Infiltration Rate
Assumed 3.94 in/hr Engineered Soil Infiltration Rate

5.5 Underground Detention

Underground detention consists of large underground storage chambers, typically made out of precast or cast-in-place concrete, but sometimes also plastic or corrugated metal. Underground detention systems can be designed for peak flow control, sediment and pollution removal or both depending on the design of the system. The biggest advantage of underground detention is that it preserves land space on sites with high land values or where there is no land available for wet detention ponds, bioretention or other traditional storm water BMPs. As they are underground and therefore not visible, they also don’t present some of the maintenance drawbacks of above ground BMPs such as nuisance birds and landscaping. Maintenance is similar to catch basin maintenance, with regular vacuuming required to remove accumulated sediment.

Underground detention has a high initial cost because of the materials required for underground detention chambers and the equipment needed for installation. The high initial cost can be offset by the ability to fully utilize the available land on a site, and not having to pay additional land acquisition costs. Long term maintenance can also be a concern. Concrete and plastic have the highest initial cost, but they are also the most durable when compared to corrugated metal, which has a lower initial cost but a limited life span requiring replacement at some point due to corrosion concerns. Being underground also doesn’t allow the public to see the BMP, which limits its educational and general informative value to the community about storm water management.

Underground detention may only be needed or cost-effective on a limited number of highly developed sites. Where land is either expensive or unavailable it may be the best BMP for meeting storm water management goals. The City of Racine currently has underground detention at a few locations including Young Industrial Park near Battan Field, Mound Avenue which has two vaults and were partially funded by a WDNR grant, and Washington Avenue at 8th Street (two vaults) and College south of Washington Avenue which were partially funded by Wisconsin Department of Transportation when the roadway was reconstructed. The Young Industrial Park chamber has a significant storage area upstream of the device to detain and store flow prior to flowing through the device which aids in overall treatment levels. Experience with these devices in Racine shows a considerably higher cost per ton of TSS (and other pollutants) removed compared to wet detention ponds, as would be expected. For example, the Mound Avenue facilities cost approximately $125,000 per ton of TSS for the drainage area. Costs for underground detention can be highly variable based on soil, groundwater, and other site conditions.

There were no sites specifically evaluated for underground detention as part of this analysis. It would be possible to install underground detention in place of wet ponds at the sites identified in section 5.3, or other sites. Analysis of sites for underground detention was not conducted due to the high costs involved, and the presence of other, most cost-effective, BMPs. This type of BMP may need to be considered further if available open land areas and other more cost effective BMPs do not provide the level of pollution reductions required.

5.6 Hydrodynamic Separators Devices (HSDs)

Hydrodynamic separator devices are commercially manufactured in-line storm water treatment devices. They are generally a storm sewer manhole with a sump, along with internal features such as baffles to increase sediment removal. The general concept of these devices is to separate oil from the storm water and to trap as much sediment as possible within a subsurface chamber. The particulate form of pollution is removed through one or more of the following processes: 1) density separation (settling or centrifugal force); 2) filtration through a media; or 3) adsorption to a media. These devices are installed along the storm sewer pipe network below ground and in general do not protrude above the ground elevation. At least one, and sometimes several, manholes are required for routine maintenance access to clean out the sediment and oil/trash separation chambers. The general theory behind these units is that they treat the typical water quality component of a storm event often referred to as the “first flush”, or often defined as the first ½” of runoff across the entire contributing area. They typically have a flow bypass for larger storm events.

Potential concerns with the use of HSDs include device limitations, cost and maintenance. Concerns with device limitations include: 1) in larger storm events how much of the trapped materials is re-suspended and transported out of the unit, and 2) how well do these units perform their function under higher peak runoff flow rates? In general these devices are only effective at removing large particles during small rainfall events. Cost is also a concern, with these devices costing a minimum of $8,000, for the smallest units and higher for larger units. They also need to be cleaned on a regular basis to insure they function properly, and require a more frequent maintenance schedule than catch basins alone.

These products are potentially appropriate for certain densely developed areas within Racine since they do not take up land space and they provide some level of storm water treatment prior to the outlet. Example product brand names include Stormceptor, which is a cylindrical device with an upper and lower chamber, and Vortechnics, which is a rectangular structure with separate chambers for oil and grit removal. The City investigated these types of devices in the “Space-Limited BMP Device

Study" (AECOM, 2003). The study evaluated vendor specific data from eight manufacturers as provided in response to a request for information. Conclusions and recommendations were made regarding types of devices. Specific potential areas for implementation were in the State Street and Main Street focus areas as well as broader potential applications city-wide.

The City has several of these types of devices installed as shown previously on Figure 4-1. The Maiden Lane and Racine Street devices are tributary to the Root River and the Oakes Road stormceptors are tributary to the Pike River. The rest of the devices in the City are tributary to Lake Michigan directly. The Maiden Lane device has a large dry detention area associated with it to detain and slow flows to the device to reduce flooding in the area and increase the level of treatment. The largest of these devices is associated with the English Street Outfall BMP. Two custom designed Vortechnics units pretreat storm sewer discharges from a large watershed area prior to additional infiltration in the multi-celled device.

5.7 Future Redevelopment

Within the city, the potential for redevelopment projects to occur exists. These sites will be required to achieve a 40 percent (or greater) TSS load reduction under the city's Post-Construction Storm Water Management Ordinance and/or NR 151 when construction takes place. The BMPs constructed for these sites may be included as management measures towards meeting the city's pollution reduction goals. At this time, an estimate has not been made to quantify the amount of TSS reduction from redevelopment. When redevelopment occurs, the Storm water Management Plan should be reviewed to determine the level of TSS reduction, and the impacts of the redevelopment should be included in the city's annual report to the WDNR.

6.0 Alternative Management Measures for TMDL Compliance

In addition to traditional storm water BMPs, the City of Racine may be able (or need) to utilize alternative management measures to comply with TMDLs. These alternative management measures are water quality trading and adaptive management. Experience with alternative management measures state-wide is still somewhat limited. As other TMDLs are finalized and implemented, water quality trading and adaptive management may be used more extensively and Racine may be able to incorporate the lessons learned into their implementation plan.

When a TMDL is developed and established for a waterbody which the City of Racine discharges to, current information and guidance for these programs should be reviewed.

6.1 Water Quality Trading

Water quality trading involves pollutant credit trading to meet permit requirements above the “credit threshold” as defined in WDNR guidance documents. The credit threshold is equal to the treatment level of statewide performance standards (currently a 20 percent reduction of TSS from urban areas). Any permitted entity can use water quality trading to demonstrate compliance with TMDLs, or “fill the gap” between the statewide performance standard and the TMDL standard. Trading can occur between two or more point sources, between point and nonpoint sources, or between two or more nonpoint sources. For example this may mean between the City of Racine MS4 and a wastewater treatment plant (WWTP) or an agricultural landowner.

A pollutant credit generator can trade with other dischargers within the drainage area for the impaired segment of a waterbody that resulted in the pollutant allocation being assigned. Trades can occur both upstream and downstream of the generator’s discharge point, though it is most beneficial to trade with sources within the same 12 digit Hydrologic Unit Code (HUC 12). The HUC 12 area for Racine is shown on Figure 6-1 and this is the area with the best chance to find favorable pollutant trading ratios. In order to implement water quality trading a trade ratio is required. The trade ratio includes several factors relating to the generation, transport, and removal of pollution. The trade ratio can vary based on these factors but can never be less than 1.2:1 for trades with non-point pollution sources and 1.1:1 for trades with point sources. Costs for purchasing trading credits are unknown at this time. The costs will vary based on the cost of implementing projects and market demands. In addition there will be administrative issues which must be addressed during the implementation. This includes determining the trade ratios, ensure implementation, and tracking the impact of the pollutant reduction on the City’s compliance with reaching a TMDL goal.

Under water quality trading, the City of Racine could secure load reductions to meet all or part of their permit requirements assuming the proper procedures are followed as described in the WDNR’s “Water Quality Trading How-To Manual” (draft March 3, 2013) and “Guidance for Implementing Water Quality Trading in WPDES Permits” (draft March 25, 2013).

6.2 Adaptive Management

While water quality trading is focused on meeting a discharge limit, adaptive management is focused on compliance with in-stream criteria. Adaptive management is only available under provisions of NR 217, and thus a wastewater treatment plant must be the lead agency. Under adaptive management, permit compliance is demonstrated by reducing in-stream pollutant levels and meeting the water quality criteria. In-stream water quality monitoring is required to show compliance. Adaptive management allows a wastewater treatment plant to initiate an adaptive management program and cooperate with other entities (MS4s, agricultural landowners, other point sources, etc) to meet the applicable water quality standards for a waterbody.

The WDNR recommends that management measures for adaptive management occur upstream of the wastewater treatment plant which initiates adaptive management. The point of compliance could be downstream of the WWTP if an adaptive management program is initiated by an NR 217 permit holder downstream of the WWTP and the City decides to join into that program. The City of Racine wastewater treatment plant discharges directly to Lake Michigan, and thus would not be eligible to initiate an adaptive management program for either the Root River or the Pike River.

Adaptive management and water quality trading are separate approaches although there are some overlapping features. The WDNR prepared a table, shown as Table 6-1, to compare the programs. Either program can be used to meet a TMDL requirement. Additional guidance is available from the WDNR in, “Adaptive Management Technical Handbook,” (January 7, 2013).

Table 6-1
Adaptive Management vs. Water Quality Trading
City of Racine TMDL Analysis

	Adaptive Management	**Trading**
Pollutants Covered	TP (and possibly TSS)	All pollutants excepts BCCs
End Goals	Attaining the water quality criteria	Offsetting the limit
Offsets	No trade ratios	Trade ratios apply
Timing	Implemented throughout the permit term	Generating credits before they can be used
In-Stream Monitoring	Required	Not required
Level of Documentation Needed	General watershed information	Field-by-field documentation

Source: WDNR

6.3 Streambank Stabilization

The WDNR has identified streambank stabilization as a potential BMP for achieving TMDL requirements. There is limited guidance on how streambank stabilization projects will be credited towards meeting pollutant allocations and what methods for analyzing streambank projects will be approved. It is believed that a process similar to the following will be used. The “base condition” erosion and pollution loads generated from an existing streambank stabilization site will be calculated. Then the “post-project condition” erosion and pollution loads will be calculated. The difference will be the pollution reduction that occurs. It is unknown whether a credit ratio (similar to a trade ratio in water quality trading) will be applied for streambank projects when compared to other urban BMPs. It is also uncertain how the sediment eroded from streambanks will be correlated to TSS. Because the City has been proactive and interested at pursuing streambank stabilization projects, this may be a way to recognize those efforts in respect to their impact on overall water quality.

7.0 Conclusion

The City of Racine is in compliance with the current storm water discharge permit and annually identifies projects throughout the City to improve storm water quality discharges. Efforts range from studies and analyses to assess the current state of water quality management, identification and submittal of grant applications, streambank stabilization, construction of various water quality best management practices (BMPs), and routine maintenance activities.

The future of water quality for the City of Racine will ultimately include compliance with total maximum daily load (TMDLs) limits as other areas in Wisconsin and around the United States are required to do based on the Environmental Protection Agency's directive for addressing impaired waterbodies, such as the Root River and Pike River. While TMDLs do not directly impact the City at this time, it is recommended that the City continue its track record of improving storm water quality on a city-wide basis but with a focus on the Root and Pike River watersheds.

Several potential BMPs were identified in this study that can provide incremental positive steps towards reducing TSS and other identified pollutants. Next steps for the City include identifying grants and prioritizing project opportunities. The City should continue to set aside funding in the storm water utility budget for preliminary engineering efforts, grant submittals, and implementation of projects in areas/situations that are beneficial from a need and financial situation.

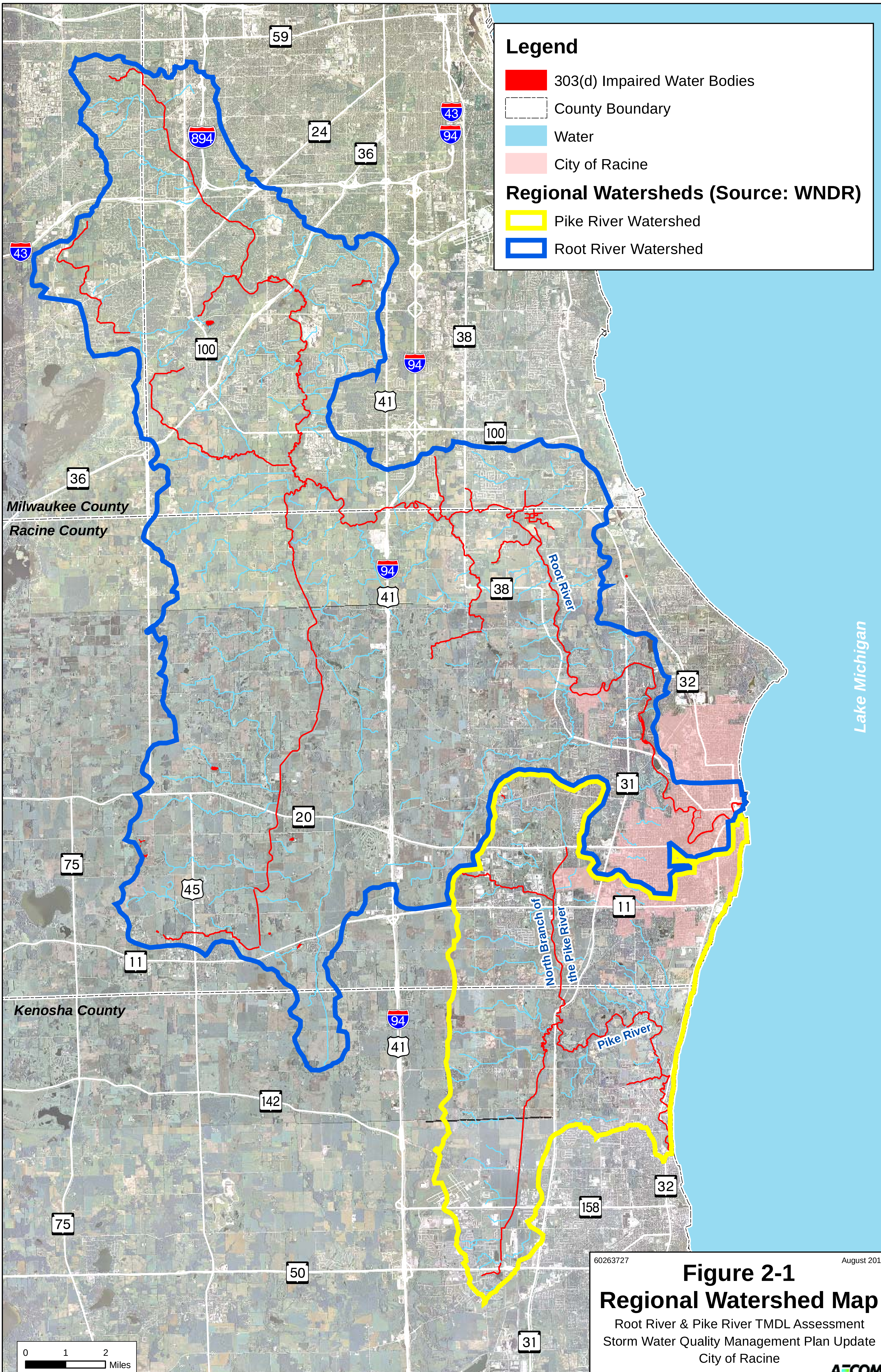

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Figure 2-1
Regional Watershed Map
Root River & Pike River TMDL Assessment
Storm Water Quality Management Plan Update
City of Racine

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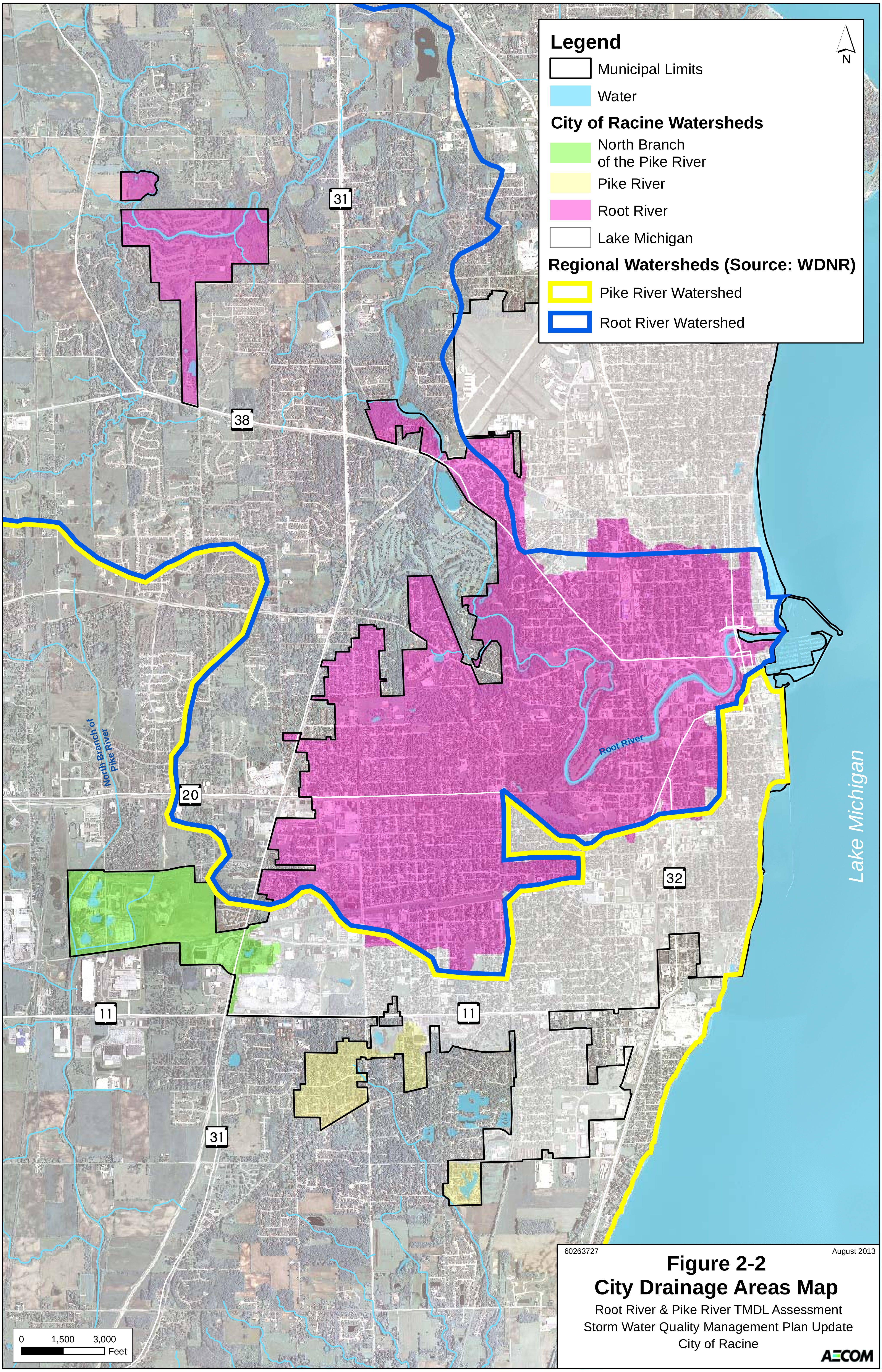

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Figure 2-2
City Drainage Areas Map

Root River & Pike River TMDL Assessment
Storm Water Quality Management Plan Update
City of Racine

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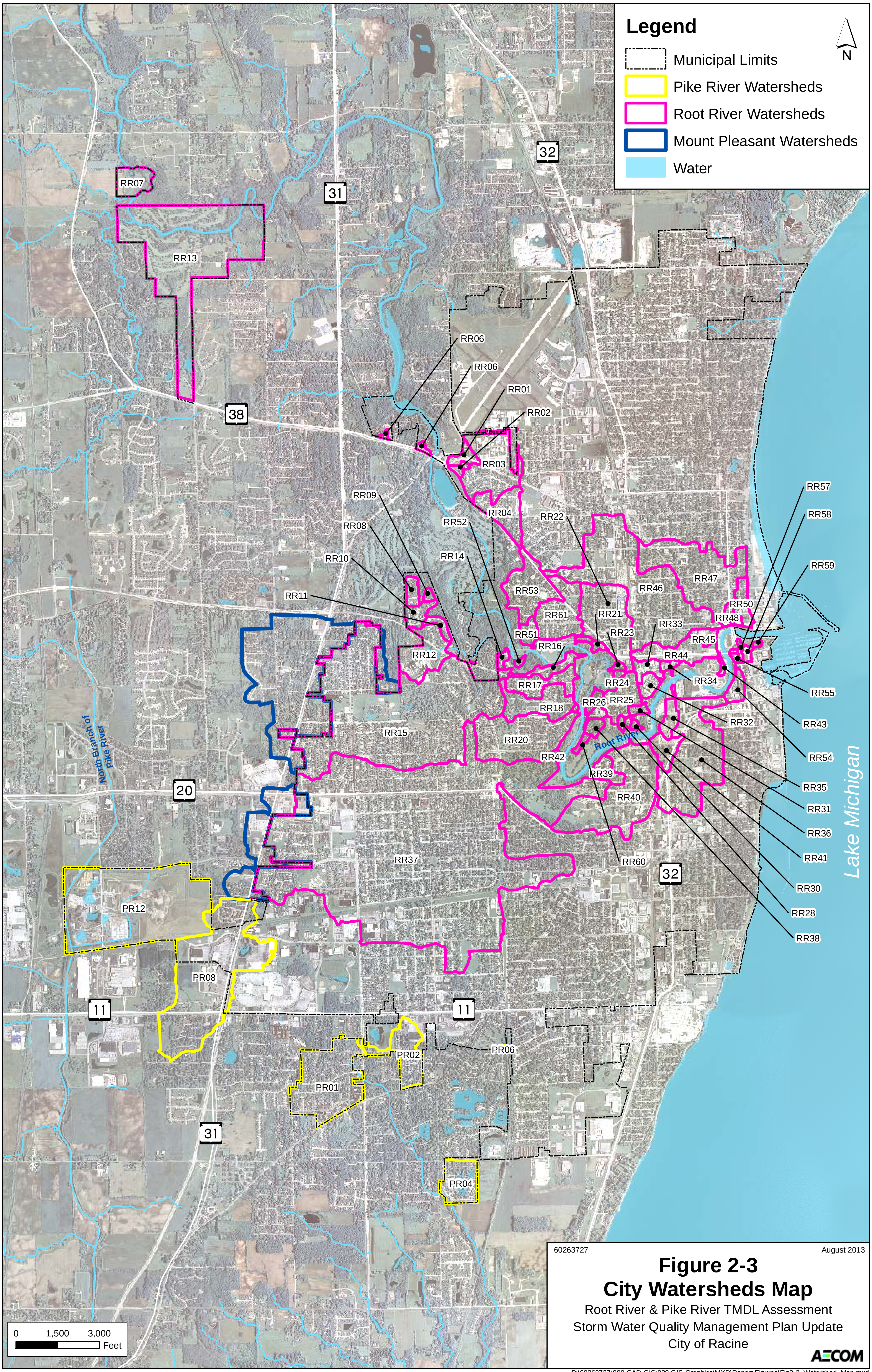

Figure 2-3
City Watersheds Map
Root River & Pike River TMDL Assessment
Storm Water Quality Management Plan Update
City of Racine

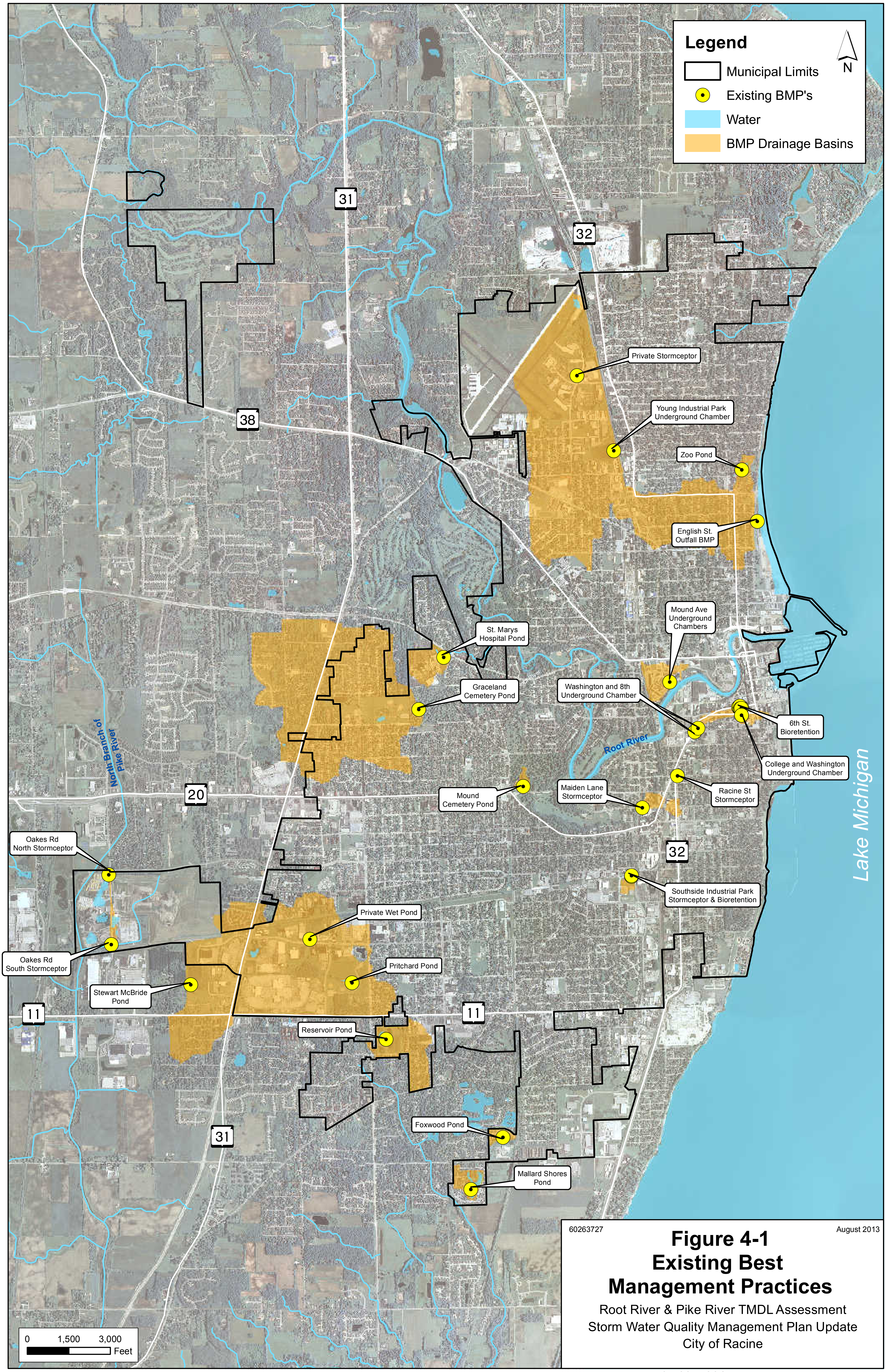

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Figure 4-1 Existing Best Management Practices

Root River & Pike River TMDL Assessment
Storm Water Quality Management Plan Update
City of Racine

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Figure 4-2
Existing TSS Loadings

Root River & Pike River TMDL Assessment
Storm Water Quality Management Plan Update
City of Racine

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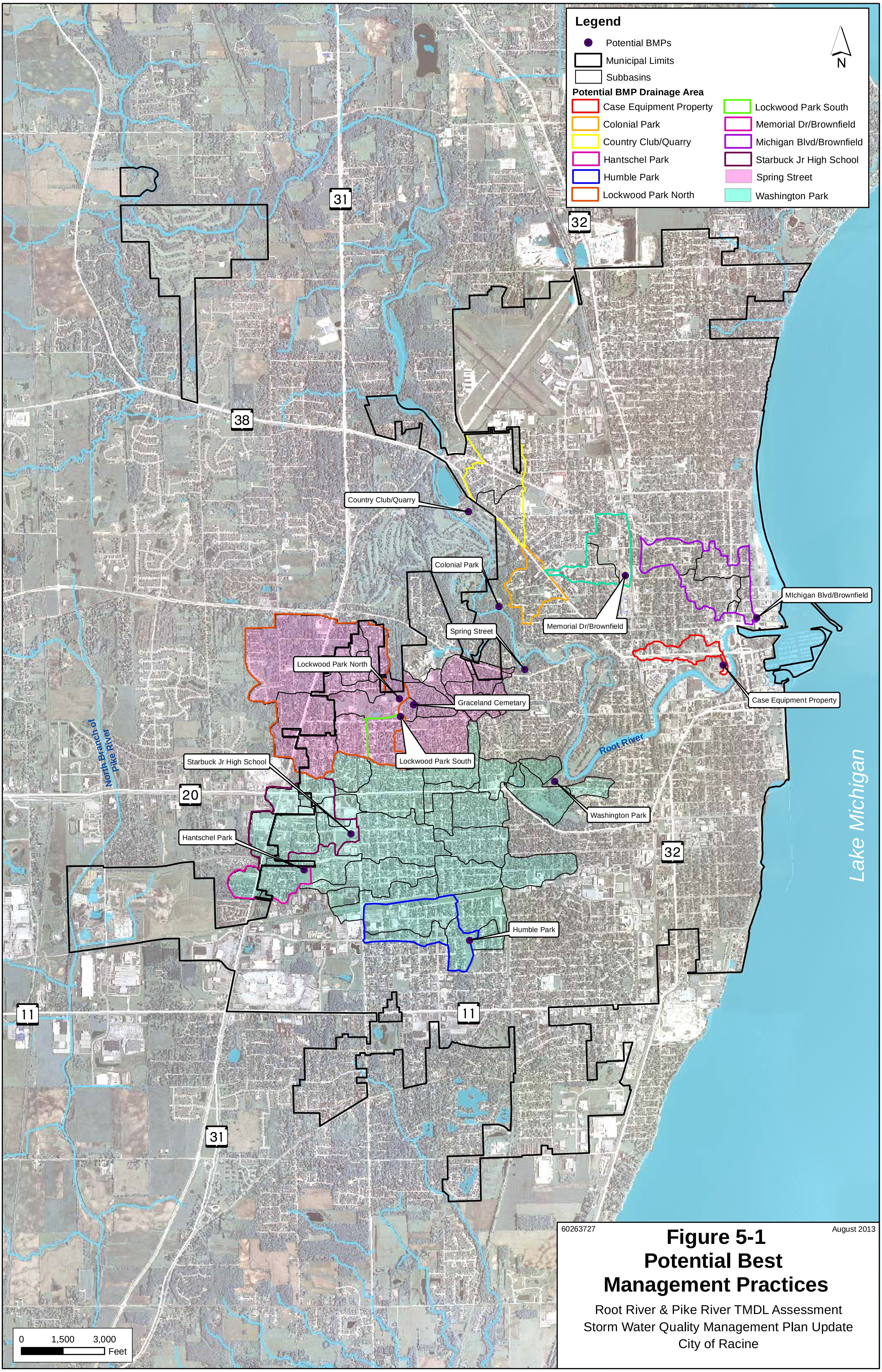

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Figure 5-1
Potential Best Management Practices

Root River & Pike River TMDL Assessment
Storm Water Quality Management Plan Update
City of Racine

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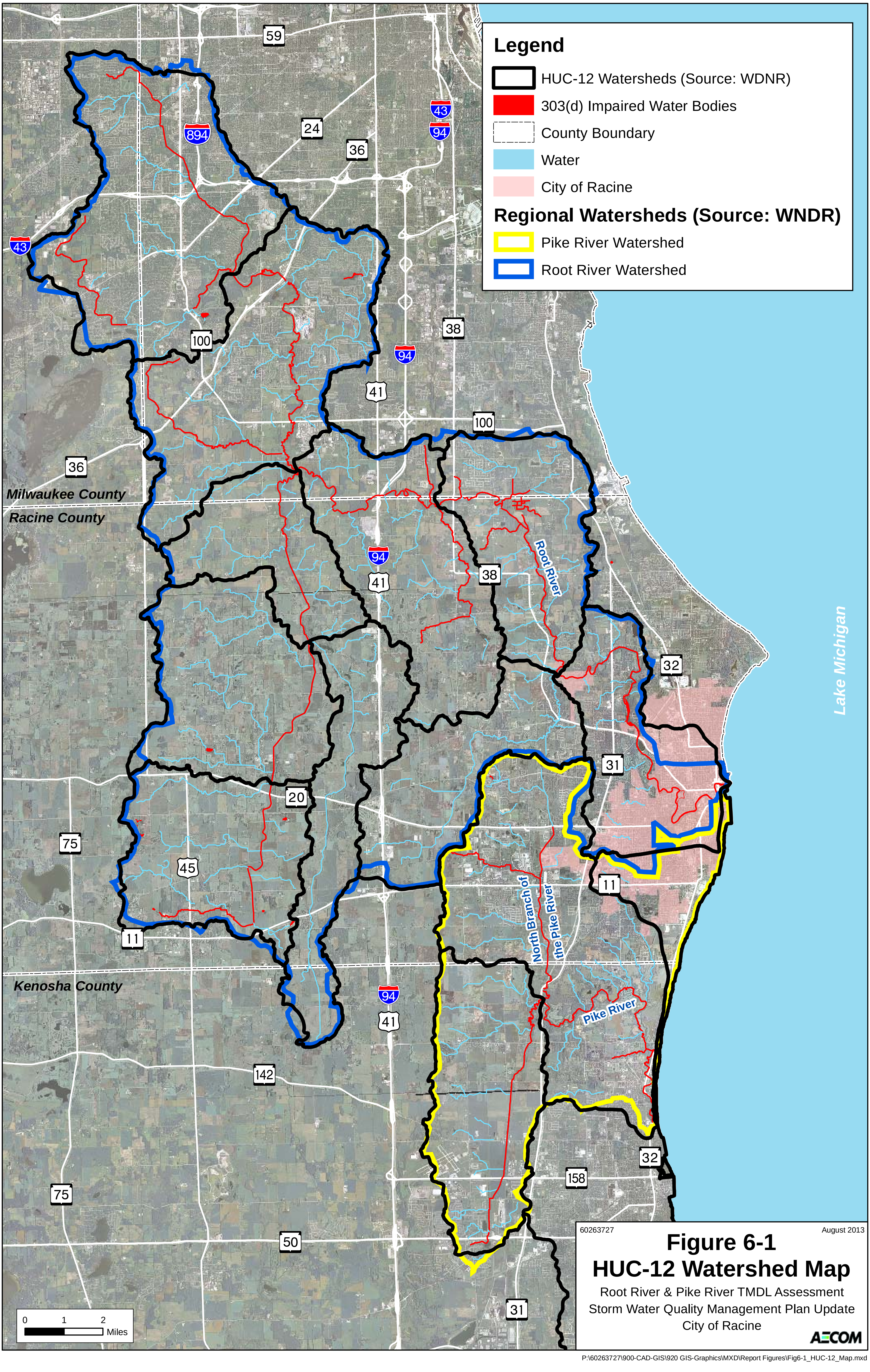

Legend
HUC-12 Watersheds (Source: WDNR)
303(d) Impaired Water Bodies
County Boundary
Water
City of Racine
Regional Watersheds (Source: WNDR)
Pike River Watershed
Root River Watershed
Milwaukee County
Racine County
Kenosha County
Lake Michigan
Root River
North Branch of the Pike River
Pike River
0 1 2 Miles
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August 2013
Figure 6-1
HUC-12 Watershed Map
Root River & Pike River TMDL Assessment
Storm Water Quality Management Plan Update
City of Racine
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Appendix A

TMDL Guidance for MS4 Permits

State of Wisconsin

CORRESPONDENCE/MEMORANDUM

DATE: DRAFT

TO: Regional Water Leaders, Runoff Management Field Supervisors
& Stormwater Program Staff (via email)

FROM: Pam Biersach, Director
Bureau of Watershed Management

SUBJECT: TMDL Guidance for MS4 Permits:
Planning, Implementation, and Modeling Guidance

This document is intended solely as guidance, and does not contain any mandatory requirements except where requirements found in statute or administrative rule are referenced. This guidance does not establish or affect legal rights or obligations, and is not finally determinative of any of the issues addressed. This guidance does not create any rights enforceable by any party in litigation with the State of Wisconsin or the Department of Natural Resources. Any regulatory decisions made by the Department of Natural Resources in any matter addressed by this guidance will be made by applying the governing statutes and administrative rules to the relevant facts.

Issue

The US Environmental Protection Agency (EPA) requires the wasteload allocations (WLA) developed during a Total Maximum Daily Load (TMDL) be reflected and implemented through storm water discharge permits. A TMDL quantifies the amount of pollution that a waterbody can assimilate and still meet water quality standards. The WLA is the portion of the assimilative capacity that is allocated to point sources. Nonpoint sources receive load allocations (LA). In many cases, municipal separate storm sewer systems (MS4s) have multiple discharge points that can be located in more than one reachshed[1]. In a TMDL, WLAs are assigned for each pollutant of concern and by reach. Unlike s. NR 151.13, in a TMDL a MS4 can have multiple and different reduction goals across their municipal boundary.

Establishing relationships between multiple point and nonpoint pollutant sources and their influences on stream flow and water quality is complex. This process is often further complicated by the spatial scale under which TMDLs are developed. In order to help make TMDL development manageable, TMDLs are often developed using large scale modeling approaches that can be difficult to translate to the smaller scale often needed for implementation. For instance, loadings from "non-traditional" permitted MS4s (WDOT and county highways and UW campus systems) are often aggregated with the loadings of traditional MS4s (cities, villages and towns). This loss in resolution can result in inconsistencies in the WLA assignment necessitating a more thorough examination and possible reallocation of a portion of the WLA to non-traditional MS4 permittees.

The Wisconsin Department of Natural Resources (DNR) will need to review, and may need to reallocate WLAs to MS4 permittees. MS4 permittees will then need to conduct storm water management planning to evaluate their

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[1] Reachsheds are also referred to as subwatersheds or segment sheds in TMDL development. A reach is a stream segment or individual lake or reservoir that is artificially assigned a compliance point or "pour point" where the applicable in-stream water quality standards must be met. Breaks for stream reaches are made at changes in stream listing (each individually named 303(d) water must have their own set of TMDLs), changes in water quality criteria, and at pour points or compliance points just upstream of significant changes in flow/assimilative capacity.

current pollutant load relative to the TMDL reduction goals and create and implement a plan to meet the TMDL reductions. This document divides DNR's guidance for implementing MS4 WLAs into 3 parts as follows:

- **Part 1** –WLAs and Reduction Targets
- **Part 2** – Planning and Compliance Benchmarks
- **Part 3** – Implementation and Modeling

PART 1 – WLAs and Reduction Targets

Discussion

Whether or not a municipality changes in size or land use, the allowable pollutant load that the receiving water can handle does not change. In the TMDL, the total allowable permitted MS4 load was determined by reach and distributed uniformly across permitted MS4s on a unit area load basis. Since the permitted MS4 allowable unit area load is the same across a reachshed, MS4 WLAs can be reallocated between each other based on area. However, this reallocation must occur at the same time step that was used in the TMDL development process.

> Example: the Rock River TMDL generated allocations on a monthly basis so any reallocation of the WLA between sources must also proceed on a monthly basis. Simply adding the monthly allocations into an annual load and reallocating using an average annual unit load approach will result in a misrepresentation of the TMDL allocations. Analysis must be conducted on a monthly basis.

It is expected that the extent area modeled for the MS4 WLA will be larger than that modeled under the s. NR 151.13 (developed urbanized area modeling analysis). This is because the s. NR 151.13 modeling area has many optional and excluded areas, whereas, the TMDL WLA analysis generally lumps all of these areas into the WLA.

In municipalities that have recently experienced significant growth, there may be a significant increase in urban area. In addition, in some instances the total actual permitted MS4 area within a reachshed is different than that used in the TMDL development process. Initially DNR believed that it would be easy to reallocate a portion of the non-point source LA to the permitted MS4s based on a unit load approach; however, the task can be more difficult than it initially appears. As explained above, the reallocation needs to be conducted using the same time step used in the development of the TMDL and at the same critical flow period used to develop the TMDL. In many cases, this critical flow period used in the development of the TMDL may not correspond with an average annual unit load.

> Example: In the Rock River TMDL and Milwaukee Area TMDLs a critical flow period was selected to generate allocations. These critical flow periods represent the 30th percentile and 25th percentile of each monthly flow respectively. Critical flow periods were selected using an iterative approach in which multiple years of data were analyzed to create a critical condition that allowed compliance with the water quality standards. For example, using 10 years of data and the 30^{th} percentile flow, the third lowest August flow was used to generate the August allocations. As a result, the allocations depicted in the TMDL represent loadings under the critical flow condition and do not equate to the average annual unit loads typically used when analyzing nonpoint or urban runoff. In most cases, the TMDL loads are lower than the average annual loads because the TMDL loads represent the loadings that occur under the critical flow period. Under a 30^{th} percentile flow, the runoff volume is low from pervious areas and this is reflected in the TMDLs unit area loads for nonpoint sources.

Realizing the complexities outlined above will make it very difficult to implement TMDLs, DNR has evaluated several other options for demonstrating compliance with TMDL WLAs. The preferred option is using the percent reduction stipulated in the TMDL. This allows both the MS4 and DNR the ability to implement the reductions without having to reallocate and track WLAs across reachsheds, MS4s, and other land uses. EPA requires that implementation of the TMDL and placement of the allocations in permits to be consistent with the TMDL. The use of a percent reduction strategy allows reduction goals consistent with the TMDL and allows implementation to continue to build on the same percent reduction strategy employed in s. NR 151.13 and to use the same models and tools that Wisconsin has already been utilizing.

Guidance

A TMDL will have a MS4 WLA and percent reduction specified for each pollutant of concern, and this is to be met within each reachshed. Individual MS4s may be located in multiple reachsheds, and as such, they may have multiple WLAs and percent reductions applicable to them.

During the first term of an MS4 permit after EPA approval of a TMDL, DNR will want each permitted MS4 to report its actual area served within each reachshed. Existing MS4 permittees should already have sewershed mapping completed to satisfy their MS4 permit conditions and this should be used as a base. The Department will provide the GIS data sets used for the TMDL reachshed boundaries through its website. The two main reasons for this evaluation are to determine if the:

- Acreage served by the MS4 in a reachshed is significantly different than the area used in the approved TMDL and determine new boundaries and areas.
- Non-traditional MS4s such as permitted universities and state and county highway facilities were not given a separate WLA and need to be identified.

The MS4 permit will require that permittees submit information to the DNR so that it may verify appropriate boundaries and areas. To accomplish this DNR will need the following information:

- Updated storm sewer system map that identifies:
    - Current municipal boundary/permitted area. For city and village MS4s, identify the current municipal boundary. For MS4s that are not a city or village, identify its permitted area. The permitted area for towns, counties and non-traditional MS4s pertains to the area within the Urbanized Area of the 2010 Decennial Census.
    - The MS4 drainage area boundary associated with each TMDL reach, and the area of each MS4 drainage area boundary within each respective reachshed.
- Identification of areas on a map and the acreage of those areas within the municipal boundary that the permittee believes it should not be responsible for meeting a WLA (see "WLA Analysis Area" in Part 3 of this document"). In addition, the permittee shall provide an explanation of why each area identified above should not be its responsibility.
  Note: This information is to be acquired by the DNR through an MS4 annual report.

DNR will evaluate this information, and after consultation with the MS4, will determine which of the two options below provides the best consistency with the TMDL allocation process while allowing ease of implementation. In most cases, using the percent reduction approach is the preferred option.

Reallocation Option: In some cases, where TMDL analysis was conducted on an average annual basis it may be appropriate to adjust WLAs based on the acreage associated with each MS4 by reachshed. If reallocating WLAs and LAs within the same reach will still not be adequate to address significant area differences between actual and TMDL modeled reachsheds, DNR will consider on a case-by-case basis as to whether a reallocation between reaches is warranted. For example, an MS4 may collect runoff from a substantial amount of area from one reachshed and discharge it directly into another reachshed.

DNR will be including reallocated WLAs in the next reissued permit of affected MS4s. MS4s will have the opportunity to comment and/or adjudicate reallocated WLAs when the permit is public noticed. EPA allows state administering agencies such as DNR to manage reallocations between MS4 WLAs and NPS LAs without having to update or redo the TMDL.

Percent Reduction Option: To assist in understanding allocations the TMDLs developed in Wisconsin have expressed reduction goals in both a WLA format and a percent reduction format. The percent reduction is calculated from the baseline condition used in the TMDL to what is needed to meet water quality standards. During the development of the TMDLs, the percent reduction is calculated using the following equation:

Percent Reduction = 100 * (1 – (WLA Loading Condition / Baseline Loading Condition))

The baseline loading condition is often described in the TMDL. While there is some variation across TMDLs in Wisconsin, in general the baseline loading condition reflects the regulatory conditions stipulated in s. NR 151.13. The difference between individual TMDLs is often weather this baseline loading condition represents the s. NR 151.13 no-controls scenario, the 20% control requirement, or the 40% control requirement. All these options share in common a starting point of the s. NR 151.13 no-controls scenario; a 20% reduction from no controls or a 40% reduction from no controls. In the case of a 20% or 40% reduction baseline loading condition, for implementation it may be easier to shift the TMDL percent reduction back to a no-controls percent reduction. This can be done using a mathematical conversion. For a TMDL that used the no-controls as a baseline no adjustment is needed.

For a TMDL that uses 20% control as the baseline loading condition the conversion to a no-controls baseline is:

Total Percent Reduction = (20 + (80 * % control in TMDL))

For a TMDL that uses 40% control as the baseline loading condition the conversion to a no-controls baseline is:

Total Percent Reduction = (40 + (60 * % control in TMDL))

Once the no-controls percent reduction is calculated, the TMDL can be implemented in a similar fashion as s. NR 151.13. For the MS4 area contained in a particular reach, the no controls load is calculated using SLAMM or P-8. The MS4 area includes the entire acreage that the MS4 is responsible for. The total percent reduction calculated from above is applied to this no controls load providing the allocated mass available to the MS4.

As new MS4 area is added or subtracted, the total percent reduction is applied to these areas based on a no controls load and the total allocated mass available to the MS4 is adjusted accordingly.

PART 2 – Storm Water Management Planning and Compliance

Storm Water Management Planning (SWMP)
DNR will be requiring a SWMP to be completed by an MS4 permittee that receives TMDL WLAs. The development of this SWMP should occur during the term of the next permit issuance/reissuance after the TMDL is approved. Each MS4 permittee should evaluate all potentially cost-effective alternatives to reduce its discharge of pollutants of concern so that its discharge is comparable to WLAs or percent reductions stipulated in the TMDL. MS4 permittees also should consider alternatives that involve working together with other MS4s that reside in the same reachshed. When developing components of a SWMP, municipalities should consider the minimum following implementation methods:

- **Redevelopment** – A focus of the SWMP should be on improving storm water treatment for areas of existing development during times of redevelopment. Older, urban development patterns typically did not include the same level of stormwater management controls that new development generally has. Reductions achieved through redevelopment can be counted towards compliance with WLAs. Each municipality should estimate the pollutant reductions that are expected to be achieved over time through redevelopment of both public and private facilities, including roadway reconstruction.

- **Ordinance Review and Updates** – A municipality may elect to revise its current post-construction storm water management ordinance to require greater levels of pollutant control for redevelopment and highway reconstruction that are above the minimum performance standards of ch. NR 151, Wis. Adm. Code and are consistent with the reduction requirements contained in the TMDL.

- **Traditional BMPs** – These include drainage and structural controls where reductions can be quantified through water quality modeling such as WinSLAMM and P-8.

- **Non-traditional BMPs –** These include "soft-control" storm water measures such as street cleaning, residential leaf and yard debris management programs as well as streambank stabilization. Quantifiable pollutant reductions may be difficult to determine for some measures but DNR and the permittee should be able to come to an agreement as to whether the measure is beneficial. In cases where quantifiable reductions are not possible, the use of agreed upon non-traditional practices shall be deemed as making progress toward compliance with the TMDL reductions.

- **Water Quality Trading and Adaptive Management -** If economically beneficial, a MS4 may wish to participate in one of these programs. MS4s are eligible to participate in water quality trading to help meet WLAs. Also a MS4 may be invited by a Waste Water Treatment Facility (WWTF) to participate in an adaptive management program pursuant to s. NR 217.18, Wis. Adm. Code, to reduce phosphorus. Water quality trading and adaptive management guidance are covered under separate DNR guidance documents.

- **Wetlands -** Wetlands protected under ch. NR 103, Wis. Adm. Code, cannot be used for storm water treatment. Wetlands constructed for the purpose of providing storm water treatment, would be eligible for treatment credit.

  Wetlands that receive runoff pollutants are expected to, at some point, reach a certain equilibrium point where they would provide minimal pollutant removal unless they are maintained by harvesting vegetation and/or have accumulated sediment removed from them. Therefore to take credit for pollutant removal within a wetland, a long term wetland maintenance plan is needed.

- **New Development -** Current ch. NR 151 post-construction performance standards for areas of new development include an 80% TSS control level and maintaining 60 - 90% of predevelopment infiltration (with certain exemptions or exclusions). Areas that have stormwater management practices designed and maintained to meet these performance standards should already be controlling TSS and total phosphorus to levels comparable to TMDL water quality targets. Placing additional controls beyond what is already required under the ch. NR 151 post-construction performance standards for new development would not be expected to have as great an effect on reducing the overall MS4 load discharged to a reach.

As discussed, SWMPs for meeting WLAs should identify what pollutant reduction measures will be employed and over what time frame reductions will occur (i.e. 20 tons/yr TSS for redevelopment sites over the next 20 years).

Compliance Points

Compliance with the MS4 WLAs in the permit will need to be achieved on a reach by reach basis. Ultimately, water quality standards must be met instream at the compliance points located at the farthest most downstream point of the reachshed. Due to the complexity of natural systems, the WLAs identified in the TMDL are the best estimate for meeting water quality standards. Once an adequate level of implementation has been established and modeling estimates percent reductions or loads similar to that required in the TMDL, monitoring can be used to judge progress and compliance in meeting the water quality standards. The MS4 is not required to perform this monitoring.

Compliance Schedule and Benchmarks

The first issuance/reissuance of an MS4 permit after approval of an applicable TMDL that includes MS4 WLAs or percent reduction targets will include a storm water management planning requirement. SWM planning will enable a MS4 permittee to determine benchmarks with respect to achieving the levels of control needed to comply with the TMDL and to determine what storm water management measures and associated costs are anticipated. It is within the 2nd reissuance of an MS4 permit after the TMDL is approved, that the applicable WLAs or percent reductions and an associated compliance schedule is expected to be included in the MS4 permit.

The compliance schedule will require that the permittee be able to show continual progress by meeting ‘benchmarks’ of performance within each permit term. In this case, a ‘benchmark’ means a level of pollutant reduction or an application of a pollutant reduction measure, which is part of a larger SWMP designed to bring the overall MS4 discharge of pollutants of concern down to a level which is comparable to the MS4’s WLAs. It is possible that certain benchmarks will not be easily quantifiable but there needs to be evidence that such benchmarks will provide a legitimate step toward reducing the discharge of pollutants of concern.

DNR may elect to place specific benchmarks in an MS4 permit. However, it is expected that MS4 permittees will have the primary role in establishing their own benchmarks for each 5-year permit term. Benchmarks should be reevaluated at least once every 5 years and are interim steps/goals of compliance. At least 15 years is expected to be allowed for compliance with WLAs provided MS4s demonstrate continual progress in meeting its benchmarks of compliance. DNR realizes that meeting certain WLAs may take longer for MS4s than would be for traditional point sources and it may take longer than 15 years. Redevelopment ordinances that comply with TMDL requirements are an excellent tool to show progress in meeting the WLA balanced with smart growth and development patterns. DNR will not require removal of existing infrastructure to comply with TMDL requirements. Rather manament practices should be installed as infrastructure is replaced.

Under a TMDL, EPA does not acknowledge the concept of maximum extent practicable as defined in s. NR 151.006 but rather extended compliance schedules can be used to allow MS4s the flexibility needed to meet TMDL goals.

Any storm water control measures employed by the MS4 permittee to reduce its discharge down to its TMDL requirements will need to be maintained or replaced with comparable stormwater control measures to maintain continued compliance with the TMDL.

Runoff Treatment outside of the MS4s Jurisdiction
In order for an MS4 to take credit for the control of pollutants by another municipality or private property owner, the MS4 must have an agreement with the entity with control over such treatment measure. This agreement must specify how the pollutant reduction credit will be shared or otherwise granted to an MS4.

Tracking
The permittee will need to track and show progress in reducing discharges of pollutants of concern. This tracking should assist in showing that compliance benchmarks have been achieved in accordance with an overall compliance schedule. A tabular summary of pollutant loading per reach will be required to be submitted to DNR with the MS4 report at least once every MS4 permit term. The summary should identify the following: reach name and number (consistent with the name and number in the TMDL report), the MS4 outfall numbers, named/labeled drainage areas, the applicable WLA or percent reduction target, pollutant reduction benchmarks, storm water management control measures implemented, and pollutant reduction achieved as compared to no controls.

PART 3 – Implementation and Modeling

<u>Discussion</u>

The following discussion highlights the main compatibility issues between TMDL development and MS4 implementation and how they will be addressed.

The first issue is the expression of the WLA itself. Since traditional point sources (municipal and industrial wastewater facilities) monitor and collect data at their outfalls on a frequent basis, the expression of the WLA as a monthly average or even as a daily maximum limitation in some instances may be appropriate; especially given that the waters are evaluated against the phosphorus criteria based on monthly sampling protocols.

However, MS4s have historically relied on modeled estimations of runoff flows and pollutant loadings as generated on an annual average basis as opposed to monitoring and collecting samples. Therefore, DNR intends to express TMDLs in MS4 permits in such a manner that allow MS4s to continue using water quality models such as WinSLAMM and P-8 for determining compliance. As with s. NR 151.13, TMDL compliance for MS4s will be by design.

The second issue is the compatibility of using existing stormwater management planning efforts for use in TMDL implementation. To achieve pollutant reductions, MS4s should look for opportunities of redevelopment and road reconstruction projects, implementation of streambank stabilization and wetland restoration projects, implementation of traditional BMPs, and possibly water quality trading and adaptive management[2]. Each of these elements can be considered for implementation to meet the requirements of a TMDL. It is likely that existing MS4 water quality modeling and mapping can be used and adjusted as necessary for SWM planning needs for TMDL implementation.

The third issue deals with different area in which the TMDL is typically applied versus prior s. NR 151.13 modeling. Because of the scale at which they are developed allocations from a TMDL have generally been applied across the entire urban area that is served by the permitted MS4. It is important to note that while many components of existing planning efforts and modeling results can be used for TMDL implementation, adjustments will likely be necessary to account for a TMDL focus on compliance by reachshed.

Guidance

TMDL-established WLAs and LAs are 'targets' of treatment performance and/or pollutant control for point and non-point sources. The WLAs and LAs are TMDL modeled estimates of the level of pollutants that can be discharged and still meet in-stream standards. The ultimate goal of a TMDL is for continual reduction of pollutants discharged to impaired waters until in-stream water quality standards are met allowing removal from the 303-d impaired waters list. The issue of removing relatively small areas from an MS4's analysis area generally has little effect on the MS4s 'target' of treatment performance. Municipalities should consider the drainage area served by their MS4 as a whole and look for the most cost-effective means to reduce discharges of pollutants of concern until their discharge is comparable with its TMDL requirements.

TMDL Analysis Area

An MS4 is to include all areas within its corporate boundary unless it is listed as optional.

Incorporation of rural areas: A municipality may have incorporated the entire township or a large portion of the rural township in which it resides. In this situation, the municipality needs to include all areas within the 2010 urbanized area and adjacent urban developed areas within its jurisdiction which drain into its MS4.

Highways: A permitted MS4 owner/operator of a highway needs to account for the pollutants generated within the Right-Of-Way (ROW). WisDOT is responsible for state highways that are not connected highways. A county is responsible for county highways that it maintains. Cities and villages need to include connecting highways as identified and listed in the Official Highway State Truck Highway System Maps at: http://www.dot.wisconsin.gov/localgov/highways/connecting.htm

Optional: The following areas are optional for an MS4 to include:

1. Area that never passes through a permittee's MS4 such as a riparian area.
2. Land zoned for agricultural use and operating as such.
3. Manufacturing, outside storage and vehicle maintenance areas of industrial facilities permitted under subch. II of ch. NR 216, Wis. Adm. Code, are optional to include. This does not include any industrial facilities that have certified a condition of "no exposure" pursuant to s. NR 216.21(3), Wis. Adm. Code. *Note: DNR recommends that municipalities include all industrial facility areas within their WLA analysis area instead of creating 'holes' within its area of analysis.*

2 The Department has prepared separate guidance documents on water quality trading and adaptive management. MS4s are considered non-point sources for the purposes of adaptive management. This does not preclude them from participating in an adaptive management program if approached by a traditional point source such as a municipal or industrial wastewater treatment facility. The "Adaptive Management Technical Handbook" is available for download at http://dnr.wi.gov/topic/surfacewater/adaptivemanagement.html

4. Any area that discharges to an adjacent municipality's MS4 (Municipality B) without passing through the jurisdictional municipality's MS4 (Municipality A). Municipality B that receives the discharge into their MS4 may choose to be responsible for this area from Municipality A. If Municipality B has a stormwater treatment practice that serves a portion of A as well as a portion of B, then the practice must be modeled as receiving loads from both areas, independent of who carries the responsibility for the area. However, if runoff from an area within Municipality A's jurisdiction drains into Municipality B's MS4 but then drains back into Municipality A's MS4 farther downgradient, then Municipality B does not have the option of including the load from Municipality A in their analysis and the load from that area is Municipality A's responsibility.
5. For towns, the area outside of the 2010 urbanized area as defined by the US Census Bureau as this area is classified as non-permitted urban and part of the non-point source load allocation (NPS LA).

MS4 Water Quality Models and Related Information

To model pollutants such as TSS and total phosphorus in the area served by the MS4, the municipality must select a model such as SLAMM, P8 or an equivalent method deemed acceptable by the Department. For the analysis to show compliance, SLAMM version 9.2 or P8 version 3.4 or a subsequent version of these models may be used.

All roadway right-of-ways within the urbanized area that are part of a county or town's MS4 are the responsibility of the county or town. Model the road based on the nearest urban land use, even if agricultural land use is on one or both sides of the road. Select the urban land use that will most likely typify the traffic that will be on that road (for example commercial or residential) and include that area in the corresponding standard land use file.

A municipality is not required to use the standard land use files if it has surveyed the land uses in its developed urban area and has "real" source area data on which to base the input files. The percent connected imperviousness beyond the standard land use files must be verified in the field. Disconnection may be assumed for residential rooftops where runoff has a flow path of 20 feet or greater over a pervious area in good condition. Disconnection for impervious surfaces other than residential rooftops may be assumed provided all of the following are met:

- The source area flow length does not exceed 75 feet,
- The pervious area is covered with a self-sustaining vegetation in "good" condition and at a slope not exceeding 8%,
- The pervious area flow length is at least as long as the contributing impervious area and there can be no additional runoff flowing into the pervious area other than that from the source area.
- The pervious area must receive runoff in a sheet flow manner across an impervious area with a pervious width at least as wide as the contributing impervious source area.

Water quality modeling is a means to determine a storm water management control practice's treatment efficiency. If the model cannot predict efficiencies for certain storm water management control measures that a municipality identifies as a water quality management practice, then a literature review should be conducted to estimate the reduction value. Proprietary stormwater management control measures that utilize settling as their means of TSS reduction should be modeled in accordance with DNR Technical Standard 1006 (Method for Predicting the Efficiency of Proprietary Storm Water Sedimentation Devices).

When designing storm water management practices, runoff draining to a management practice from off-site must be taken into account in determining the treatment efficiency of the measure. Any impact on the efficiency must be compensated for by increasing the size of the measure accordingly.

Storm water management practices on private property that drain to an MS4 can be given treatment credit, provided the municipality enters into an agreement or has an equivalent enforceable mechanism with the facility/land owner that will ensure the management practice is properly maintained. An operation and maintenance plan, including a maintenance schedule, must be developed for the stormwater management practice in accordance with relevant DNR technical standards. The agreement or equivalent mechanism between the municipality and the private owner should include the following:

- A description of the stormwater management practice including dimensions and location.
- Identify the owner of the property on which the stormwater management practice is located.
- Identify who is responsible for implementing the operation and maintenance plan.
- Outline a means of terminating the agreement that includes notifying DNR.

The efficiency of a storm water manament practice on private property must be modeled using the best information the municipality can obtain on the design of the practice. For example, permanent pool area is not sufficient information to know the pollutant reduction efficiency of a wet detention basin even if it matches the area requirements identified in Technical Standard 1001 Wet Detention Basin for an 80% reduction. Information on the depth of the wet pool and the outlet design are critical features that determine the level of control a detention pond is providing.

Modeling Clarifications

- TMDL allocations are applied with the goal of reducing in-steam pollutant concentrations in lakes and streams. Pollutant loadings to internally drained areas including wetlands, do not count against an MS4 allocation.
- Where water is pumped rather than gravity draining from an internally drained area or wetland, the MS4 will be expected to monitor the discharge to determine the mass of pollutants discharged to the surface water to which the TMDL applies.
- If a portion of a municipality's MS4 drains to a stormwater treatment facility in an adjacent municipality, the municipality generating the load will not receive any treatment credit due to the downstream municipality's treatment facility unless there is an inter-municipal agreement where the downstream municipality agrees to allow the upstream municipality to take credit for such treatment. DNR anticipates that such an agreement would have the upstream municipality assist with the construction and/or maintenance of the treatment facility. This contract must be in writing with signatures from both municipalities specifying how the treatment credit will be shared.
- For reporting purposes, the pollutant load/reductions must be summarized by TMDL reachshed. Additionally, pollutant loads for grouped drainage areas as modeled shall also be reported. Drainage areas may be grouped at the discretion of the modeler for such reasons as to emphasize higher priority areas, balance model development with targeting or for cost-effectiveness.
- Credit should not be taken for cleaning of non-curbed streets.
- The additional runoff volume from areas that are outside of the analysis area needs to be accounted for when it drains into treatment devices. The pollutant load can be "turned off" but the runoff hydrology needs to be accounted for to properly calculate the treatment efficiency of the device.
- Due to concerns of sediment resuspension, basins with an outlet on the bottom are generally not eligible for pollutant removal based solely on settling. However, credit may be taken for treatment due to infiltration or filtration. Features to prevent scour should always be included for any practice where appropriate.
- To model a combination of mechanical broom and vacuum assisted street cleaning, it may require an analysis of several model runs depending on the timing of the mechanical and vacuum cleaning. If mechanical broom and vacuum cleaning occur at generally the same time (e.g. within two weeks of each other) then only the removal efficiency of the vacuum cleaning should be taken. If the municipality performs broom sweeping in the spring or fall and vacuum clean the remained of the year, calculate the combined cleaning efficiency using the following method:

(A) Model the entire street cleaning program as if entire period is done by a mechanical broom cleaner.
(B) Model just the period of time for vacuum cleaning (do not include the mechanical broom cleaning).
(C) Model the same period as B) but with a mechanical broom.
(D) The overall combined efficiency would be A + B – C.

WinSLAMM clarification

- WinSLAMM 9.3.4 and earlier versions of WinSLAMM result in double counting of pollutant removal for most treatment practices modeled in series. WinSLAMM 9.2 and subsequent versions contain warnings to help alert modelers of this issue. The modeler will need to make adjustments to ensure that the results do not include double credit for removal of the same particle size. PV & Associates has created a document titled 'Modeling Practices in Series Using WinSLAMM' which helps to guide a user as to whether and or how certain practices can be modeled in series and this document is available at: http://winslamm.com/Select_documentation.html
- In WinSLAMM 9.4 and earlier versions, when street cleaning is applied across a larger modeled area with devices that serve only a certain area within the larger modeled area, it is acceptable to first take credit for street cleaning across the entire larger area but then the treatment efficiency for other devices must be reduced by the efficiency of the street cleaning to prevent double counting.

P8 clarifications

- P8 does not account for scour and sediment resuspension. DNR requires that a wet basin with less than a 3-foot permanent pool have its treatment efficiency reduced. A basin with zero permanent pool depth should be considered to get zero credit for pollutant removal due to settling and a basin with 3 or more feet of permanent pool depth can be given the full pollutant removal efficiency credited by settling. The pollutant removal efficiency may be given straight-line depreciation such that a basin with a 1.5 foot-deep permanent pool would be eligible for 1/2 the pollutant removal efficiency that would be credited due to settling.
- A device that DNR gives no credit for pollutant removal may still be modeled if it is in series with other practices because of its benefit on runoff storage capacity that may enhance the treatment efficiency of downgradient treatment devices. To do so, turn the treatment efficiency off in P-8.
- P8 should be started an extra year or at least several months before the "keep dates", in order to allow the model to build up representative pollutant concentrations in wet basins.

Approved By:

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On Behalf of the Storm Water Liaison Team

Appendix B

Pollution Loading Summary Tables

Appendix B
Root River Watershed
Pollution Loading Results by Watershed
City of Racine TMDL Analysis

Watershed	Area Included in Analysis (acres)	Base Load		Existing Load		Percent Reduction	
		TSS (tons/year)	TP (lbs/year)	TSS (tons/year)	TP (lbs/year)	TSS (tons/year)	TP (lbs/year)
RR01	8.2	1.7	8.3	1.5	7.6	12.4%	8.2%
RR02	4.5	0.8	4.4	0.7	4.1	11.0%	7.3%
RR03	85.3	16.5	80.3	15.2	75.8	8.0%	5.6%
RR04	43.7	6.3	42.9	5.7	40.2	10.1%	6.3%
RR06	4.2	0.9	4.4	0.8	4.0	12.8%	9.8%
RR07	25.5	1.5	13.4	0.3	3.0	81.8%	78.0%
RR08	10.5	1.2	9.3	1.1	8.7	12.4%	7.3%
RR09	3.4	0.4	3.0	0.3	2.8	12.6%	7.4%
RR10	15.7	1.8	13.8	1.6	12.8	11.9%	7.2%
RR11	8.2	0.9	7.4	0.8	6.8	12.3%	7.2%
RR12	53.1	9.0	53.6	3.4	28.3	61.8%	47.3%
RR13	321.7	20.6	188.8	5.9	63.6	71.4%	66.3%
RR14	4.8	0.5	3.9	0.5	3.6	13.1%	8.1%
RR15	512.1	62.8	470.0	48.0	391.7	23.6%	16.6%
RR16	16.2	2.1	14.6	1.9	13.7	9.8%	6.2%
RR17	35.3	4.8	34.0	4.4	31.9	9.7%	6.2%
RR18	53.6	6.3	44.3	5.8	42.2	8.3%	4.9%
RR19	1.2	0.2	1.1	0.2	1.0	10.4%	6.8%
RR20	115.1	13.4	98.2	12.2	93.0	8.8%	5.4%
RR21	3.6	0.5	3.4	0.5	3.2	10.8%	6.5%
RR22	95.4	15.2	91.8	13.7	86.1	9.7%	6.2%
RR23	3.0	0.4	2.8	0.4	2.6	10.7%	6.9%
RR24	2.7	0.5	2.6	0.4	2.5	10.5%	6.8%
RR25	35.5	4.9	34.4	4.4	32.3	9.8%	6.0%
RR26	7.1	0.9	6.5	0.8	6.0	10.8%	6.7%
RR27	6.6	0.9	6.3	0.8	6.0	8.9%	5.3%
RR28	2.6	0.3	2.6	0.3	2.4	9.7%	6.0%
RR29	1.9	0.3	1.8	0.2	1.7	9.5%	6.1%
RR30	2.5	0.3	2.1	0.3	2.0	11.0%	7.6%
RR31	5.4	0.7	4.4	0.6	4.1	10.3%	6.4%
RR32	12.9	3.1	10.4	3.1	10.4	0.0%	0.0%
RR33	11.7	2.8	10.8	2.8	10.8	0.0%	0.0%
RR34	4.6	1.1	4.7	1.1	4.7	0.0%	0.0%
RR35	14.4	3.6	12.6	3.4	12.0	7.2%	5.0%
RR36	151.9	26.8	147.4	24.3	138.3	9.6%	6.2%
RR37	1282.1	189.2	1225.4	171.5	1151.9	9.4%	6.0%
RR38	7.8	0.9	6.9	0.8	6.4	11.1%	6.9%
RR39	15.8	2.0	14.3	1.8	13.4	9.9%	6.3%
RR40	154.5	24.7	135.9	22.3	127.1	9.8%	6.5%
RR41	20.5	3.6	19.3	3.3	18.1	9.1%	6.1%
RR42	2.6	0.2	1.4	0.2	1.4	4.4%	2.2%
RR43	2.3	0.5	2.1	0.5	2.0	7.4%	5.1%
RR44	41.4	8.7	40.6	7.9	38.3	8.9%	5.8%
RR45	9.4	2.3	8.5	2.2	8.0	7.2%	4.9%
RR46	253.1	42.1	243.0	38.4	229.1	8.8%	5.7%
RR47	142.8	22.8	144.9	20.5	135.7	10.2%	6.4%

Appendix B
Root River Watershed
Pollution Loading Results by Watershed
City of Racine TMDL Analysis

Watershed	Area Included in Analysis (acres)	Base Load		Existing Load		Percent Reduction	
		TSS (tons/year)	TP (lbs/year)	TSS (tons/year)	TP (lbs/year)	TSS (tons/year)	TP (lbs/year)
RR48	5.0	0.9	5.0	0.8	4.7	10.4%	6.4%
RR49	2.5	0.7	2.3	0.6	2.2	7.8%	5.1%
RR50	17.5	3.3	16.8	3.1	15.9	8.4%	5.6%
RR51	11.9	1.5	10.5	1.3	9.9	10.1%	6.4%
RR53	63.0	8.8	55.1	7.8	51.4	10.9%	6.9%
RR54	13.3	2.7	13.4	2.4	12.5	10.9%	6.7%
RR55	2.2	0.5	2.3	0.4	2.1	10.9%	6.7%
RR56	0.9	0.2	0.9	0.2	0.8	10.7%	6.7%
RR57	2.8	0.6	2.9	0.5	2.7	11.3%	6.9%
RR58	4.2	0.8	4.3	0.7	4.0	11.8%	7.0%
RR59	1.5	0.2	1.4	0.2	1.3	12.6%	8.5%
RR60	3.9	0.5	3.6	0.5	3.4	9.9%	6.3%
RR61	66.6	10.3	61.5	9.4	57.7	9.2%	6.1%
Totals	**3811.5**	**542.5**	**3462.7**	**464.6**	**3059.6**	**14.4%**	**11.6%**

Appendix B
Pike River Watershed
Pollution Loading Results by Watershed
City of Racine TMDL Analysis

Watershed	Area Included in Analysis (acres)	Base Load		Existing Load		Percent Reduction	
		TSS (tons/year)	TP (lbs/year)	TSS (tons/year)	TP (lbs/year)	TSS (tons/year)	TP (lbs/year)
PR01	127.0	15.5	115.6	13.6	102.6	12.2%	11.3%
PR02	49.0	6.6	43.8	2.8	25.1	57.0%	42.7%
PR03	2.6	0.3	2.3	0.3	2.2	12.3%	7.6%
PR04	37.8	3.8	29.0	2.0	19.2	47.5%	33.7%
PR06	0.5	0.0	0.3	0.0	0.2	25.4%	22.1%
Totals	**216.9**	**26.3**	**191.1**	**18.7**	**149.3**	**28.6%**	**21.9%**

Appendix B
North Branch of the Pike River Watershed
Pollution Loading Results by Watershed
City of Racine TMDL Analysis

Watershed	Municipality	Area Included in Analysis (acres)	Base Load		Existing Load		Percent Reduction	
			TSS (tons/year)	TP (lbs/year)	TSS (tons/year)	TP (lbs/year)	TSS (tons/year)	TP (lbs/year)
PR08	Racine	102.0	21.3	90.7	5.1	34.8	76.0%	61.6%
PR12	Mount Pleasant	167.2	20.2	131.1	4.8	57.2	76.3%	56.4%
PR12	Racine	173.9	46.8	166.6	43.0	158.0	8.0%	5.2%
Totals		**443.1**	**88.3**	**388.4**	**52.9**	**250.0**	**40.0%**	**35.6%**