FINAL REPORT

Total Maximum Daily Loads for Total Phosphorus,
Total Suspended Solids, and
Fecal Coliform
Milwaukee River Basin, Wisconsin

EPA Grants 00E00591-2, 00E00592-2, 00E00593-2,
and 00E00594-2

Prepared for:

U.S. Environmental
Protection Agency
Region 5

On Behalf of:

Wisconsin Department of
Natural Resources

Milwaukee Metropolitan
Sewerage District

March 19, 2018

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Table of Contents

Appendices

List of Figures

List of Tables

List of Acronyms and Terms

303(d) List	List of Impaired Waters
AESOP	Advanced Ecological Simulation Program
AM	Wisconsin's Watershed Adaptive Management Option
AOC	Area of Concern
BMPs	Best Management Practices
CAFO	Concentrated Animal Feeding Operation
cfu	Colony Forming Units
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CSOs	Combined Sewer Overflows
DATCP	Department of Agriculture, Trade, and Consumer Protection
DO	Dissolved Oxygen
EC	*E. coli*
ECOM	Estuarine Coastal and Ocean Model
FAL	Fish and Aquatic Life
FC	Fecal Coliform
FSA	Farm Service Agency
GLRI	Great Lakes Restoration Initiative
HSPF	Hydrological Simulation Program—Fortran
ISS	Inline Storage System
LA	Load Allocation
LAL	Limited Aquatic Life
LCD	Land Conservation Department
LDC	Load Duration Curve
LFF	Limited Forage Fish
LSPC	Load Simulation Program in C++

LTCP	Long-Term Control Plan
LWRM	Land and Water Resources Management
mL	milliliters
MMSD	Milwaukee Metropolitan Sewerage District
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
NCCW	Non-Contact Cooling Water
NOD	Notice of Discharge
NPS Program	Nonpoint Source Pollution Abatement Program
NRCS	Natural Resources Conservation Service
PI	Phosphorus Index
POTW	Publicly Owned Treatment Works
PR-50	SEWRPC Planning Report No. 50
RC	Reserve Capacity
RCA	Row-Column AESOP (Advanced Ecological Simulation Program) Model
RWQMP	Regional Water Quality Management Plan
RWQMPU	Regional Water Quality Management Plan Update
SEWRPC	Southeastern Wisconsin Regional Planning Commission
SLAMM	Source Loading and Management Model
SSOs	Sanitary Sewer Overflows
STORET	USEPA Storage and Retrieval Data Warehouse
SUSTAIN	System for Urban Stormwater Treatment and Analysis Integration
SWAT	Soil and Water Assessment Tool
SWRM	Soil and Water Resources Management
SWWT or Sweet Water	Southeastern Wisconsin Watershed Trust
TBEL	Technology-Based Effluent Limit

TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TR-39	SEWRPC Technical Report No. 39
TRM	Targeted Runoff Management
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WATs	Watershed Action Teams
WDNR	Wisconsin Department of Natural Resources
WisCALM	Wisconsin Consolidated Assessment and Listing Methodology
WisDOT	Wisconsin Department of Transportation
WLA	Wasteload Allocation
WPAP	Water Pollution Abatement Program
WPDES	Wisconsin Pollutant Discharge Elimination System
WQBEL	Water Quality-Based Effluent Limit
WQI	Water Quality Initiative, a combined planning effort between WDNR, MMSD, and SEWRPC to assess water resources within the Greater Milwaukee Watersheds
WQT	Water Quality Trading
WRPs	Watershed Restoration Plans
WWSF	Warm Water Sport Fish
WWTF	Wastewater Treatment Facility

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Section 1
Introduction

U.S. Environmental Protection Agency (USEPA) regulations and the Clean Water Act require states to identify waterbodies that do not meet established water quality standards and to develop total maximum daily loads (TMDLs) for those impaired waters. The TMDL is the maximum amount (expressed in load per day) of a pollutant a waterbody can receive from both point and nonpoint sources and still meet water quality standards or targets. Elevated phosphorus, sediment, and bacteria levels in the Milwaukee River Basin (Basin) have led to low dissolved oxygen concentrations, degraded habitat, excessive algal growth, turbidity, and recreational impairments. As a result, impairments to beneficial uses within the Basin, such as preservation and enhancement of fish and other aquatic life and recreational use, have occurred.

Developing a large-scale TMDL is a very costly and labor intensive endeavor. While the Wisconsin Department of Natural Resources (WDNR) normally has taken the lead role in developing TMDLs in the state, the Milwaukee Metropolitan Sewerage District (MMSD), in partnership with Southeastern Wisconsin Regional Planning Commission (SEWRPC) and numerous other team members had already developed water quality models and tools that could be used to support development of a Milwaukee Basin TMDL. Thus, when a Great Lakes Restoration Initiative (GLRI) funding opportunity became available, MMSD commissioned a 3rd party TMDL study and developed TMDLs for phosphorus, sediment (as measured by total suspended solids), and bacteria in the Basin. The purpose of the TMDL study was to allocate loads of total phosphorus (TP), total suspended solids (TSS), and bacteria (fecal coliform) in a manner that will result in attainment of applicable designated uses and water quality standards throughout the Basin. MMSD developed the TMDLs with guidance from the WDNR and USEPA. A team of local agencies was established to lead the development of the TMDL study, referred to as the TMDL Development Team. The team included MMSD staff, SEWRPC staff, and Southeastern Wisconsin Watersheds Trust (Sweet Water) representatives, with assistance from WDNR and USEPA Region 5 staff. CDM Smith and several subcontractors provided consulting assistance to the TMDL Development Team. Much of the technical data and modeling used as the basis for the TMDL calculations was provided by SEWRPC. The TMDL calculation approaches and resulting load allocations were developed by and vetted through the TMDL Development Team.

The Milwaukee River Basin is comprised of the Menomonee River, Kinnickinnic River, and Milwaukee River watersheds, and the Milwaukee Harbor Estuary. The TMDL study area does not include an approximately 40-square-mile portion of the area known as the Lake Michigan direct drainage area. This area is drained by a number of small streams, drainage swales, and storm sewers that discharge directly to Lake Michigan. **Figure 1-1** presents the TMDL watershed study area. **Figures 1-2** through **1-5** present the study area by watershed. TMDLs for the different waterbodies within the Basin were developed simultaneously under a watershed framework to account for each waterbody's effect on downstream waters, for example, river reaches that flow into the Milwaukee Harbor Estuary.

The purpose of this document is to describe the overall TMDL development process, the water quality impairments within the Basin, the technical approach and assumptions used to develop TMDLs for each impaired waterbody, the load and wasteload allocations by source that must be met to achieve water quality standards and targets, and the management practices that can be considered for TMDL implementation. The allocated loads are presented in a series of tables in Appendix A to this document. An implementation plan for the TMDLs will be developed, as discussed in Section 7. Stakeholder input and coordination with cooperating agencies has been sought throughout the TMDL development process and will continue during development of the implementation plan.

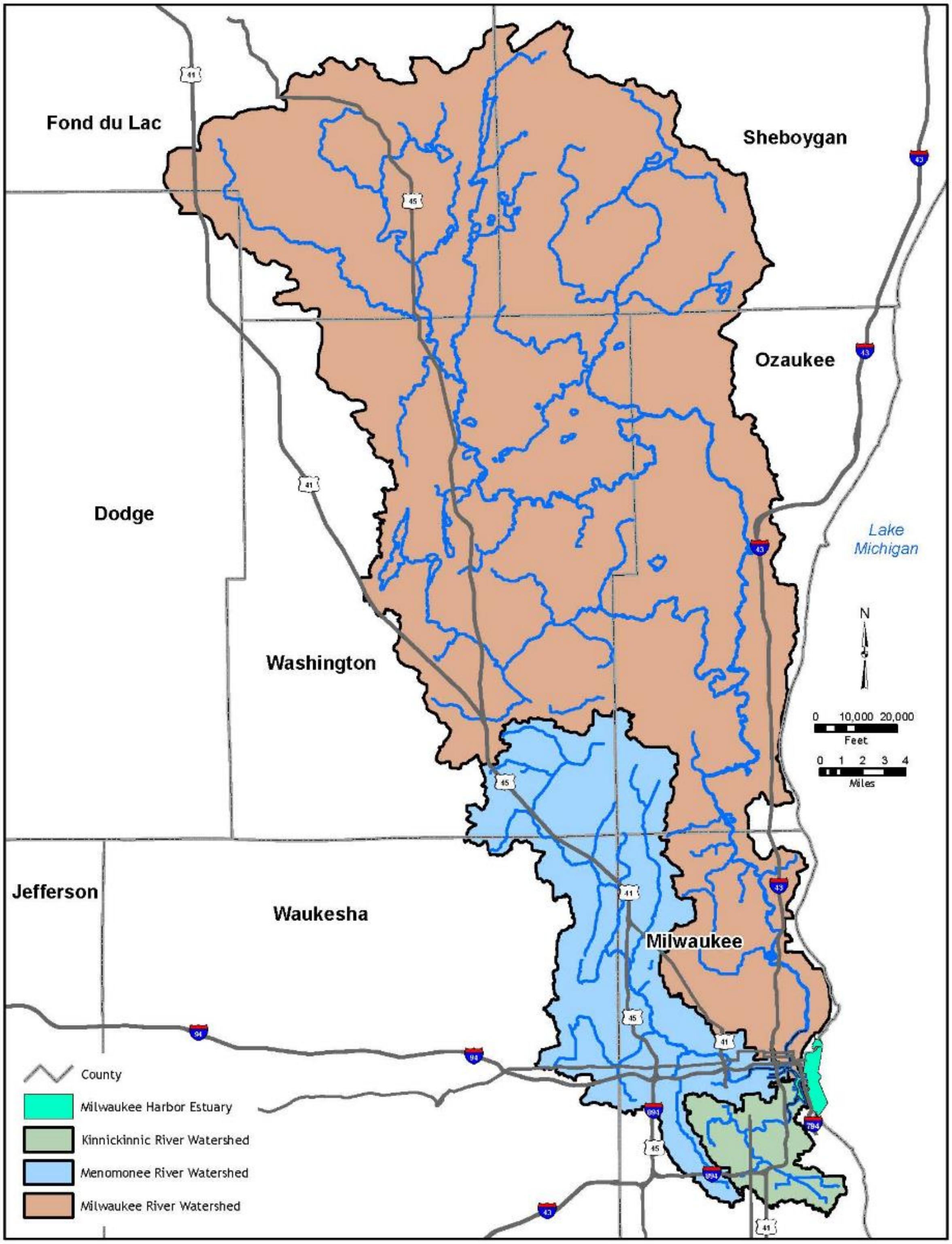


Figure 1-1. Milwaukee River Basin TMDL Study Area

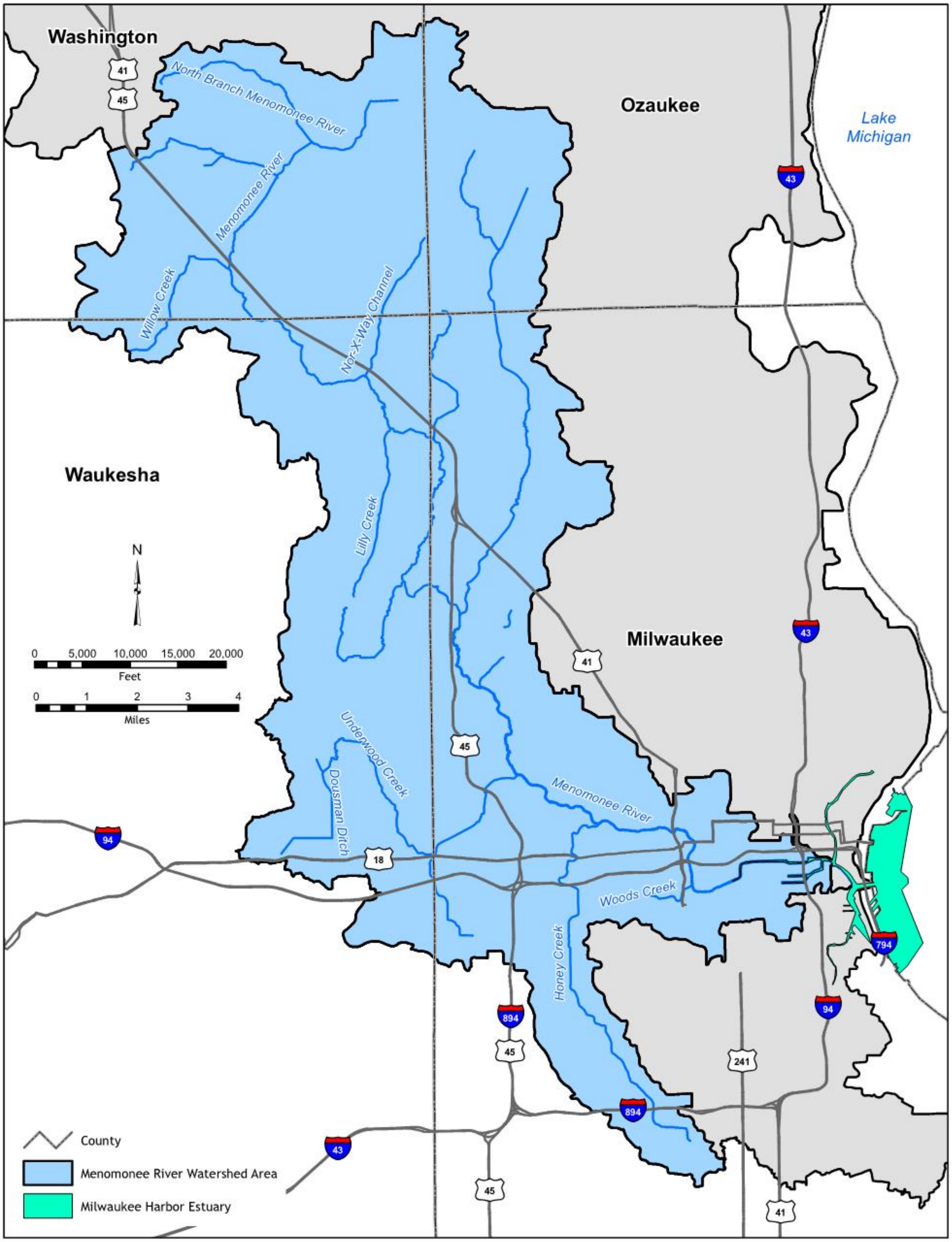


Figure 1-2. Menomonee River Watershed

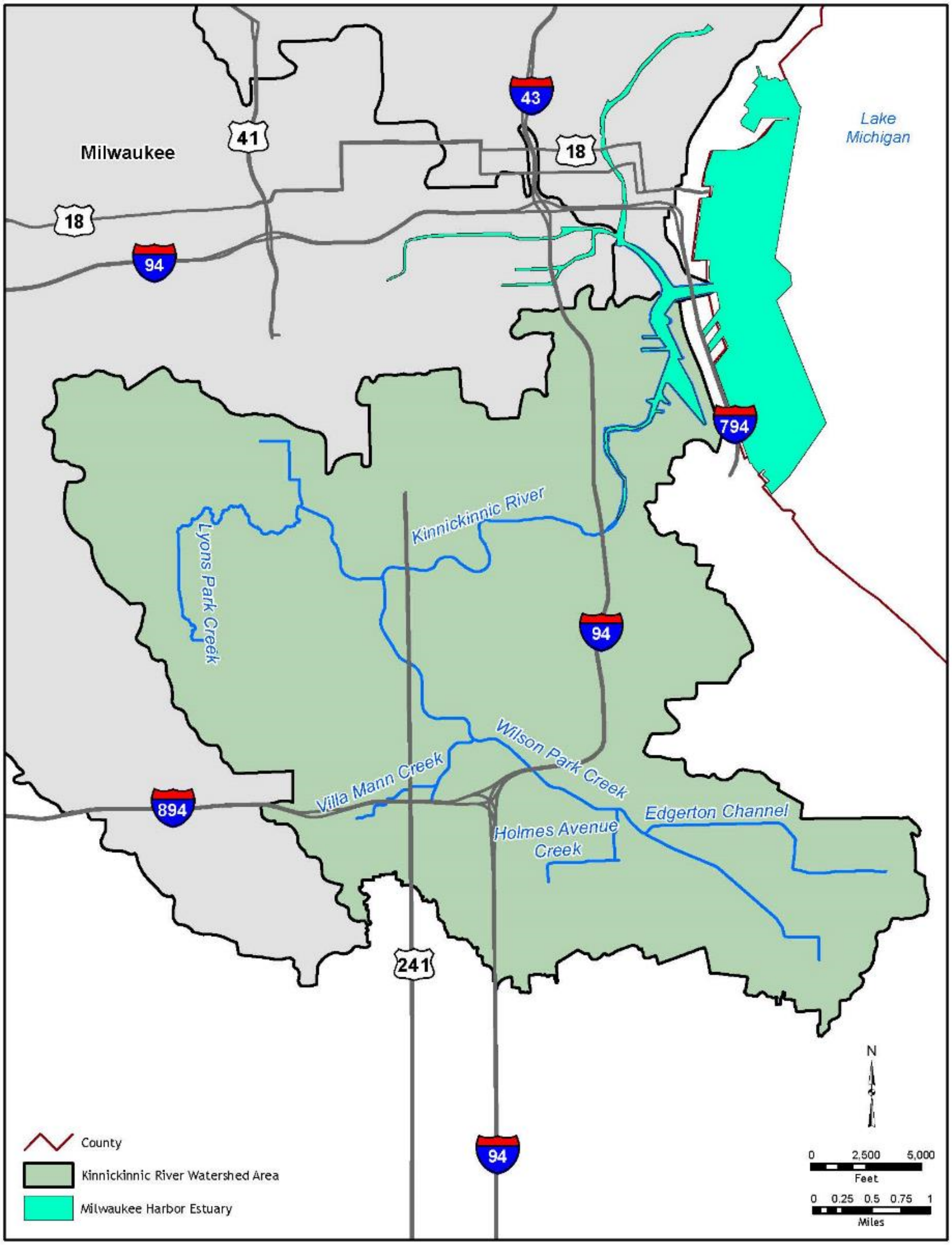


Figure 1-3. Kinnickinnic River Watershed

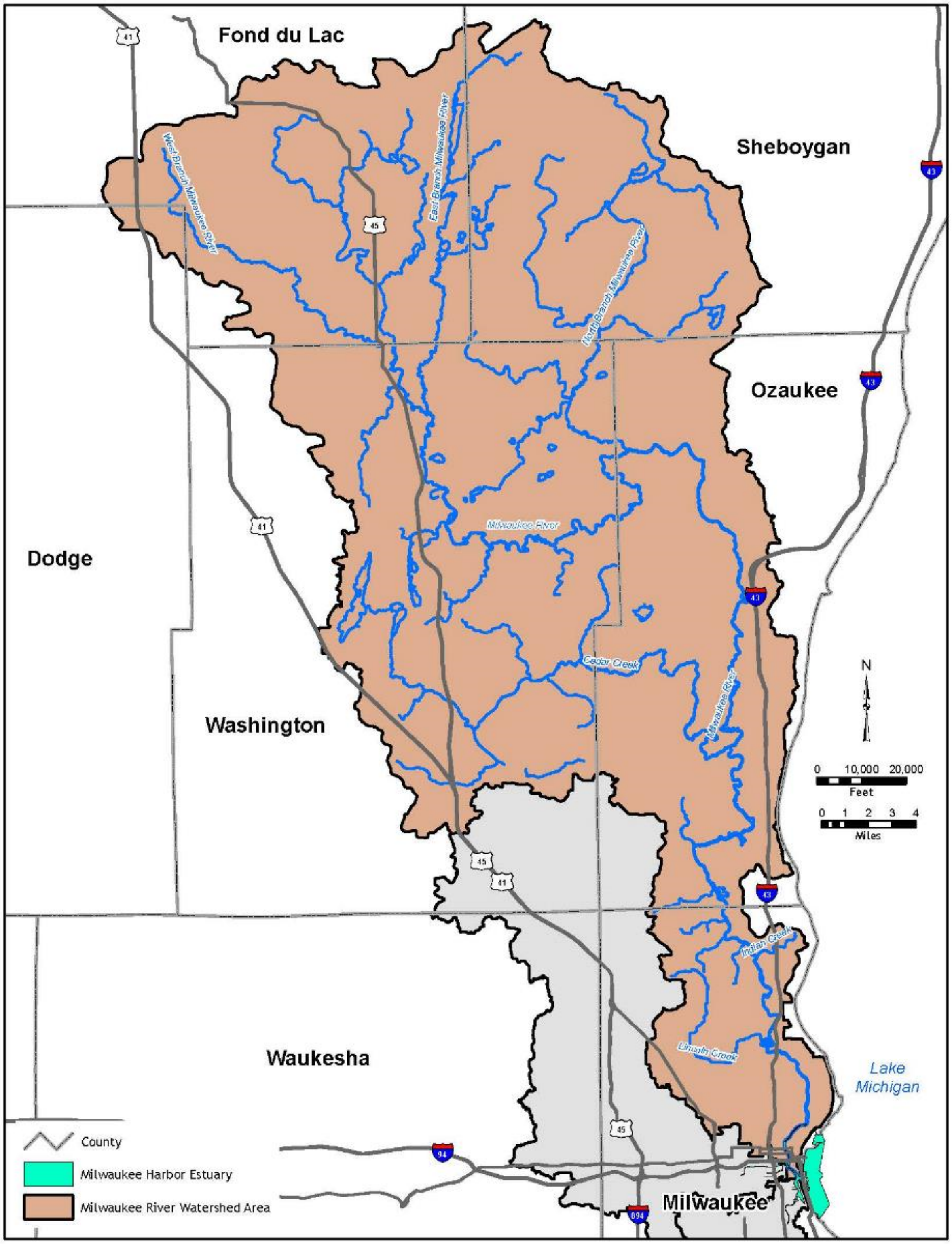


Figure 1-4. Milwaukee River Watershed

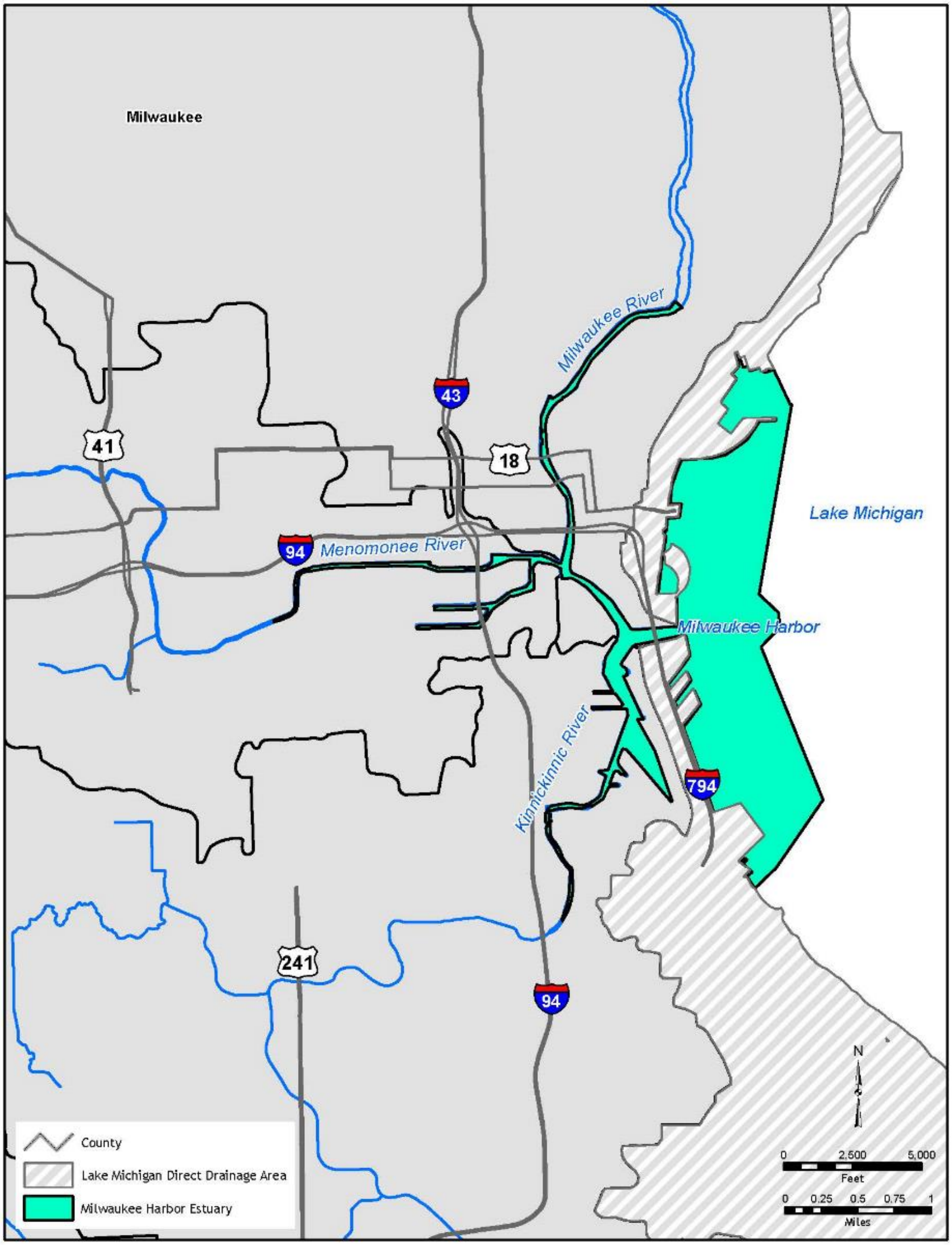


Figure 1-5. Milwaukee Harbor Estuary

1.1 Background

Investments made at the municipal and regional level in the Milwaukee, Menomonee, and Kinnickinnic watersheds have reduced pollutant contributions from wastewater effluents, stormwater discharges, and combined sewer and separate sewer overflows, yet manmade stressors continue to degrade water quality and threaten drinking water and the quality of life we all enjoy. The TMDL analysis is the right step forward for these watersheds. The TMDL analysis addresses pollutants from various sources, and facilitates partnerships and effective implementation. The TMDL provides the framework for restoring the desired uses and quality of our waters.

The waters of the Milwaukee River Basin have attracted people and supported our economy since the last glaciers retreated. To Native Americans, the waters offered an abundance of fish, wildlife, and plants that provided food, fiber, and medicine. Many areas where we now see rivers were then more modest streams, punctuated by vast marshes and swampland. Waterfowl flocked to these shores, nesting and resting on their long migrations.

The history of what happened next is well known. Rivers were dammed. Swamps were drained. Farms covered the landscape where plows dug deep furrows in the soil. Rivers were moved and literally put in boxes (channelized). The rivers became the first sewers. Beginning in the middle of the nineteenth century, the rivers experienced one abuse after another.

A series by the Milwaukee Journal Sentinel (Smith, 2014) chronicles much of this history—both the abuse and the beginnings of recovery—since the 1960s. The history of recovery includes the control of much of the pollution that once came from point sources, like sewage treatment facilities and industrial plants. Farmers are learning how new practices can save money and increase yields while still protecting the water and wetlands. Cities are learning new ways of building streets and street drainage to protect streams from flashy flows that rip away stream banks and threaten expensive infrastructure like bridges. Dotted across the landscape are innumerable efforts by watershed organizations, land trusts, and resource organizations like Ducks Unlimited. Protecting wetlands, replanting stream banks, and building rain gardens are helping to heal the waters. MMSD has spent over $380 million on watercourse improvement projects that typically involve replacement of concrete lining with a more habitat-sensitive and natural streambed, as well as buffer strips and other features to enhance water quality. MMSD plans to allocate over $400 million more for future improvements.

Because of these investments of money and care, the water is cleaner, safer, and capable of supporting more diverse wildlife than in the recent past. We also know that the way forward will require better information so that we can mark progress and find solutions that cost less while producing multiple benefits for the waters and for people. Phosphorus, sediment, and bacteria are often found together, so activities targeted at reducing one of the pollutants may also reduce the other two. Implementation planning after the approval of this TMDL will outline such practices.

This document provides background on the study area, summarizes the approaches used in the TMDL calculations, and outlines the level of pollutant reductions needed to make the rivers a safe place to fish and swim. Phosphorus, sediment, and bacteria are among the most serious and widespread pollutants in the watersheds. An explanation of why they are of concern is provided below.

1.1.1 Phosphorus

When a large amount of phosphorus enters a water body, it fertilizes the aquatic system, allowing more plants and algae to grow, leading to excessive aquatic plant growth, often referred to as an algal bloom. Eutrophication can be detrimental to aquatic life, reduce recreational opportunities, and affect the economic well-being of the surrounding community.

Overabundant aquatic plant growth in a water body can lead to a number of other undesirable consequences. Excessive growth of vegetation in a water body blocks sunlight from penetrating the water, choking out beneficial submerged aquatic vegetation. Large areas of excessive vegetation growth can inhibit or prevent access to a waterway, which restricts use of the water for fishing, boating, and swimming. Toxic blue-green algae (cyanobacteria) blooms can also occur in highly eutrophic areas, which may be harmful to fish and pose health risks to humans. Nearly all of these environmental impacts have economic impacts to the local community and the state.

1.1.1.1 Phosphorus Impacts

Although phosphorus is an essential nutrient for plant growth, excess phosphorus is a concern for most aquatic ecosystems. When a large amount of phosphorus enters a waterbody, it fertilizes the aquatic system, leading to excessive aquatic plant growth. This condition of nutrient enrichment and high plant productivity is referred to as eutrophication. Overabundant aquatic plant growth in a waterbody can lead to a number of undesirable consequences, including shading of the water column, choking out of beneficial aquatic vegetation that stabilizes bottom sediments and serves as important habitat for macroinvertebrates and fish, and inhibiting or preventing access for fishing, boating, and swimming.

Figure 1-6. North Branch of the Milwaukee River
(Photo courtesy of Will Wawrzyn)

Blue-green algae (cyanobacteria) blooms can also occur in these highly eutrophic areas. These naturally occurring aquatic organisms can produce compounds that are toxic to people and animals. Health impacts include rashes, sore throat, stomach cramps, diarrhea, vomiting, headache, fever, muscle weakness, or difficulty breathing (Wisconsin DNR and Wisconsin Department of Health Services web searches, "Blue-Green Algae"). Pets may experience seizures, vomiting, or diarrhea after contact and/or ingestion with waters containing these toxins. The Department of Health Services reports that some dogs have died in Wisconsin from drinking waters experiencing a toxic algal bloom.

Algal blooms, particularly those that form surface scums, are unsightly and can have unpleasant odors. This makes recreational use of the waterbody unpleasant, and can affect the everyday quality of life of people who live close to the affected waterbody. When the large masses of aquatic plants from the bloom die, the decomposition of the organic matter depletes the supply of dissolved oxygen in the water, suffocating fish and other aquatic life. Depending on the severity of the low dissolved oxygen event, large fish kills can occur. Furthermore, depletion of oxygen can cause phosphorus release from bottom sediments (i.e., internal loading).

Previous studies of the amount and sources of phosphorus in our waters show that phosphorus can be traced to a variety of sources, in both rural and urban settings. Individual concentrations of total phosphorus in the mainstem rivers ranged from below the limit of detection to 3.0 mg/L (SEWRPC, 2007). The water quality standard is 0.1 mg/L for rivers and 0.075 mg/L for streams, as specified in ch. NR 102, Wis. Adm. Code. The mean concentrations of total phosphorus during the period of record used for TMDL development were 0.095 mg/L in the Kinnickinnic River, 0.116 mg/L in the Menomonee River, and 0.129 mg/L in the Milwaukee River (see Section 1.3.1 for more discussion).

Figure 1-7. Duckweed Bloom on the Little Menomonee, Downstream from County Line Road in Milwaukee County
(Photo courtesy of Will Wawrzyn)

1.1.1.2 Phosphorus in Rural Areas

Phosphorus is an element well-known to gardeners and farmers and is a key ingredient in the fertilizers purchased at garden centers for vegetable and flower gardens. Phosphorus is applied, either as manure or as commercial fertilizer, as an essential plant nutrient for growing food. But too much phosphorus on the land means phosphorus can reach surface waters in amounts that have a deleterious effect on water quality. Excessive growth of aquatic plants occurs when stimulated by phosphorus-rich waters, creating dissolved oxygen impairments within water bodies, and resulting in biological and habitat impairments.

Upstream in the rural parts of the Menomonee and Milwaukee watersheds, crop production and livestock operations can introduce phosphorus into streams indirectly through runoff or through direct loading. Manure is rich in phosphorus, and when livestock are pastured near streams or allowed to cross streams, manure can wash or be directly deposited into streams. Poor management of manure, including excessive application to farm fields or improper storage, can result in excessive loads of phosphorus entering waterbodies when it washes off the land or drains through tiles in its dissolved form. Commercial fertilizers can also be high in phosphorus, and can wash off of farms, golf courses, lawns, and other rural land uses during rain events. According to the Regional Water Quality Management Plan Update (SEWRPC, 2007), polluted stormwater runoff from rural areas accounts for 25 percent of the phosphorus in the streams of the Milwaukee River Basin. Another source is from small, rural areas where stormwater runoff from precipitation events can pick up pet waste, fertilizer, and other phosphorus-containing organic material. These materials can break down and release phosphorus into the waterbody. Septic tank effluent, which contains 80 to 100 percent of the phosphorus concentration in raw sewage (Lusk *et al.*, no date), can enter streams as a result of failing septic systems. Phosphorus is present in any soil containing organic

Figure 1-8. Milwaukee River, Upstream from Grafton
(Photo courtesy of Will Wawrzyn)

matter so any soil erosion event contributes some level of phosphorus to surface waters regardless of land use.

1.1.1.3 Urban Sources of Phosphorus

Sources of phosphorus in urban areas include municipal and industrial wastewater effluents, sewer overflows, and stormwater. According to the Regional Water Quality Management Plan Update (SEWRPC, 2007), polluted stormwater runoff in urban areas accounts for 25 percent of the phosphorus in the streams of the Milwaukee River Basin, while treated wastewater discharges and sewer overflows account for 48 percent and 2 percent of phosphorus in our waters, respectively.

Stormwater runoff consists of rain and melting snow that washes away pollutants from rooftops, driveways, lawns, streets, parking lots, construction sites, and industrial storage yards. Storm sewers are separate pipes that collect stormwater runoff from inlets, catch basins, or drains that are generally located along street curbs and in parking areas. Storm sewers convey the stormwater to rivers, streams, and lakes. Unlike sanitary sewers which collect wastewater from homes and businesses and convey it to a wastewater treatment plant, most storm water does not go to a wastewater treatment plant but rather relies on treatment and management practices such as rain gardens, swales, infiltration practices, wet ponds, street sweeping and bioretention systems.

Overflows that occur in combined sewer systems where sanitary flow is contained in the same pipe as stormwater are called Combined Sewer Overflows (CSOs). Parts of Milwaukee and Shorewood are served by combined sewer systems. Under most flow conditions, both stormwater and sewage from these systems are conveyed to and treated at the wastewater treatment plant. During large rain events stormwater flow increases significantly, sometimes exceeding the conveyance and storage capacity of the combined sewer. Under these conditions, the system will discharge the stormwater/sewage mixture into nearby waterbodies.

Overflows that occur in separate sewer systems where sanitary flow is contained in a separate pipe from stormwater are called Sanitary Sewer Overflows (SSOs). Though the pipes are separate, stormwater can enter the sanitary pipes during significant rain events and exceed the capacity of the system. Stormwater can enter sanitary pipes from improper connections such as sump pumps and roof drains that are hooked into the system, or from infiltration of water through leaks in the sanitary sewer pipes. Similar to CSOs, the stormwater/sewage mixture is discharged into nearby waterbodies to prevent it from backing up into homes.

1.1.2 Sediment and Total Suspended Solids

Waterbodies in the Basin have been identified as impaired for both total suspended solids (TSS) and sedimentation. Eroded material that enters streams and remains in suspension in the water column may be classified as TSS. As water velocities and turbulence decrease, particulates such as silt, sand, and gravel can eventually settle to the substrata resulting in sedimentation. As sedimentation is difficult to measure, the TMDL project focused on TSS to address the impacts of sediments in these waterbodies.

TSS is a mixture of soil particles, inorganic matter, and organic matter. These materials enter a waterbody by a variety of means, such as farm field erosion, stream bank erosion, suspension of river sediment that is churned up by high flows or other disturbance of the stream bottom, stormwater runoff from urbanized areas such as parking lots and streets, and direct discharges from wastewater treatment plants. TSS is measured as the total weight of material per volume of water. A related impact is turbidity, which relates to the amount of light that penetrates the water or is scattered and dissipated.

Sedimentation contributes to shallower, filled-in lakes and streams as some of the solids settle out. These settleable solids can suffocate benthic organisms and fish eggs. In addition, the sediment may smother insect larvae and other fish food sources.

1.1.2.1 Sediment and TSS Impacts

Sedimentation is the process whereby substrata are covered and interstitial spaces are filled by deposited sediment. Sedimentation of substrata may be measured in several ways, including the area of streambed covered, the depth of sedimentation, the size classification of sediment covering the substrata, and the percentage of interstitial spaces filled. When sediments settle to the bottom of a river, they can smother the eggs of fish and aquatic insects, as well as suffocate newly hatched insect larvae. Settling sediments can also fill in spaces between rocks, which could have been used by aquatic organisms for homes. Excess sediments can also cause an increase in surface water temperature, because the sediment particles absorb heat from sunlight. This can cause dissolved oxygen levels to fall even further (warmer waters hold less dissolved oxygen), and further harm aquatic life. Because some species are more tolerant of warmer waters and low dissolved oxygen, the species diversity decreases, and those species that are more tolerant tend to dominate the ecosystem. These are typically “rough fish” and some, such as Carp, can be responsible for re-suspending sediment.

In addition to its direct effects, sediment may also carry nutrients, heavy metals, and other pollutants into waterbodies. A large proportion of the phosphorus that moves from land to water is attached to sediment particles. This phenomenon can be seen in both spatial and temporal patterns of phosphorus and sediment movement. In general, this means that managing sediment sources can help manage phosphorus sources (Sharpley *et al.*, 1990). Phosphorus also moves off the landscape in a dissolved form, which is more readily available to algae (Robinson *et al*., 1992).

Total suspended solids (TSS) can scatter and absorb sunlight, reducing the amount of light that reaches submerged aquatic vegetation, thereby reducing its photosynthetic rate and growth. Bottom-rooted aquatic plants (called macrophytes) produce life-giving oxygen, provide food and habitat for fish and other aquatic life, stabilize bottom sediments, protect shorelines from erosion, and take up nutrients that would otherwise contribute to nuisance algae growth. If light is completely blocked from bottom dwelling plants, these plants will stop producing oxygen and die. The decomposition of organic matter can also deplete the supply of dissolved oxygen in the water, possibly suffocating fish and other aquatic life. Significantly reduced water clarity can also have direct impacts on aquatic fauna, including fish, waterfowl, frogs, turtles, and insects. Suspended sediments may interfere with the ability of fish and waterfowl to see and catch food, and can clog the gills of fish and invertebrates, making it difficult for them to breathe.

1.1.2.2 Rural Sources of Sedimentation and TSS

In rural portions of the basin, TSS and sedimentation is largely associated with agricultural practices that allow for the erosion of soil. Plowed fields during the fall and spring periods and row crops are especially susceptible to erosion. Farming practices that avoid soil disturbances or minimally disturb soils (like no-till farming and cover crop installation) are less likely to produce solids runoff. Grass swales, streambank stabilization, and stream buffers can minimize erosion of streambanks, helping to reduce the migration of soils to surface waters.

Figure 1-9. TSS in Rural Creek Not Protected from Erosion
(Photo courtesy of Will Wawrzyn)

Altered hydrology (or water flow) can also lead to increased solids loads. Tile drains convey water more quickly to streams, increasing the velocity of the stream and eroding streambanks more quickly. Stream channelization, where a stream is "straightened", can have the same effect. Construction activities in rural areas, as in urban areas, can cause sediment to run off the land surface during rain events and contribute to the solids load.

In rural areas with large stretches of woodland and wetland, solids runoff may be associated with natural organic materials flowing into streams. In this TMDL analysis, this source is allocated as part of the background TSS loads.

1.1.2.3 Urban Sources of Sedimentation and TSS

Urban areas can also contribute to high levels of TSS and sedimentation, but the sources are quite different. TSS in urban stormwater is a complex mixture. It includes metal from rusting vehicles, particles from vehicle exhaust, tires, brake linings, worn and weathered pavement, particles sloughed off from aging asphalt-shingled rooftops, and soot from residential chimneys as well as industrial smokestacks (UW Extension, 1997). The median particle size diameter from the Nationwide Urban Runoff Program particle size distribution for urban runoff modeling is eight times smaller than a grain of sand. The smaller the particle size, the greater the total surface area for adsorption of other pollutants such as phosphorus and heavy metals. Connected impervious areas such as highways, streets, and parking lots convey runoff readily and rapidly and thus are more efficient at transporting sediment and adsorbed pollutants to streams. For example, particles sloughed off of tires contribute cadmium and zinc particles; brake pads account for as much as 50 percent of the copper in streams (Natural Resources Defense Council, 1999).

Figure 1-10. Failing Streambank
(Source: SEWRPC Technical Report No. 39)

Another important source of TSS and sedimentation is soil erosion caused by construction activity. Although construction sites are required to prepare erosion and sediment control plans, plans are not always implemented properly and the practices are not always designed or installed to manage heavy rains. A single incident can result in a massive load of solids in a very short period of time.

Streambank scouring and erosion can be a significant source of solids, and is worsened by sharp peaks in runoff volume and flow in urbanized areas or during extended periods when streamflows are maintained at channel-forming volumes as a result of increased imperviousness. This is due to the fact that impervious areas eliminate the ability for the landscape to naturally store and infiltrate stormwater. This added volume is then delivered through municipal separate storm sewer systems (MS4s) well ahead of the peak flow that the receiving waterway experiences in response to the watershed at large. A waterway experiencing these effects is often referred to as a “flashy system.” Furthermore, when management techniques used to address peak flow do not address the total runoff volume, streams can spend longer periods of time at the channel-forming flow. Finally, manipulation of naturalized stream sections through concrete lining, enclosing, and straightening conveys water more quickly. This results in the loss of natural processes to control sediment and typically causes severe streambank scouring at the point where the system becomes naturalized again. MMSD continues to restore natural channels to streams to reduce this impact. Just like grass swales and stream buffers in rural areas, green infrastructure practices such as green roofs, permeable pavement, and bioretention (e.g., rain gardens), can store water, slow it down, and filter out sediment before it enters urban streams.

1.1.3 Fecal Coliform

The presence of fecal coliforms is indicative of fecal contamination and of the potential presence of enteric pathogens (disease-causing organisms that originate in the digestive system), especially bacterial pathogens. Higher levels of fecal coliform in a waterbody therefore indicates an increased risk of illness from ingestion of the water during recreational activities, restricting the waterbody’s use for certain types of recreation, and creating the potential for beach closures.

Feces may contain pathogenic bacteria, viruses, protozoa, and parasites. Because pathogens are not easily detected, fecal indicator bacteria are used to identify the presence of fecal contamination in waterbodies. A commonly used indicator organism is fecal coliform, a type of bacteria that live in the intestines of warm-blooded animals (humans, pets, farm animals, and wildlife). Presence of fecal coliform does not mean that disease-causing organisms are present, but signifies a high risk that disease causing organisms from human or animal feces may have reached the water. The risk of disease is greater when the source of the fecal matter is from human rather than animal sources (Frank, 2012).

While there are other indicator organisms used to detect bacterial contamination, including *E. coli*, fecal coliform has historically been the most commonly used indicator organism (Frank, 2011) and a large amount of fecal coliform data has been collected throughout the TMDL study area. Therefore, this TMDL effort focuses on fecal coliform bacteria as the indicator organism to address pathogen impairments in conformance with WDNR water quality standards and 303(d) list impairments.

Recreational water quality criteria for the outer harbor and nearshore area of Lake Michigan are based on *E. coli* concentrations, so an *E. coli* to fecal coliform translator was developed for the TMDL effort, as discussed in Section 3.2.3. While the TMDL allocations are expressed only in terms of fecal coliform, enteric pathogens are the cause of the impairments that the TMDL is intended to address.

1.1.3.1 Bacteria Impacts

Pathogen contamination of surface water can cause water borne illnesses, including diarrhea, from bacteria, viral, and fungal microorganisms (Craun *et al*., 2006). Pathogens can cause gastrointestinal illness and diseases such as typhoid, dysentery, hepatitis A, and cholera. Sampling for the presence of fecal coliform as an indicator of disease causing organisms is performed in recreational and drinking waters to indicate the risk of contamination to drinking water supplies and risk of illness from recreational activities such as wading, swimming, and boating.

1.1.3.2 Rural Sources of Bacteria

In rural areas, bacterial contamination is mainly associated with livestock management and manure applications. Where animals are kept and how manure is managed determines whether fecal coliform reaches a river or stream. For example, livestock wading in a stream (**Figure 1-11**) can result in significant bacteria loads. Where livestock are pastured adjacent to a stream, rain events can wash manure into the waterbody. Manure is often used as fertilizer on agricultural fields, and can run off into adjacent waterbodies during precipitation events.

Figure 1-11. Livestock in Creek
(no photo credit)

Septic tanks are another potential source in rural areas. When a septic drain field fails, septic effluent can pond at the surface and either drain or wash into a waterbody. Wildlife may also contribute to fecal loads in rural areas.

1.1.3.3 Urban Sources of Bacteria

Fecal contamination can also come from human and animal sources in urban areas. Just as with rural areas, wildlife (birds and mammals) can be contributors in areas where they gather in large numbers. For example, high concentrations of resident Canada Geese in some urban parks or associated with stormwater ponds can be a significant source of fecal material. On some beaches in the Milwaukee area, gulls are a major source of fecal pollution. While rural areas have concentrations of livestock, urban areas have concentrations of pets, with dogs being the greatest source of pet-related fecal material. Bacteria from wildlife and pets collect on the impervious surfaces and can be washed into the storm sewer system and eventually discharged into waterbodies.

Human sources of fecal matter in our rivers are associated with multiple pathways. In the Milwaukee area, CSOs and SSOs can occur throughout the urban areas of our watersheds. The Regional Water Quality Management Plan found that in the Milwaukee River watershed 6.6 percent of the fecal load in streams was from CSOs and about 3.3 percent was from SSOs on an annual basis. CSOs occur about 2-3 times per year. SSOs occur more frequently, but discharge a lower overall volume. Ninety percent of the fecal load was found to be from runoff (urban and rural combined). Watershed Restoration Plans completed for the Menomonee and Kinnickinnic Rivers (http://www.mmsd.com/waterquality/water-quality-research-group) found that in large portions of these watersheds, the source of the fecal load was "unknown." Potential sources of this "unknown" load are improper connections of sanitary sewers to storm sewers and leaking sewer pipes, especially from the hundreds of miles of private sewer laterals that are not as frequently inspected and replaced compared to municipal sewer lines, or the build-up and wash-off of bacteria from impervious surfaces associated with dry-weather illicit discharges and wet weather flows.

An ongoing study by Milwaukee Riverkeeper (http://milwaukeeriverkeeper.org/bacteriatesting/) shows the potential magnitude of human fecal matter in our rivers. **Figure 1-12** shows locations along a portion of the Menomonee River where special analysis (using a human-specific indicator organism called *Bacteroides*) to identify human fecal contamination was performed. Of 92 stormwater outfalls targeted for testing for human fecal material because of high fecal coliform loads, 25 had human fecal contamination at all times sampled, in wet or dry weather, suggesting the presence of improper connections between the sanitary and storm sewer systems.

In one area suspected of having problems with leaky sewer laterals, inspections of 76 private laterals revealed that 21 had major leaks, averaging 3 gallons per minute. This means that a normal toilet flush could completely escape from the sewer pipe. Another 20 laterals had more moderate leaks (Frank, 2013). This leaking sewage can infiltrate either into the storm sewer pipe bedding or into the sewer directly at broken sections of pipe or connections and eventually be discharged to waterbodies.

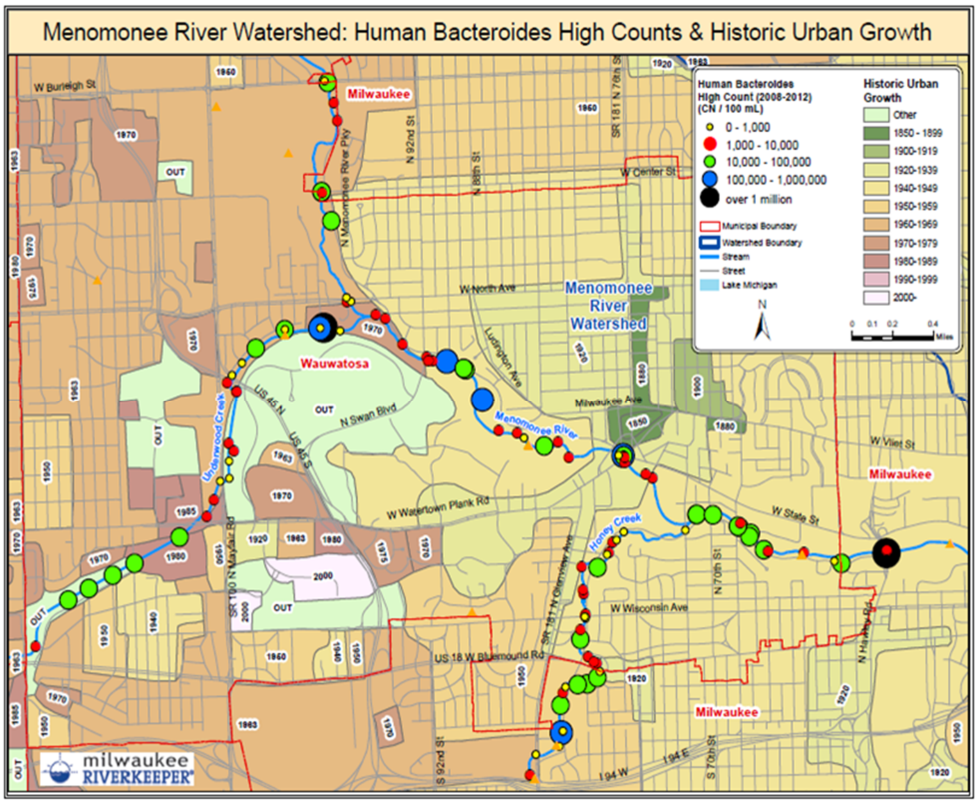


Figure 1-12. Menomonee River Watershed Human *Bacteroides* Concentrations
(Source: Milwaukee Riverkeeper)

1.1.4 Role of the TMDL Analysis in Addressing Phosphorus, TSS, and Bacteria

The TMDL analysis evaluates and quantifies pollutant loadings to our rivers from all sources, and quantifies baseline loads and load reduction targets for urban and rural runoff by smaller subwatershed management units (See Appendix A). Baseline conditions, flows and loads for each source are discussed further in Section 4. Because sources of phosphorus, solids (expressed as TSS), and bacteria (expressed as fecal coliform) are reported at the subwatershed scale, the study will assist landowners, regulators, and watershed organizations to better target efforts at reducing these pollutants in rural areas entering surface waters because they will know which areas and which sources are contributing the highest phosphorus loads. Identifying areas with the highest loadings will also assist municipalities with targeting the location of new or retrofitted stormwater management facilities and green infrastructure in urbanized areas.

Many industrial and municipal wastewater treatment facilities already have permit limits (either technology-based effluent limits or "TBELs" or water quality-based effluent limits or "WQBELs") for phosphorus, TSS, and fecal coliform. These limitations may be revised, as necessary and appropriate to conform to the requirements of the TMDL. If limitations are not already included in WPDES permits, limits must be included in the upcoming permitting cycle following approval of the TMDL.

1.2 Technical Foundation for the TMDLs

In the last ten plus years, there has been extensive study of water quality in the Milwaukee River Basin. From 2003 to 2007, SEWRPC prepared the Regional Water Quality Management Plan Update (RWQMPU). Created in 1960, SEWRPC is the official metropolitan planning organization and regional planning commission for the seven county southeastern Wisconsin area. SEWRPC prepared the RWQMPU in its role as the state-designated and federally-recognized areawide water quality management planning agency for the southeastern Wisconsin region. The RWQMPU is documented in SEWRPC Planning Report No. 50 (PR-50), entitled "Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds" (SEWRPC, 2007, http://www.sewrpc.org/SEWRPCFiles/Publications/pr/pr-050_part-1_water_quality_plan_for_greater_mke_watersheds.pdf). The "Greater Milwaukee Watersheds" is an area defined by SEWRPC that includes the watersheds for which the TMDLs were calculated. The objectives of the RWQMPU were to: 1) evaluate current water quality conditions with respect to designated use objectives and associated water quality standards; 2) evaluate methods of improving water quality through the reduction of water pollution; and 3) recommend the most cost-effective approaches to improving water quality over time.

A companion report, SEWRPC Technical Report No. 39 (TR-39), entitled "Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds" (SEWRPC, 2007, http://www.sewrpc.org/SEWRPCFiles/Publications/TechRep/tr-039-part-01-water-quality-greater-mke-watersheds.pdf), presents the data upon which the RWQMPU was based. TR-39 characterizes existing water quality conditions, trends over time, and sources of water quality pollution. SEWRPC's studies were performed in parallel with MMSD's 2020 Facilities Plan, which focuses on water quality within the MMSD planning area. Both studies have a common goal of improving water quality in Southeastern Wisconsin and together are referred to as the Water Quality Initiative (WQI) for the region.

The work completed for the WQI set a foundation upon which scientifically sound TMDLs could be developed. The studies provided valuable information on existing water quality, identification, and quantification of pollutant sources, and recommendations for activities to achieve required pollutant reductions. The WQI work was prepared under the guidance of a technical advisory committee, of which WDNR and USEPA were members. Models that were developed for the WQI were used in the TMDL development.

1.3 Problem Statement

Under Section 303(d) of the Clean Water Act, USEPA requires states to develop a list of impaired waters. This list is commonly referred to as a "303(d) list". Several segments of the Menomonee River, Kinnickinnic River, and Milwaukee River watersheds, and the Milwaukee Harbor Estuary are on WDNR's 303(d) list for the following impairments:

- Low Dissolved Oxygen
- Degraded Biological Community
- Degraded Habitat
- Recreational Restrictions – Pathogens

Pollutants contributing to these impairments are Total Phosphorus (TP), Total Suspended Solids (TSS), and Bacteria (fecal coliform and *E. coli* indicator bacteria).

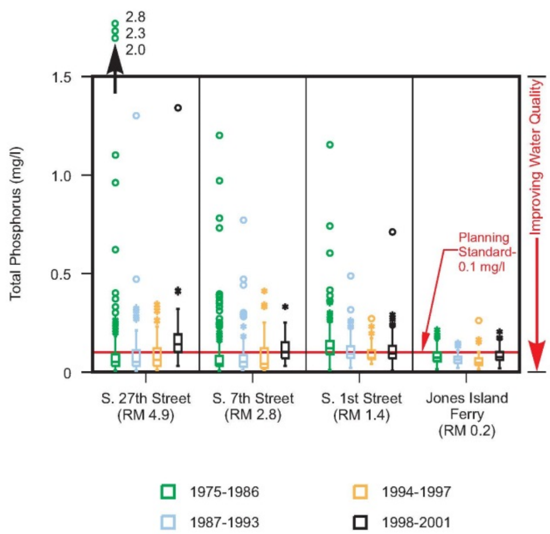
The RWQMPU documents describe historical water quality throughout the Basin. Considerable data have been collected on the mainstems of the major rivers, with additional data collected from smaller tributaries. Select figures (box and whisker plots) from the RWQMPU documentation are provided below to illustrate water quality conditions in the Menomonee River, Kinnickinnic River, and Milwaukee River watersheds. Major sources of data include MMSD, WDNR, the U.S. Geological Survey (USGS), the Washington County Land and Water Conservation Division, the City of Racine Health Department, the University of Wisconsin-Milwaukee, and the USEPA STORET legacy and modern databases. Additional data is available on MMSD's website http://www.mmsd.com/waterquality/wq-monitoring-data.

1.3.1 Total Phosphorus

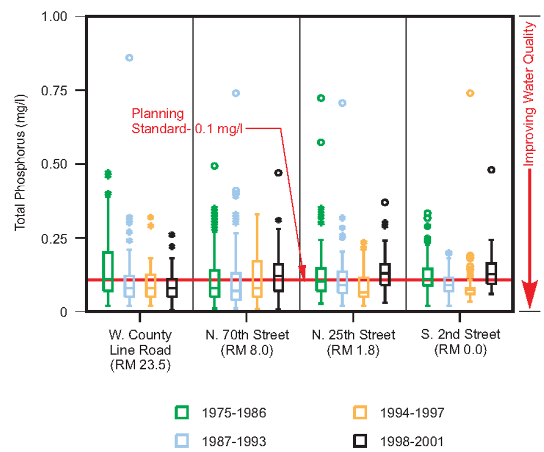
Concentrations of total phosphorus in the mainstem rivers of the Basin ranged from below the limit of detection to 3.0 mg/L (SEWRPC, 2007). The RWQMPU documents provide more detailed information for each of these water quality parameters. Period of record, water quality trends, mean values, median values, and concentration plots are provided.

The mean concentrations of total phosphorus during the period of record (2003 – 2007) were 0.095 mg/L in the Kinnickinnic River, 0.116 mg/L in the Menomonee River, and 0.129 mg/L in the Milwaukee River. The water quality criteria of 0.1 mg/L for non-wadeable (i.e., larger) streams and 0.075 mg/L for wadeable (i.e., smaller) streams, listed in ch. NR 102, Wis. Adm. Code, were often exceeded. Data collected in 2014 by MMSD, WDNR, and Milwaukee Riverkeeper staff and stream monitoring volunteers showed that out of 450 samples analyzed only 43% were meeting the water quality criteria (Milwaukee Riverkeeper, 2014).

TOTAL PHOSPHORUS CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE KINNICKINNIC RIVER: 1975-2001

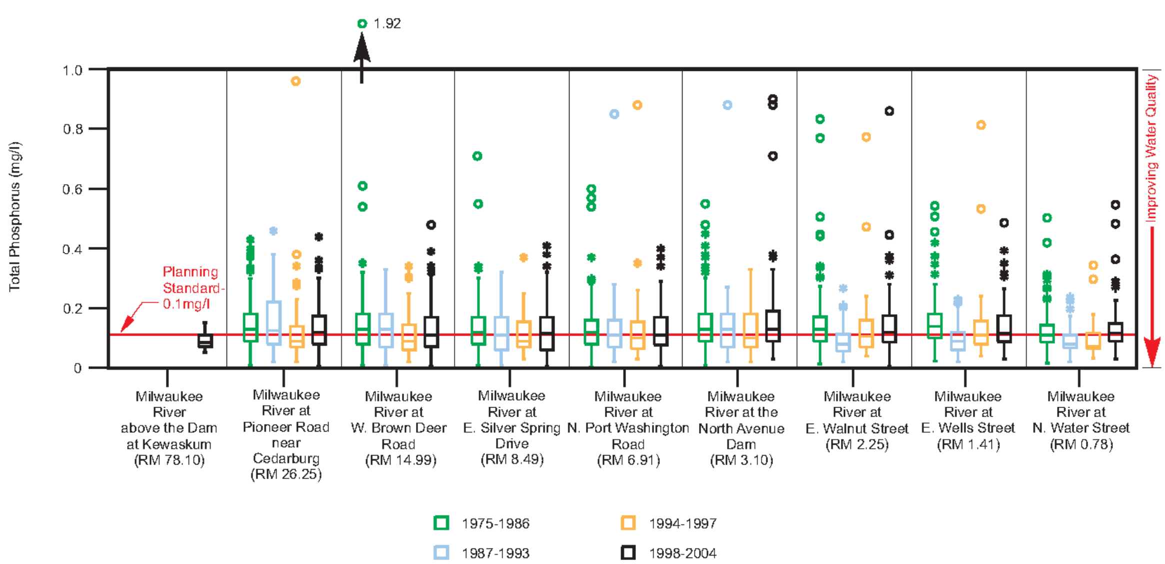


TOTAL PHOSPHORUS CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MENOMONEE RIVER: 1975-2001



Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

TOTAL PHOSPHORUS CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MILWAUKEE RIVER: 1975-2004



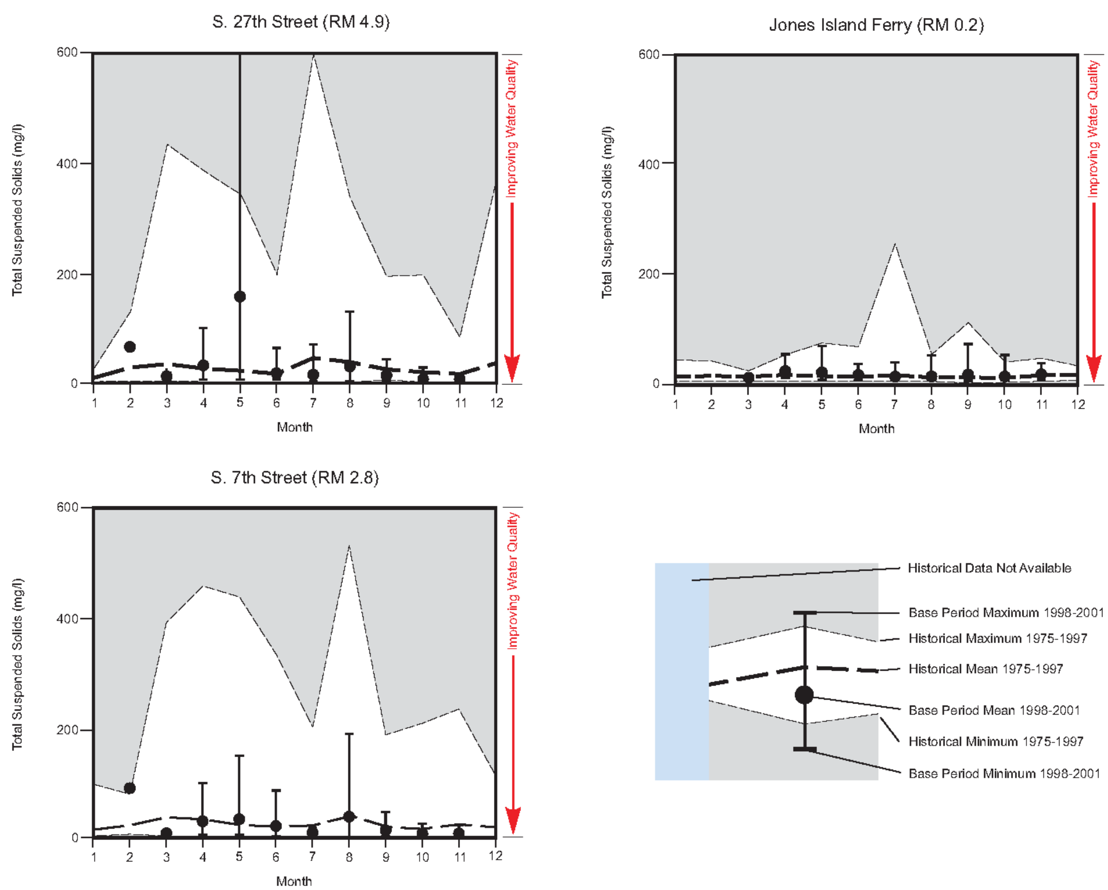
Source: U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

1.3.2 Total Suspended Solids

Concentrations of total suspended solids in samples collected from the mainstem rivers of the Basin show considerable variability, ranging from below the detection limit to 1,400 mg/L (SEWRPC, 2007). The mean concentrations of TSS during the period of record (2003 – 2007) were 20.5 mg/L in the Kinnickinnic River, 21.4 mg/L in the Menomonee River, and 25.1 mg/L in the Milwaukee River. A water quality target of 12 mg/L, expressed as the median of monthly samples collected between May and October, was established for this TMDL effort. See Section 3.2.2 for additional background on how 12 mg/L was selected as a water quality target.

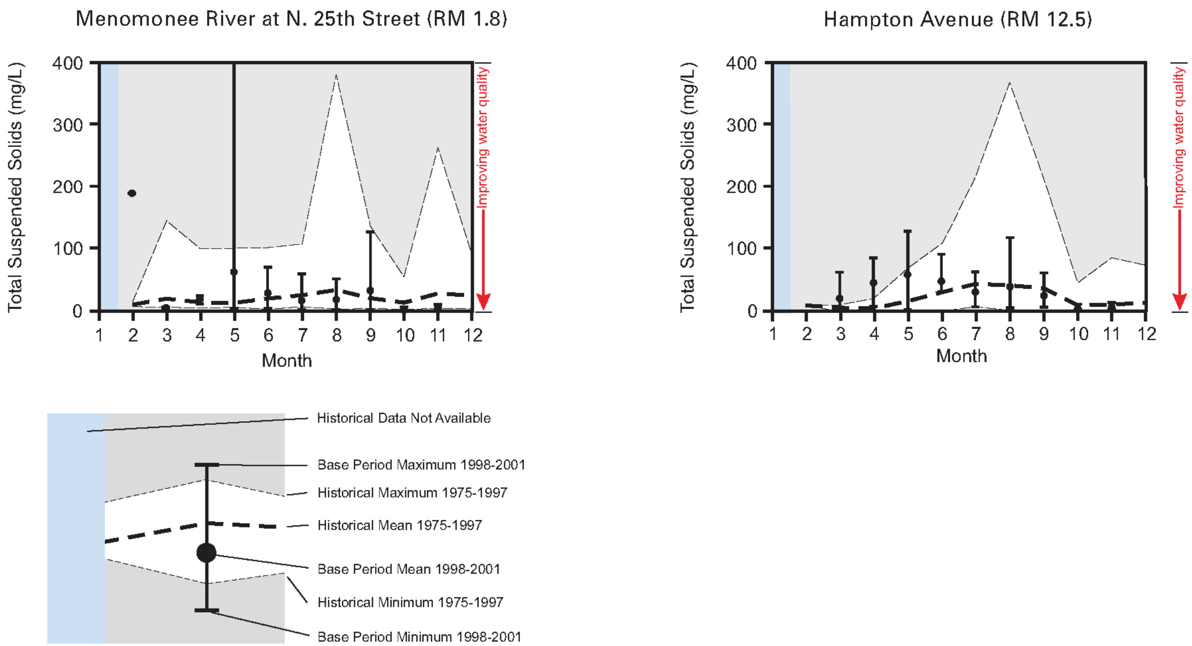
Data collected in 2014 by MMSD, WDNR, and Milwaukee Riverkeeper staff and stream monitoring volunteers showed that out of 435 turbidity measurements taken only 68% were meeting a water quality target set by the height in the transparency tube being at least 54.7 cm, which indicates turbidity acceptable for aquatic life (Milwaukee Riverkeeper, 2014). Significant portions of the Basin also show signs of sedimentation. Original gravel and cobbled substrate have been filled with sediment and portions of streams and rivers have required dredging to maintain navigability.

HISTORICAL AND BASE PERIOD CONCENTRATIONS OF TOTAL SUSPENDED SOLIDS ALONG THE MAINSTEM OF THE KINNICKINNIC RIVER: 1975-2001



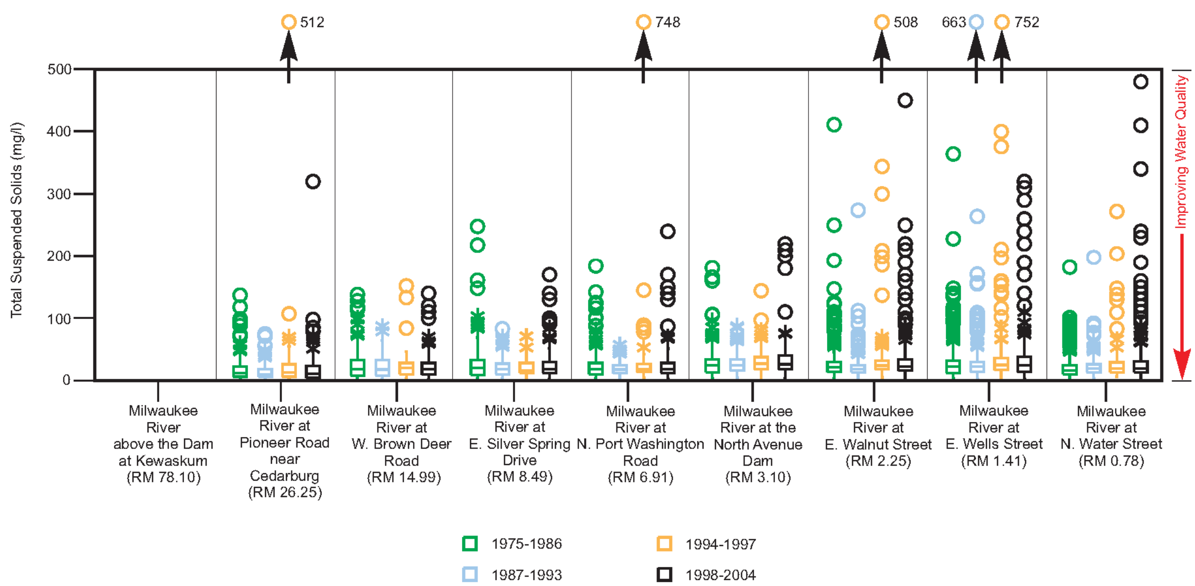
Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

HISTORICAL AND BASE PERIOD CONCENTRATIONS OF TOTAL SUSPENDED SOLIDS ALONG THE MAINSTEM OF THE MENOMONEE RIVER: 1975-2001



Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

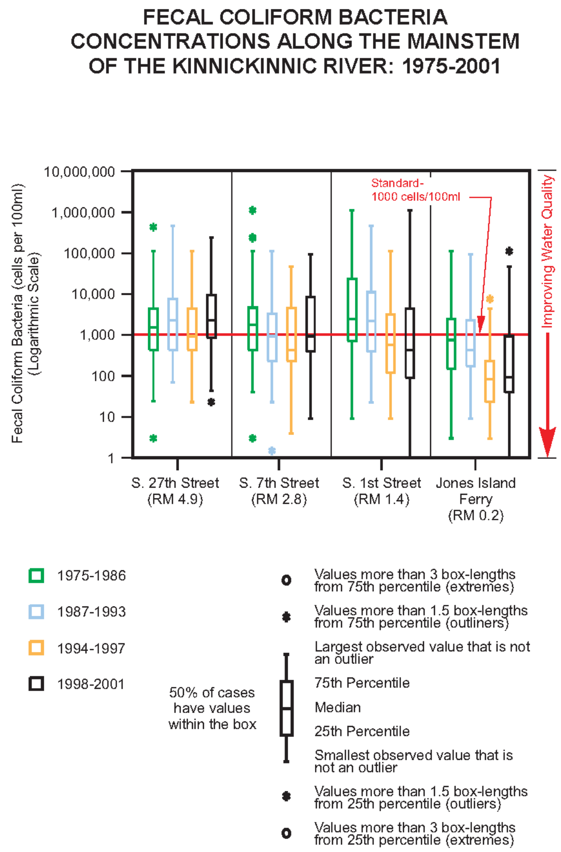
CONCENTRATIONS OF TOTAL SUSPENDED SOLIDS AT SITES ALONG THE MAINSTEM OF THE MILWAUKEE RIVER: 1975-2004

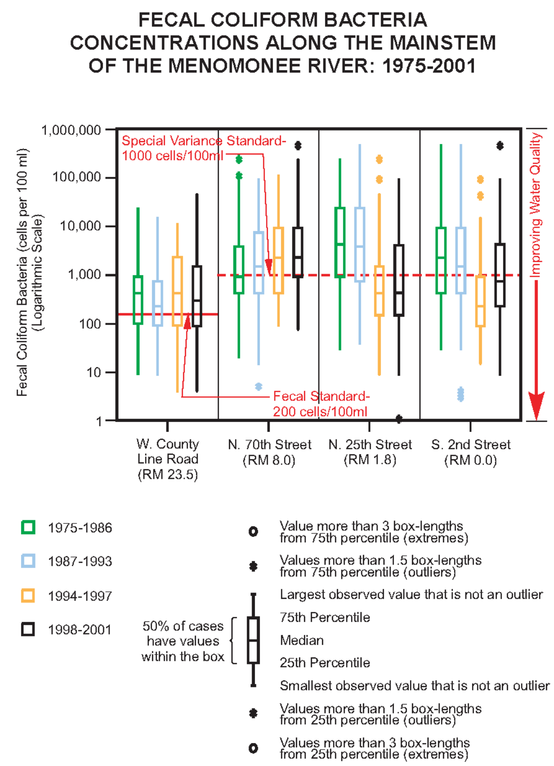


Source: U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

1.3.3 Fecal Coliform

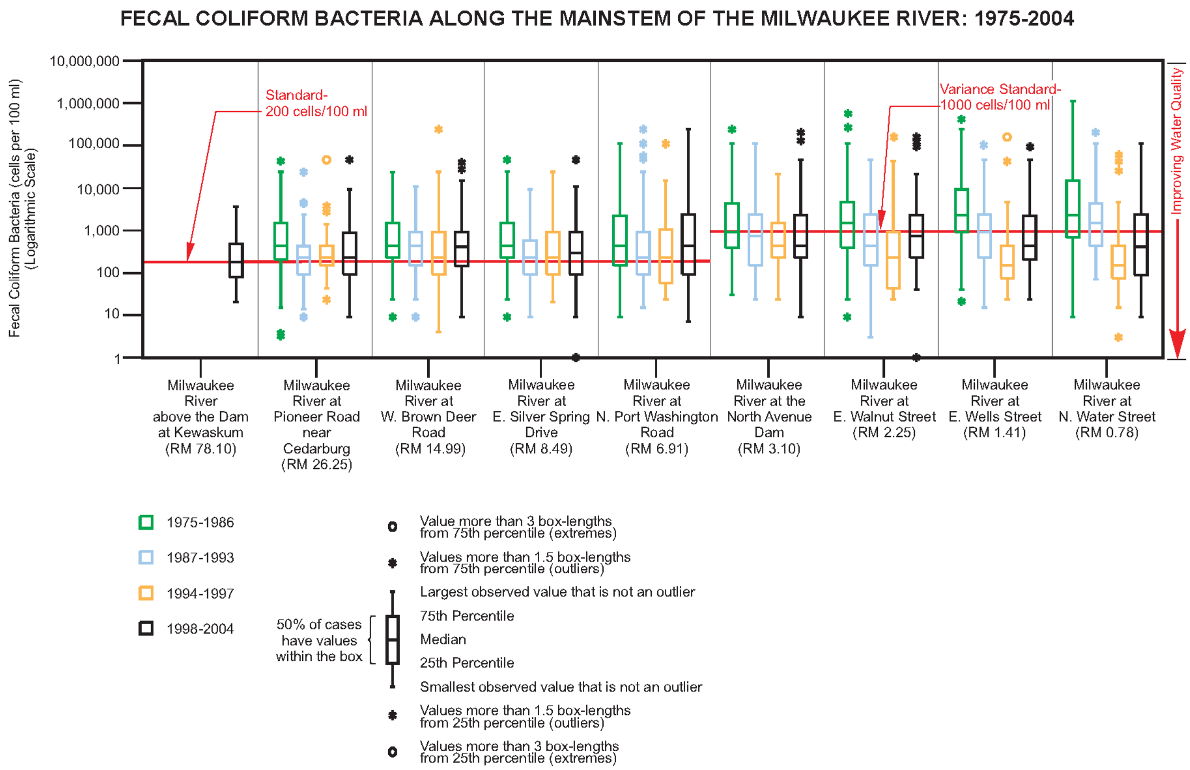
Bacteria measured as fecal coliform counts have ranged from less than one cell per 100 mL to over 2 million cells per 100 mL throughout the waterbodies in the Basin (SEWRPC, 2007). Counts in most samples exceeded the standard for full recreational use (200 cells per 100 mL geometric mean, s. NR 102.04(6), Wis. Adm. Code. Many samples of fecal coliform bacteria in the estuary, portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers exceeded the variance geometric mean standard of 1,000 cells per 100 mL (s. NR 104.06(2), Wis. Adm. Code). Data collected in 2014 by MMSD, WDNR, and Milwaukee Riverkeeper staff and stream monitoring volunteers showed that out of 238 samples analyzed only 50% were meeting the water quality criteria (Milwaukee Riverkeeper, 2014).





Source: *U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.*

MMSD has been routinely monitoring for *E. coli* in the Kinnickinnic, Menomonee, and Milwaukee Rivers since 2000. Concentrations of *E. coli* at stations along the mainstems of the rivers range from 0.5 to 160,000 cells per 100 mL, routinely exceeding existing beach water quality criteria (geometric mean of 126 cells per 100 mL and statistical threshold value of 410 cells per 100 mL as specified in s. 40 CFR Part 131.41; beach criteria listed here for comparison to measured concentrations in absence of stream criteria for *E.coli*). The mean concentrations in the estuary portion of the Milwaukee River were significantly higher than the mean concentrations in the river upstream from the estuary.



Source: U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

The 2014 303(d) list has been approved by USEPA and the 2016 303(d) list is pending USEPA approval. The TMDLs presented here are intended to address impairments on the 2014 303(d) list, but the TMDL allocations are calculated for both impaired and unimpaired waterbodies, so future listings for P, TSS, and bacteria will also be covered by these TMDLs. **Table 1-1** presents the approved 2014 303(d) listed waters and **Figures 1-13** through **1-16** present maps of the segments.

Table 1-1 also summarizes assessment units (stream miles), pollutants, impairments, and designated uses for each of the impaired waters covered in this TMDL study. Designated uses, sometimes also called “beneficial uses”, include public water supply, protection for fish and wildlife, recreational, and human health. Water quality criteria are designed to protect the designated uses, used to assess the general health of surface waters, and to set permit limits. The use designation process involves evaluation of the resource and its natural characteristics to determine the water’s highest ‘attainable’ use according to its potential.

Designated uses are specified in code (Chapters NR 104 and NR 102, Wis. Adm. Code) for each waterbody or segment, whether or not they are currently attained. If the designated use has not been specifically listed in code, its designated use is Fish and Aquatic Life (FAL), by default. In some cases, deviations from the standard designated use have been specified in code. These variances from the designated use are not permanent, but rather are to be revisited as new information becomes available. The variances listed in Table 1-1 for fecal coliform or dissolved oxygen are being reevaluated as part of this TMDL study. Based on the TMDL analysis, the variances for fecal coliform prevent downstream waters from attaining standards and are proposed for removal from ch. NR 104, Wis. Adm. Code.

For additional information on the waterbody use information presented, see WDNR's Surface Water Use Designations website: http://dnr.wi.gov/topic/SurfaceWater/usedesignations.html

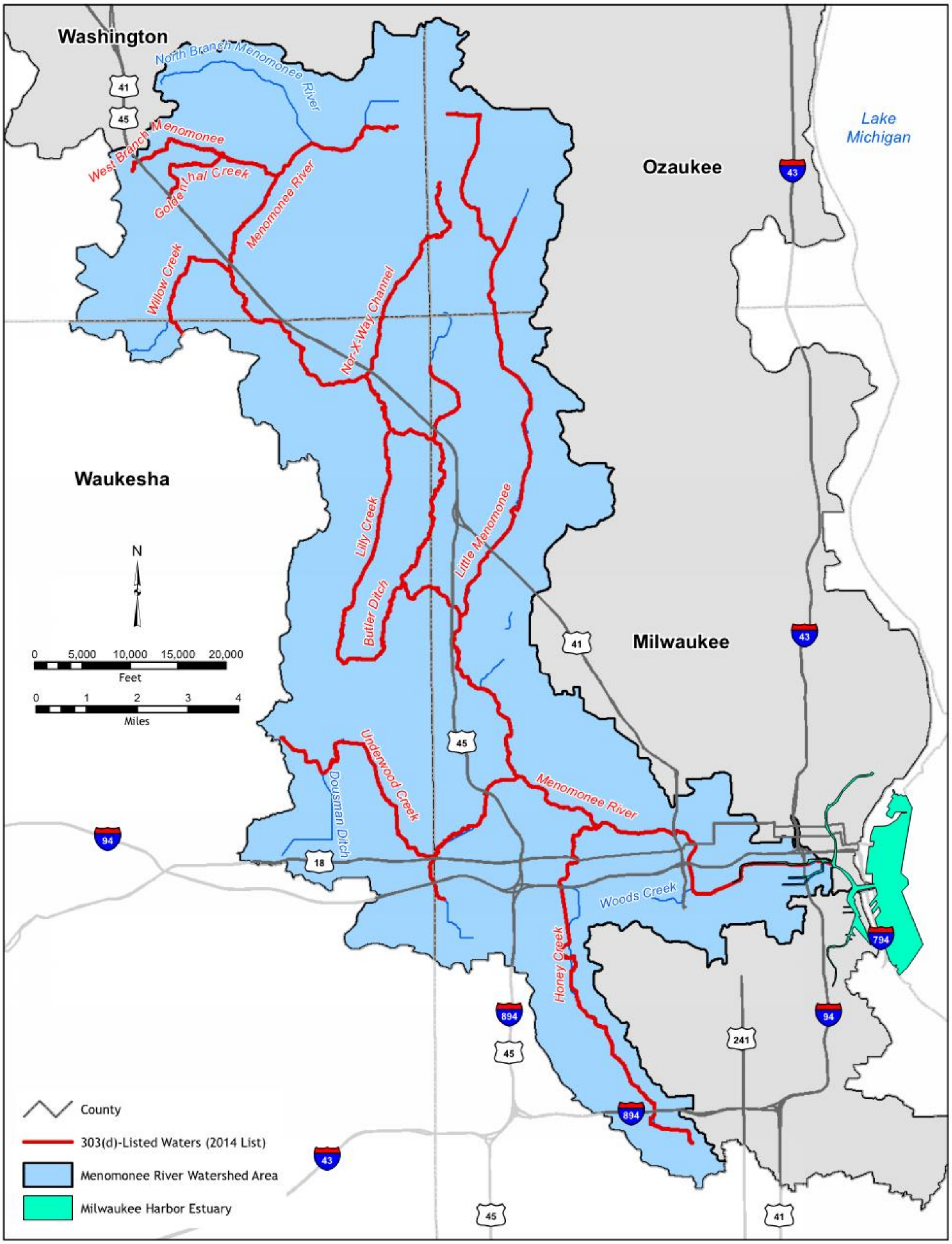


Figure 1-13. Impaired Waters in the Menomonee River Watershed

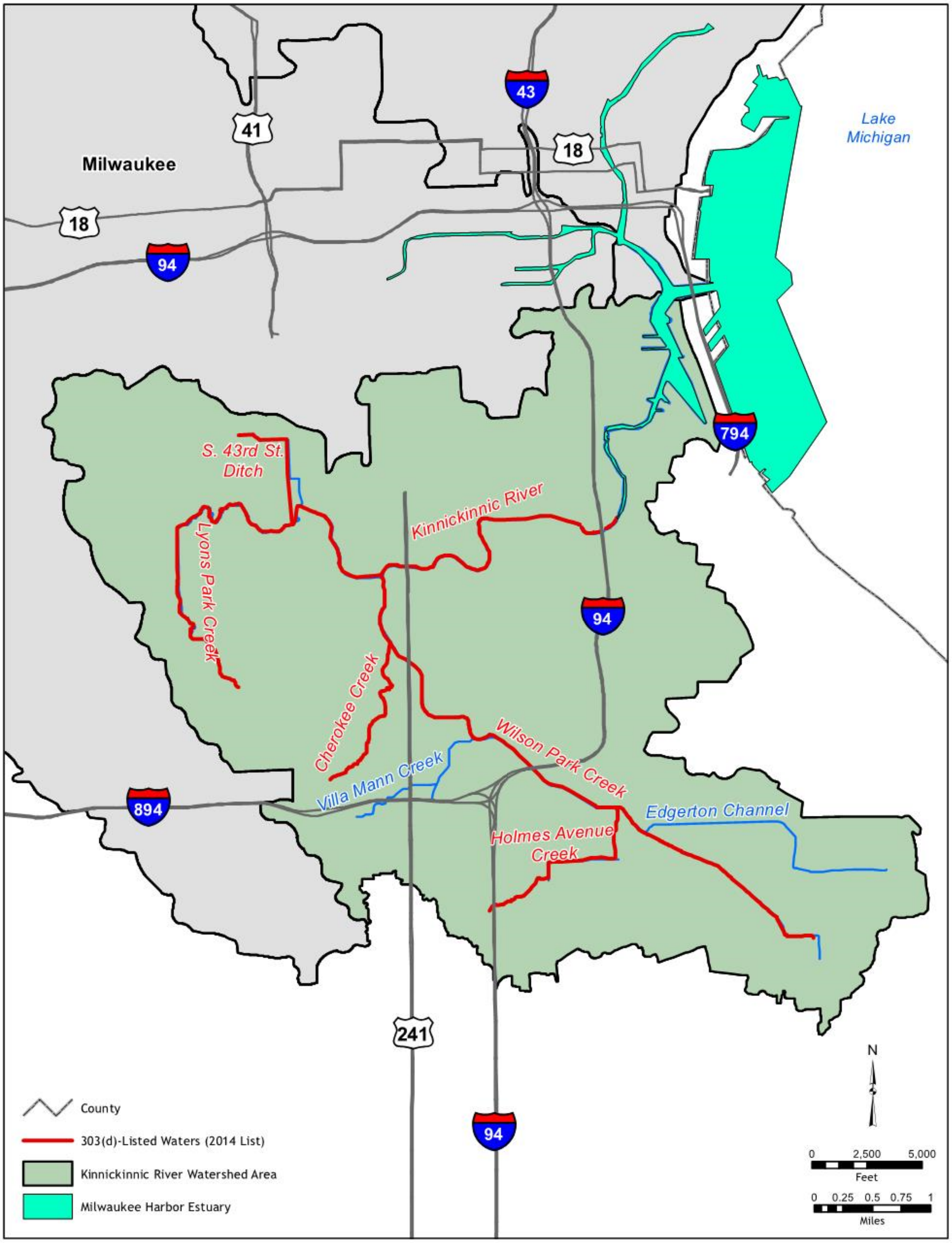


Figure 1-14. Impaired Waters in the Kinnickinnic River Watershed

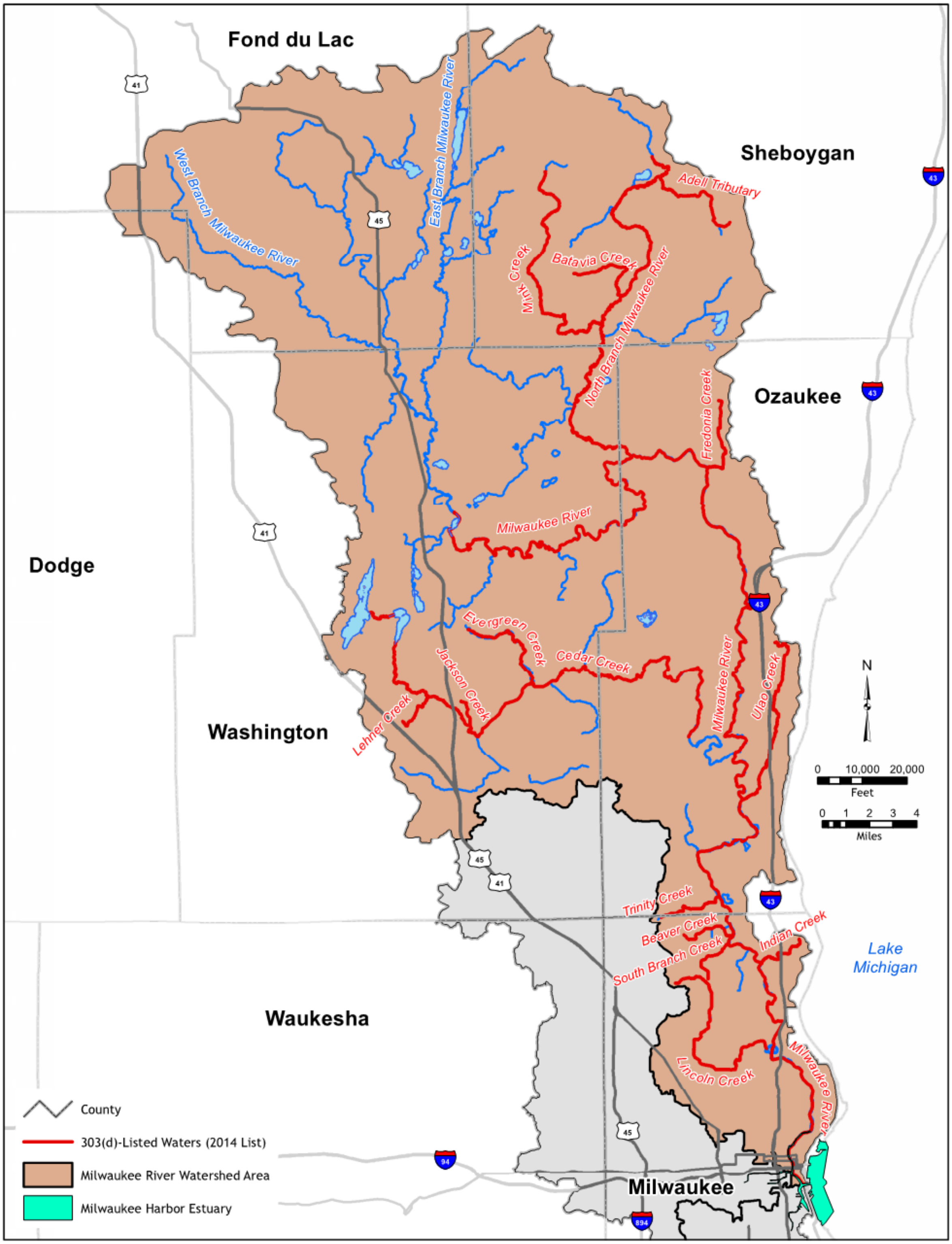


Figure 1-15. Impaired Waters in the Milwaukee River Watershed

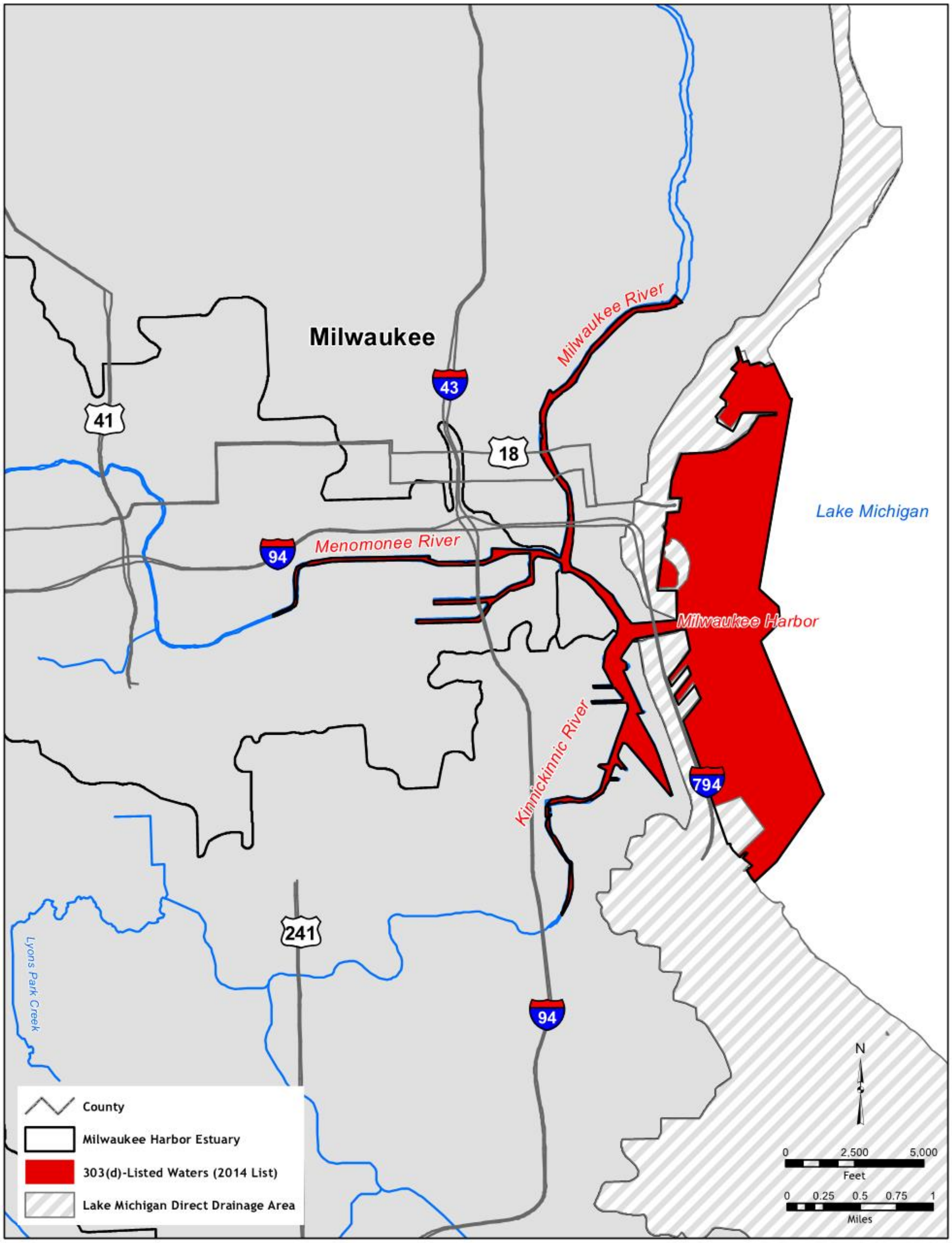


Figure 1-16. Impaired Waters in the Milwaukee Harbor Estuary

Table 1-1. Approved 2014 303(d)-Listed Segments Included in the Milwaukee River Basin TMDLs

Water Body	Description [1]	Representative TMDL Reach(es)	Counties	Water Body ID Code	Pollutants	Impairments	Current Status[2]	Designated Use [3]
Menomonee River Watershed								
Butler Ditch	Mile 0-2.90	MN-08	Waukesha	18100	Fecal Coliform	Recreational Restrictions – Pathogens	FAL – Supporting	Default FAL
Goldenthal Creek	Mile 0-3.50	MN-03	Washington	18900	Fecal Coliform	Recreational Restrictions – Pathogens	FAL – Not Assessed	Default FAL
Honey Creek	Mile 0-8.96	MN-15	Milwaukee	16300	Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Degraded Biological Community	FAL – Not Supporting	Default FAL Variance
Lilly Creek	Mile 0-4.70	MN-07	Waukesha	18400	Fecal Coliform	Recreational Restrictions – Pathogens	FAL – Not Supporting	Default FAL
Little Menomonee River	Mile 0-9	MN-09	Milwaukee, Ozaukee	17600	Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Degraded Biological Community	WWSF – Not Supporting	Default FAL
Menomonee River	Mile 2.2-2.67	MN-16	Milwaukee	16000	*E. coli*, Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Low DO	FAL – Not Supporting	Default FAL Variance
Menomonee River	Mile 2.66-6.27	MN-16	Milwaukee	16000	Fecal Coliform	Recreational Restrictions – Pathogens	WWSF – Fully Supporting	Default FAL Variance
Menomonee River	Mile 6.27-30.14	MN-1, MN-6, MN-10, MN-14, MN-16	Milwaukee, Waukesha, Washington	16000	Total Phosphorus	Impairment Unknown	FAL – Not Supporting	Default FAL
Nor-X-Way Channel	Mile 0-4.90	MN-05	Ozaukee, Washington, Waukesha	18450	Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Water Quality Use Restrictions	FAL – Not Supporting	Default FAL
Southbranch Underwood Creek	Mile 0-1.00	MN-13	Milwaukee, Waukesha	16800	Total Phosphorus	Degraded Biological Community	FAL – Not Supporting	Default FAL Variance
Underwood Creek	Mile 0-2.84	MN-12	Milwaukee	16700	Fecal Coliform	Recreational Restrictions – Pathogens, Degraded Biological Community	FAL – Not Supporting	Default FAL Variance
Underwood Creek	Mile 2.84-8.54	MN-11, MN-12	Milwaukee, Waukesha	16700	Fecal Coliform	Recreational Restrictions – Pathogens, Degraded Biological Community	FAL – Not Supporting	Default FAL Variance
West Branch Menomonee River	Mile 0-2.45	MN-02	Washington	5033615	Fecal Coliform	Recreational Restrictions – Pathogens	FAL – Not Assessed	Default FAL
Willow Creek	Mile 0-2.80	MN-04	Washington, Waukesha	18800	Fecal Coliform	Recreational Restrictions – Pathogens	FAL – Supporting	Default FAL
Kinnickinnic River Watershed								
Cherokee Creek	Mile 0-1.60	KK-6	Milwaukee	15250	Fecal Coliform	Recreational Restrictions – Pathogens	LAL – Supporting	Default FAL
Holmes Avenue Creek	Mile 0-1.80	KK-5	Milwaukee	15550	Fecal Coliform	Recreational Restrictions – Pathogens	LAL – Supporting	Default FAL
Kinnickinnic River	Mile 2.4-2.83	KK-7	Milwaukee	15100	*E. coli*, Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Low DO, Degraded Biological Community	FAL – Not Supporting	Default FAL Variance
Kinnickinnic River	Mile 2.84-9.94	KK-1, KK-2, KK-7	Milwaukee	15100	Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Degraded Biological Community	LAL – Not Supporting	Default FAL Variance
South 43rd Street Ditch	Mile 0-1.16	KK-3	Milwaukee	15900	Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Degraded Biological Community	LAL – Not Supporting	Default FAL Variance
Wilson Park Creek	Mile 0-3.5	KK-4	Milwaukee	15200	Fecal Coliform	Recreational Restrictions – Pathogens	LAL – Fully Supporting	Default FAL
Wilson Park Creek	Mile 3.5-5.5	KK-4	Milwaukee	15200	Fecal Coliform	Recreational Restrictions – Pathogens	FAL – Not Assessed	LFF
Milwaukee River Watershed								
Adell Tributary	Mile 0-4.96	MI-09	Sheboygan	33000	Sediment/TSS	Degraded Habitat	LFF – Not Supporting	WWSF
Batavia Creek	Mile 0-4.1	MI-10	Sheboygan	31400	Total Phosphorus	Impairment Unknown	FAL – Not Supporting	Default FAL
Beaver Creek	Mile 0-2.69	MI-28	Milwaukee	20000	Total Phosphorus	Impairment Unknown	FAL – Not Supporting	Default FAL
Cedar Creek	Mile 5.01-32.71	MI-21, MI-22, MI-24	Ozaukee, Washington	21300	Total Phosphorus	Impairment Unknown	WWSF – Not Supporting	Default FAL
Evergreen Creek	Mile 0-5.21	MI-23	Washington	23000	Sediment/TSS	Degraded Habitat	WWSF – Not Supporting	Default FAL
Fredonia Creek	Mile 0-4.2	MI-15	Ozaukee	26600	Total Phosphorus	Impairment Unknown	FAL – Not Supporting	Default FAL
Indian Creek	Mile 0-2.63	MI-30	Milwaukee	19600	Total Phosphorus, Sediment/TSS	Low DO, Degraded Biological Community, Elevated Water Temperature, Degraded Habitat	LFF – Not Supporting	Default FAL Variance
Jackson Creek	Mile 0-1.25	MI-20	Washington	23900	Sediment/TSS	Degraded Habitat	LFF – Not Supporting	Default FAL

Water Body	Description [1]	Representative TMDL Reach(es)	Counties	Water Body ID Code	Pollutants	Impairments	Current Status[2]	Designated Use [3]
Lehner Creek	Mile 0-2.12	MI-19	Washington	24400	Sediment/TSS	Elevated Water Temperature, Degraded Habitat	WWSF – Not Supporting	WWSF
Lincoln Creek	Mile 0-9.70	MI-31	Milwaukee	19400	Total Phosphorus, Sediment/TSS	Low DO, Degraded Biological Community, Elevated Water Temperature, Degraded Habitat	FAL – Not Supporting	Default FAL Variance
Milwaukee River	Mile 3.1-19.35	MI-27, MI-32	Milwaukee, Ozaukee	15000	*E. coli,* Total Phosphorus	Recreational Restrictions – Pathogens, Impairment Unknown	FAL – Not Supporting	WWSF
Milwaukee River	Mile 19.35-29.33	MI-17, MI-25	Ozaukee	15000	*E. coli*	Recreational Restrictions – Pathogens	FAL – Supporting	WWSF
Milwaukee River	Mile 29.33-68.5	MI-6, MI-7, MI-15, MI-16, MI-17	Ozaukee, Washington	15000	Total Phosphorus	Impairment Unknown	FAL – Not Supporting	Default FAL
Milwaukee River North Branch	Mile 0-23.5	MI-08, MI-10, MI-13	Ozaukee, Sheboygan, Washington	27100	Total Phosphorus	Degraded Biological Community	FAL – Not Supporting	Default FAL
Mink Creek	Mile 0-13.2	MI-12	Sheboygan	30600	Total Phosphorus	Impairment Unknown	FAL – Not Supporting	Default FAL
South Branch Creek	Mile 0-2.36	MI-29	Milwaukee	3000073	Total Phosphorus, Sediment/TSS	Degraded Biological Community, Degraded Habitat	LAL – Not Supporting	Default FAL
Ulao Creek	Mile 0-8.6	MI-25	Ozaukee	21200	Total Phosphorus	Degraded Biological Community	FAL – Not Supporting	Default FAL
Un. Creek (Trinity Creek) (T09n R21e Se Ne 35)	Mile 0-3.1	MI-27	Ozaukee	20400	Total Phosphorus	Impairment Unknown	FAL – Not Supporting	LFF
Milwaukee Harbor Estuary								
Menomonee River	Mile 0-2.2	Estuary	Milwaukee	16000	*E. coli*, Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Low DO	FAL – Not Supporting	Default FAL Variance
Kinnickinnic River	Mile 0-2.4	Estuary	Milwaukee	15100	*E. coli*, Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Low DO, Degraded Biological Community	FAL – Not Supporting	Default FAL Variance
Milwaukee River	Mile 0-2.9	Estuary	Milwaukee	15000	*E. coli*, Total Phosphorus	Recreational Restrictions – Pathogens, Low DO	WWSF – Not Supporting	Default FAL Variance
Milwaukee River	Mile 2.9-3.1	Estuary	Milwaukee	15000	*E. coli,* Total Phosphorus	Recreational Restrictions – Pathogens, Impairment Unknown	FAL – Not Supporting	WWSF
Outer Harbor	Mile 0-0.32	Estuary	Milwaukee	15010	*E. coli*	Recreational Restrictions – Pathogens	FAL – Not Supporting	Default FAL

(1) Description corresponds with assessment units. In some cases, more than one assessment unit maybe covered within the listed mileage.
(2) FAL = Fish and Aquatic Life, WWSF = Warm Water Sport Fish, LAL = Limited Aquatic Life, LFF = Limited Forage Fish
(3) Variances are either for Fecal Coliform or Dissolved Oxygen and are listed in chapter NR 102, Wisconsin Administrative Code.

Section 2
Watershed Characterization

2.1 Watershed Characteristics

The Milwaukee River Basin encompasses nearly 850 square miles of land in portions of Dodge, Fond du Lac, Milwaukee, Ozaukee, Sheboygan, Washington, and Waukesha counties in Wisconsin (see **Figure 1-1** in Section 1). Surface water quality varies throughout the Basin, ranging from nearly pristine trout streams in the headwaters to degraded conditions in the southern urban areas. The southern quarter of the Basin is the most densely populated area in the state, holding 90% of the Basin's population, approximately 1.3 million people. Many of the people living in the Basin depend on Lake Michigan for their drinking water. Agriculture, manufacturing, tourism and outdoor recreation are all leading industries, and are all fundamentally dependent upon access to an adequate supply of quality water.

For this study, the Basin is considered to be represented by three watersheds, the Menomonee, Kinnickinnic, and Milwaukee River, each tributary to the Milwaukee Harbor Estuary. Collectively, the Basin contains about 400 miles of streams, 57 named lakes, and many small lakes and ponds. Note that the TMDL study limits do not include the areas of direct discharge to Lake Michigan.

The Milwaukee Estuary Area of Concern (AOC) encompasses the lower portion of the Basin, including lands that drain directly to the AOC via separate storm sewers and combined sewer systems. The Milwaukee Estuary was designated an AOC by the USEPA Great Lakes Program in the mid-1980s because of historic modifications and pollutant loads that contributed contaminants to the AOC and Lake Michigan. The AOC includes the lower 3.1 miles of the Milwaukee River downstream of the former North Avenue Dam; the lower 3 miles of the Menomonee River downstream of 35th Street; the lower 2.5 miles of the Kinnickinnic River downstream of Chase Avenue; the inner and outer harbor; and the nearshore waters of Lake Michigan, bounded by a line extending north from Sheridan Park to the City of Milwaukee's Linnwood water intake. The AOC is listed for 11 USEPA Great Lakes beneficial use impairments, some of which are intended to be addressed by these TMDLs, including eutrophication or undesirable algae, degradation of fish and wildlife populations, and degradation of aesthetics. Other impairments due to toxics and contaminated sediments are not intended to be addressed by these TMDLs.

2.1.1 Menomonee River Watershed

The Menomonee River watershed is located in the southwestern portion of the Milwaukee River Basin and covers an area of approximately 137 square miles, extending over Milwaukee, Ozaukee, Washington, and Waukesha Counties. The watershed contains over 75 total stream miles, and is characterized by small to medium sized warm water streams that exhibit flashy flow patterns. The Menomonee River discharges into Milwaukee Harbor, which is tributary to Lake Michigan. Other watershed characteristics are described below, obtained from the more comprehensive RWQMPU documentation. **Figure 2-1** contains representative photos of the Menomonee River.

River Mile 6.1 River Mile 13.9

Figure 2-1. Representative Photos of the Menomonee River
(Source: SEWRPC TR-39)

2.1.1.1 Land Use

The Menomonee River watershed is predominantly urbanized, with urban land uses making up approximately 63 percent of total land area. Residential land represents the largest urban land use in the watershed. As of 2000, the population in the watershed was approximately 320,000 persons. The percentages of the watershed in rural and other open space included about 17 percent in agricultural and related rural uses, about 2 percent in woodlands, about 8 percent in surface water and wetlands, and about 8 percent in other open lands as of 2000. By 2020, the percentage of the watershed area made up of urban land uses is projected to increase to 76 percent. Projected year 2020 land use for the Milwaukee River Basin is shown in **Figure B.1** in Appendix B. **Figure 2-2** summarizes land use information for the Menomonee River watershed from 1970, 1990, and 2000 and quantifies the percent change from 1970 to 2000. All urban categories of land use experienced increases while rural areas were reduced. The 2020 land use was used in this study for the source area assessment and quantification of loads.

LAND USE IN THE MENOMONEE RIVER WATERSHED: 1970-2000[a,b]

Category	1970		1990		2000		Change 1970-2000	
	Square Miles	Percent of Total	Square Miles	Percent of Total	Square Miles	Percent of Total	Square Miles	Percent
Urban								
Residential	33.4	24.6	38.6	28.4	40.5	29.8	7.1	21.3
Commercial	2.8	2.1	4.5	3.3	5.5	4.0	2.7	96.4
Industrial and Extractive	4.4	3.2	6.0	4.4	6.9	5.1	2.5	56.8
Transportation, Communication, and Utilities[c]	18.8	13.9	19.8	14.6	22.7	16.8	3.9	20.7
Governmental and Institutional	5.3	3.9	5.8	4.3	5.7	4.2	0.4	7.5
Recreational	4.3	3.2	5.0	3.7	5.3	3.9	1.0	23.3
Subtotal	69.0	50.9	79.7	58.7	86.7	63.8	17.7	25.7
Rural								
Agricultural and Related	40.6	29.9	30.0	22.1	23.4	17.2	-17.2	-42.4
Water	0.5	0.4	0.8	0.6	0.8	0.5	0.3	60.0
Wetlands	9.7	7.1	10.3	7.6	10.6	7.8	0.9	9.3
Woodlands	3.8	2.8	3.4	2.5	3.3	2.4	-0.5	-13.2
Unused and Other Open Lands	12.1	8.9	11.5	8.5	11.0	8.1	-1.1	-9.1
Subtotal	66.7	49.1	56.0	41.3	49.1	36.2	-17.6	-26.4
Total	135.7	100.0	135.7	100.0	135.8	100.0	0.1	0.0

[a] *As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b] *As part of the regional land use inventory for the year 2000, the delineation of existing land use was referenced to real property boundary information not available for prior inventories. This change increases the precision of the land use inventory and makes it more usable to public agencies and private interests throughout the Region. As a result of the change, however, year 2000 land use inventory data are not strictly comparable with data from the 1990 and prior inventories. At the county and regional level, the most significant effect of the change is to increase the transportation, communication, and utilities category, the result of the use of narrower estimated right-of-ways in prior inventories. The treatment of streets and highways generally diminishes the area of adjacent land uses traversed by those streets and highways in the 2000 land use inventory relative to prior inventories.*

[c] *Off-street parking of more than 10 spaces are included with the associated land use.*

Source: SEWRPC.

Figure 2-2. Land Use in the Menomonee River Watershed

2.1.1.2 Hydrology

The Menomonee watershed is characterized by small to medium sized streams that exhibit flashy flow patterns, as the watershed has been extensively modified from its natural condition. Most of the streams in the watershed have been channelized and/or lined with concrete to allow stormwater to drain at a faster rate. This means they often run too high and fast when it rains, and too low and slow when the weather is dry. These problems are rooted in historic channel modifications and growing urban land use. The waterways in the Menomonee River watershed were some of the earliest in Wisconsin to be dammed and ditched in order to facilitate drainage and supply water for irrigation and power. The percentage of the landscape covered by impervious surfaces increased as did the accompanying underground network of storm sewers designed to rapidly deliver stormwater into the river. Flooding became a growing problem, leading to stream channel lining, deepening, straightening, and relocating to move stormwater quickly downstream.

These activities, especially channel lining, have destroyed miles of habitat for animals and plants that live in or along rivers and streams. About 8 percent of the streams in the watershed are concrete-lined or enclosed. Lined streams provide almost no habitat and also degrade conditions in unlined downstream sections by creating highly erosive flow velocities during wet weather. Channel obstructions create further impacts. The watershed contains 36 dams and concrete drop structures and 269 culverts and bridges. The agricultural land near the upper reach of the Menomonee River is rapidly being developed.

Since 1975, measurements of stream flow have been taken at a number of locations along the Menomonee River and its tributaries. The period of record for most of these stations is rather short, with data collection occurring over periods ranging from about six months to about eight years. A few stations have longer periods of record. Information can be found on the USGS website (http://wi.water.usgs.gov/) including historic and real-time flow data.

Mean monthly streamflow tends to reach a low point during the late summer or early fall. The exact timing of this minimum appears to depend on the location of the station in the watershed, occurring earlier at upstream stations. Mean monthly discharge rises from this low point to a peak in December. It then declines to a second minimum that occurs in January. Flow rises to the highest levels during spring snowmelt and rain events. It remains high through March and April. There is some variability associated with these patterns. Flow information from individual monitoring stations throughout the watershed is contained within the RWQMPU documentation. **Figure 2-3** contains streamflow information for the Menomonee River watershed.

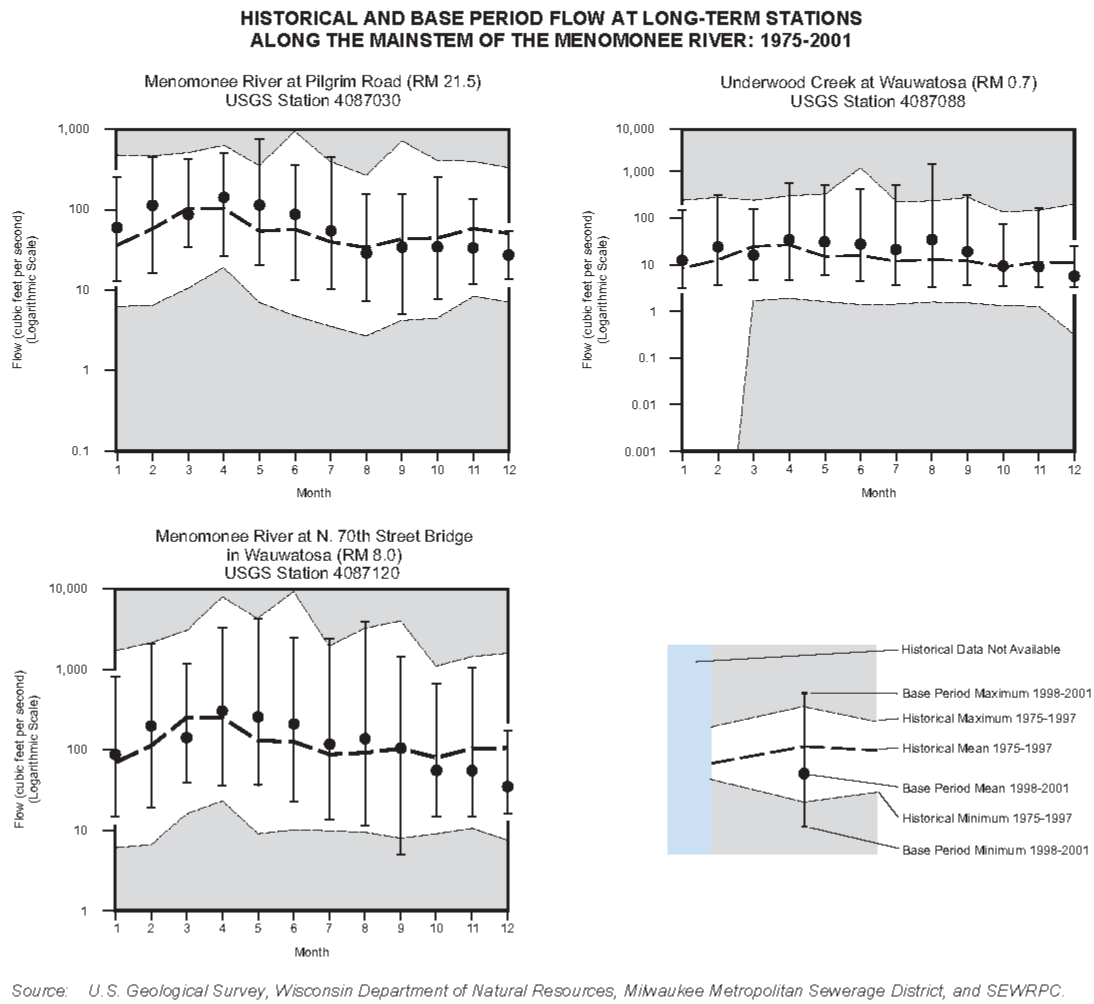


Figure 2-3. Streamflow in the Menomonee River Watershed

Recent MMSD projects that change the hydrology and or improve the habitat in the Menomonee River include:

- The County Grounds Detention Basin: This $90 million project captures and stores potential floodwater in one large basin that covers about 65 acres and holds 315 million gallons of water. An underground tunnel, which is 17 feet in diameter and a half-mile long, channels excess water from Underwood Creek into the Basin. From there it will slowly release into the Menomonee River. During extreme storms, the Basin could fill in about four hours. If completely filled, it can take four days to drain into the river.

- The Hart Park Project: Wauwatosa's Hart Park expanded from 20 acres to 50 acres when MMSD completed its $48 million flood management project near the city's thriving downtown. Together, the bigger park and a series of flood levees help temporarily store floodwater that could otherwise damage homes and businesses or get into the sewer system, raising the threat of basement backups and sewage overflows.

- Menomonee River Concrete Removal: This project opens 37 miles of river for Lake Michigan fish. Fish from Lake Michigan will soon be able to migrate 37 miles farther north on the Menomonee River, opening up new fishing spots and recreation. A concrete removal project in Milwaukee is now complete using a $1.1 million grant from the GLRI and additional funding and resources from the U.S. Fish and Wildlife Service, WDNR, and MMSD. Prior to this project, a steep pitched, concrete channel in the Menomonee River prevented most game fish from swimming further north than Wisconsin Avenue in Milwaukee. Removing the concrete and naturalizing the river will allow fish to travel an additional 17 miles north on the Menomonee River to Menomonee Falls and an additional 20 miles of tributaries that feed into the Menomonee River. After concrete is removed, a more naturalized pool/riffle system will be installed to give fish areas to rest as they migrate north.

- Schoonmaker Creek: Earthmovers are transforming part of a Wauwatosa creek to reduce the risk of flooding for neighbors and businesses. The $6 million effort, part of a larger flood management project, removes Schoonmaker Creek from a concrete culvert underground, creates more storage for floodwater along the Menomonee River, and provides environmental and habitat improvements for both waterways. Currently, the creek runs underground for about 500 feet from the railroad tracks, south, to the Menomonee River. When the improvements are complete, Schoonmaker will flow above ground into a wetland that is supported and buffered by rock features along the river to prevent erosion.

- Removal of Five Low Gradient Barriers: The purpose of this project is to improve hydraulic function, aquatic connectivity, and habitat along more than 34 miles of stream. The project scope is to remove five manmade barriers to fish passage in the Menomonee River channel. The five channel locations will be modified through bioengineering to restore natural hydraulic function and to improve habitat by mimicking the pool and riffle sequences of the natural river system. Under existing conditions, fish passage from Lake Michigan to the upper reaches of the Menomonee River watershed is restricted in low (base) flow conditions. Each barrier completely spans the river channel. Three of the crossings are from a single 24-inch Metropolitan Interceptor Sewer that crosses the river at three locations. At each of these locations the sewer creates a 1 to 1.5 foot drop that impairs fish passage during low-flow conditions. The fourth location is an old low dam/grade control structure with a 2 to 3 foot drop constructed in the 1930s. The last barrier is an old concrete road crossing that creates a one-foot drop and then a shallow area ten feet in width behind the drop that is impassable under low-flow conditions.

- Underwood Creek: The purpose of the project is to reduce public safety risk, provide wetland mitigation, improve aquatic habitat, and to satisfy WDNR and U.S. Army Corps of Engineers (USACE) requirements for the Milwaukee County Grounds Floodwater Management Facility project. The project scope includes the design and construction of removing approximately 4,400 linear feet of concrete channel liner on Underwood Creek from the Canadian Pacific Railway Bridge to the confluence with the Menomonee River, and replacing it with a bioengineered channel. The project will construct a series of pools and riffles in a low-flow channel to enhance the natural functions of Underwood Creek. The project also includes reconstructing the channel in areas where the riparian floodplain was lowered to recreate a more aesthetic and natural watercourse corridor. The project maintains the current level of flood management.

2.1.1.3 Sources

Sources of pollution in the Menomonee River watershed include both point source and nonpoint source contributions from SSOs, CSOs, industrial discharges, and polluted runoff from urban, rural, and agricultural areas.

Point Sources

There are no public or private sewage treatment plants discharging into the Menomonee River watershed. About 77 percent of the watershed is contained within planned sewer service areas: 41 percent within MMSD's planned sewer service area and 36 percent within the sanitary sewer service areas of local municipalities that are connected to MMSD's conveyance and treatment systems.

MMSD has 28 CSO outfalls within the watershed that may discharge a combination of stormwater runoff and sanitary sewage from the combined sewer system during very large stormwater and snowmelt events. Prior to 1994, overflows from these sites typically occurred around 50 times per year. Since MMSD's Inline Storage System (ISS) came online in 1994, the average number of CSOs per year has declined to fewer than three. Since 1995, SSOs have been reported at 26 locations: 7 within the MMSD's system and 19 within local municipalities. The number of SSO events occurring per year has declined compared to the time period prior to completion of the MMSD Water Pollution Abatement Program facilities in 1993. At the rare times when they occur, overflows contribute phosphorus, TSS, and bacteria to waters in the watershed.

Stormwater regulated under the MS4 program is a significant source of phosphorus, TSS, and bacteria in the watershed, as discussed in Section 1.1. About 8 percent of the watershed is served by combined sanitary and storm sewers that convey sewage and stormwater to MMSD's sewage treatment facilities, resulting in a high degree of stormwater precipitation related pollution control from the combined sewer service area. Including combined sewer overflow, runoff tributary to the combined sewer system on an annual average is treated to a 98 percent reduction in total suspended solids, whereas runoff modeling completed under the MS4 program reports a median 32 percent reduction total suspended solids from their respective storm sewer systems.

As of February 2016, 68 industrial dischargers and other point sources were permitted through the WPDES program to discharge wastewater to streams in the Menomonee River watershed. Approximately 84 percent of the permitted facilities discharge only non-contact cooling water, which may contain phosphorus. Facilities, including municipal water supply systems, add phosphates (orthophosphate or phosphate based additives) for corrosion control and to reduce lead/copper from leaching into the water. Many NCCW facilities rely on municipal water for cooling so phosphorus added by the municipality gets passed through the NCCW discharge. The standard additive for corrosion resistance is orthophosphate; however, multiple municipal facilities utilize sodium silicate including Delafield Waterworks, Franklin Water Utility, Germantown Water Utility, Kewaskum Waterworks, Mukwonago Waterworks, Oak Creek Waterworks, Oostburg Waterworks, Prairie Village Water Trust, Saukville Waterworks, Sheboygan Water Works, Sussex Water Utility, Town of Brookfield, Waldo Waterworks, and Waukesha Water Utility.

Nonpoint Sources

Nonpoint sources of TP, TSS, and bacteria include polluted runoff from urban, rural, and agricultural areas not regulated by a WPDES permit. As of 2000, about 36 percent of the watershed was in rural and other open land uses. Runoff from these land uses can contain pet waste, manure, fertilizer, and phosphorus-rich soil as discussed in Section 1.1.1.

About 3 percent of the watershed consists of urban areas outside of the planned sewer service area. Failure of onsite sewage treatment systems is an issue of concern in these portions of the watershed, and can contain locally-high levels of phosphorus and bacteria.

2.1.2 Kinnickinnic River Watershed

The Kinnickinnic River watershed is located in the southern portion of the Milwaukee River Basin and covers an area of approximately 20 square miles within Milwaukee County. The watershed contains approximately 22 total stream miles. The Kinnickinnic River originates in central Milwaukee County and flows approximately eight miles in an easterly direction to its confluence with the Milwaukee River. Along with the main river, many of the tributaries have been extensively modified through straightening, enclosure, and concrete lining. Other watershed characteristics are described below, obtained from the more comprehensive RWQMPU documentation. **Figure 2-4** contains representative photos of the Kinnickinnic River.

River Mile 2.8

River Mile 3.28

Figure 2-4. Representative Photos of the Kinnickinnic River
(Source: SEWRPC TR-39)

2.1.2.1 Land Use

The Kinnickinnic River watershed is highly urbanized, with urban land uses making up approximately 93 percent of total land area. Residential land represents the largest urban land use in the watershed. As of 2000, population in the watershed was approximately 150,000 persons. Approximately 7 percent of the watershed was in rural/open space land uses in 2000. Non-urban uses include about 5.5 percent of the total area in unused and other open lands and about 1 percent in surface water and wetlands. Most of the open spaces remaining in the watershed are located in Milwaukee County near Mitchell International Airport. Urban development exists throughout almost the entire Kinnickinnic River watershed. By 2020, the percentage of the watershed area made up of urban land uses is projected to increase to 96 percent. Projected year 2020 land use for the Milwaukee River Basin is shown in **Figure B.1** in Appendix B. **Figure 2-5** provides historic land use information for the Kinnickinnic River watershed.

LAND USE IN THE KINNICKINNIC RIVER WATERSHED: 1970-2000[a,b]

Category	1970		1990		2000		Change 1970-2000	
	Square Miles	Percent of Total	Square Miles	Percent of Total	Square Miles	Percent of Total	Square Miles	Percent
Urban								
Residential	8.6	33.9	8.8	34.6	8.8	34.6	0.2	2.3
Commercial	1.1	4.3	1.4	5.5	1.5	5.9	0.4	36.4
Industrial and Extractive	1.8	7.1	1.9	7.5	1.9	7.5	0.1	5.6
Transportation, Communication, and Utilities[c]	7.8	30.7	8.2	32.3	8.3	32.7	0.5	6.4
Governmental and Institutional	2.0	7.9	1.9	7.5	1.9	7.5	-0.1	-5.0
Recreational	1.1	4.3	1.1	4.3	1.1	4.3	0.0	0.0
Subtotal	22.4	88.2	23.3	91.7	23.5	92.5	1.1	4.9
Rural								
Agricultural and Related	0.3	1.1	0.2	0.8	0.1	0.4	-0.2	-66.7
Water	0.2	0.8	0.2	0.8	0.2	0.8	0.0	0.0
Wetlands	0.1	0.4	0.1	0.4	0.1	0.4	0.0	0.0
Woodlands	0.2	0.8	0.1	0.4	0.1	0.4	-0.1	-50.0
Unused and Other Open Lands[d]	2.2	8.7	1.5	5.9	1.4	5.5	-0.8	-36.4
Subtotal	3.0	11.8	2.1	8.3	1.9	7.5	-1.1	-12.1
Total	25.4	100.0	25.4	100.0	25.4	100.0	0.0	- -

[a] *As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b] *As part of the regional land use inventory for the year 2000, the delineation of existing land use was referenced to real property boundary information not available for prior inventories. This change increases the precision of the land use inventory and makes it more usable to public agencies and private interests throughout the Region. As a result of the change, however, year 2000 land use inventory data are not strictly comparable with data from the 1990 and prior inventories. At the county and regional level, the most significant effect of the change is to increase the transportation, communication, and utilities category, the result of the use of narrower estimated right-of-ways in prior inventories. The treatment of streets and highways generally diminishes the area of adjacent land uses traversed by those streets and highways in the 2000 land use inventory relative to prior inventories.*

[c] *Off-street parking of more than 10 spaces are included with the associated land use.*

[d] *For inventory purposes and for identifying changes in urban land use over time, this category is designated as rural; however, the unused and other open lands in this watershed are predominantly urban in character.*

Source: SEWRPC.

Figure 2-5. Land Use in the Kinnickinnic River Watershed

2.1.2.2 Hydrology

The Kinnickinnic River watershed has been extensively modified from its natural condition. The watershed is the most urbanized of the Milwaukee River Basin. The urbanization led to a significant increase in impervious surfaces, resulting in increased streamflow and peak flashiness. This affected the stability of streambanks and streambeds, and increased pollutant loadings and sediment. The watershed is 40 percent impervious.

Most of the streams in the watershed have been channelized and/or lined with concrete to allow stormwater to drain at a faster rate. About 30 percent of the streams within the watershed are concrete lined, an additional 30 percent are in an enclosed channel, and most of the remaining streams are open channels that are unstable and eroding. The upper un-channelized sections of the Kinnickinnic River are severely down cut or eroded and laterally unstable. Comparison of historic longitudinal profiles indicates that as much as four to five feet of incision has occurred since the 1970s.

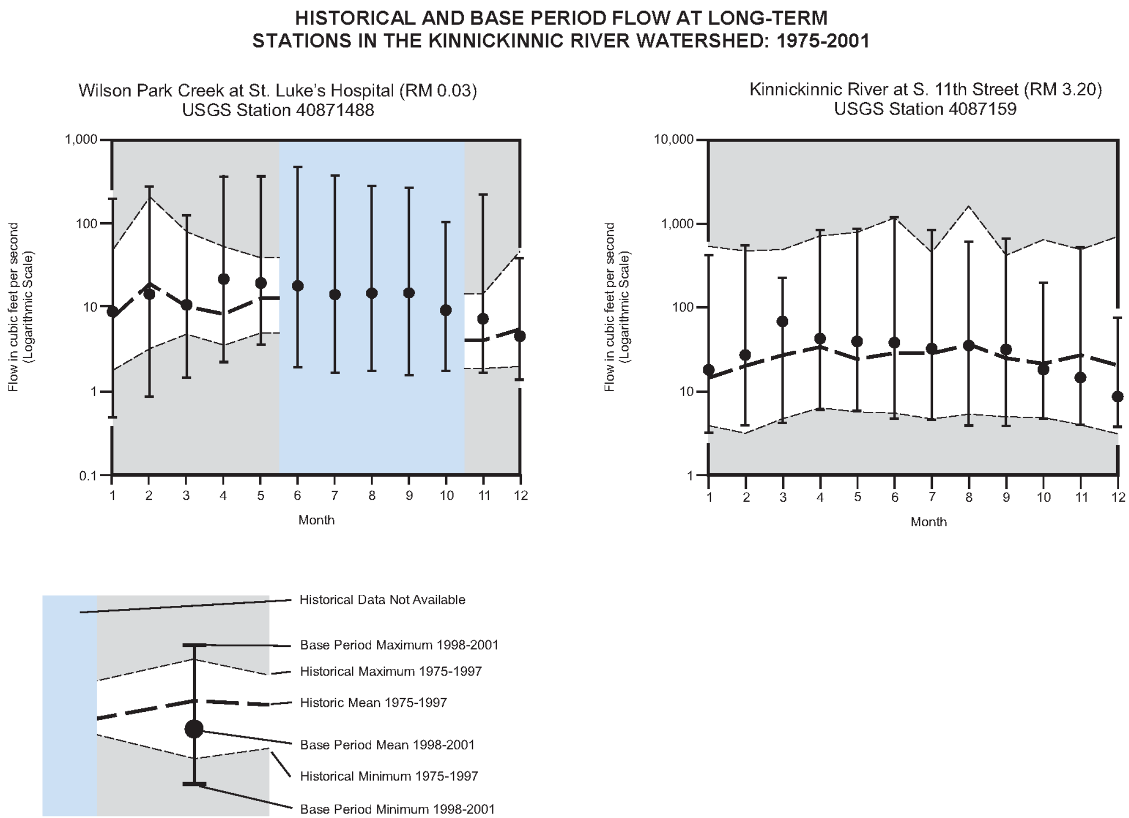
This channel instability is due to a combination of elements: a large amount of urban development and associated impervious area; a stormwater management system designed to move runoff quickly off the land surface and into the stream; significant encroachment of urban development near the stream, which confines flows within a narrow area and exposes the streambank and streambed to extremely high velocities and shear stresses; and steep slopes.

Since 1975, flow has been monitored at a number of locations along the Kinnickinnic River and its tributaries. The period of record for most of these stations is rather short, with data collection occurring over periods ranging from about six months to about six years. Mean monthly streamflow tends to reach a low point during the winter. The exact timing of this minimum appears to depend on the location of the station in the watershed, occurring earlier at upstream stations. Mean monthly flow peaks in April due to spring snowmelt and rains, then declines slightly through the spring and summer. Flows continue to decline through autumn back to winter minimums. Some variability is associated with these patterns from year to year. Flow information from individual monitoring stations throughout the watershed is contained within the RWQMPU documentation. **Figure 2-6** provides streamflow information for the Kinnickinnic River watershed.

Projects underway by MMSD that will affect future hydrology and habitat include:

- Kinnickinnic River Project: This project will build a safer urban wilderness with flood management and habitat restoration. The watershed now sees salmon and trout leave the estuary for a river run to spawn, migrating through Wisconsin's most impervious, densely-urbanized watershed. Tightly bound by residential properties, the Kinnickinnic River is lined with miles of concrete, an outdated form of flood management that actually makes the waterway dangerous during heavy rain with powerful currents that have claimed lives.

- The Kinnickinnic River Stakeholder group came up with an approved alternative plan in 2009 that included purchasing 83 homes near the current banks of the river to make more room for the river. When concrete is removed from the channel, a larger channel will be needed to accommodate a slower, wider river. Concrete ends up whisking water downstream faster in a narrower path compared to naturalized waterways. MMSD started purchasing homes through voluntary sales in 2010. Workers removed 1,000 feet of concrete between the I-94 Bridge and 6th Street in Milwaukee in 2011, widened the channel and erected retaining walls in a landlocked area with steep slopes to prevent erosion. A nearby bike trail makes it easy for neighbors to enjoy the views and fish from the banks when the salmon and trout visit in spring and fall.



Source: U.S. Geological Survey and SEWRPC.

Figure 2-6. Streamflow in the Kinnickinnic River Watershed

2.1.2.3 Sources

Sources of pollution in the Kinnickinnic River watershed include point source and nonpoint source contributions from industrial discharges, CSOs, SSOs, and polluted runoff from urban areas.

Point Sources

There are no public or private sewage treatment plants discharging into the Kinnickinnic River watershed. The entire watershed is contained within MMSD's planned sewer service area.

MMSD has 26 CSO outfalls that may discharge a combination of stormwater runoff and sanitary sewage from the combined sewer system during very large stormwater and snowmelt events. Prior to 1994, overflows from these sites typically occurred around 50 times per year. Since MMSD's ISS came online in 1994, the average number of CSOs per year has declined to fewer than three. Since 1995, SSOs have been reported at eight locations: four within MMSD's system and four within local municipalities. The number of SSO events occurring per year has declined compared to the time period prior to completion of the MMSD Water Pollution Abatement Program facilities in 1993. At the rare times when they occur, overflows contribute phosphorus, TSS, and bacteria to waters in the watershed.

Stormwater regulated under the MS4 program is a significant source of phosphorus, TSS, and bacteria in the watershed, as discussed in Section 1.1. About 17 percent of the watershed is served by combined sanitary and storm sewers, which convey sewage and stormwater to MMSD's sewage treatment facilities, resulting in a higher degree of precipitation related pollution control from the combined sewer service area. Including combined sewer overflow, runoff tributary to the combined sewer system on an annual average is treated to a 98 percent reduction in total suspended solids, whereas runoff modeling completed under the MS4 program reports a median 32 percent reduction total suspended solids from their respective storm sewer systems.

As of February 2016, 24 industrial dischargers and other point sources were permitted through the WPDES program to discharge wastewater to streams in the watershed. Approximately 75 percent of the permitted facilities discharge only non-contact cooling water, which may contain phosphorus.

Nonpoint Sources

The Kinnickinnic River watershed is dominated by urban land uses and contains only 7.5% non-urban lands. Therefore, runoff from rural and agricultural areas and failure of onsite sewage treatment systems are not issues in this watershed.

2.1.3 Milwaukee River Watershed

The Milwaukee River watershed is located in the northern portion of the Milwaukee River Basin and covers an area of approximately 700 square miles, extending over Dodge, Fond du Lac, Milwaukee, Ozaukee, Sheboygan, and Washington Counties. The watershed includes four subwatersheds, corresponding to USGS 12-digit Hydrologic Unit Codes (HUC-12s): Cedar Creek, Milwaukee River North, Milwaukee River East-West, and Milwaukee River South, which discharges into Milwaukee Harbor. Collectively, the watershed contains over 300 total stream miles and numerous named lakes and ponds, including 20 lakes with a surface area of 50 acres or more. Other watershed characteristics are described below, obtained from the more comprehensive RWQMPU documentation. **Figure 2-7** contains representative photos from the Milwaukee River watershed.

River Mile 76.97

River Mile 0.71

Figure 2-7. Representative Photos from the Milwaukee River Watershed
(Source: SEWRPC TR-39)

2.1.3.1 Land Use

The Milwaukee River watershed is a mixed-use watershed, having both rural and urbanized land uses. Approximately 79 percent of the overall watershed is rural and other open space land uses, with significant urbanization in the southern portion. As of 2000, these rural and open space uses included about 4 percent of the total area of the watershed in unused and other open lands, about 50 percent in agricultural use, and about 17 percent in surface water and wetlands. The remaining approximately 21 percent of the total watershed is devoted to urban uses.

LAND USE IN THE MILWAUKEE RIVER WATERSHED: 2000[a,b]

Category	2000[c]	
	Square Miles	Percent of Total
Urban		
Residential	71.64	10.2
Commercial	6.32	0.9
Industrial and Extractive	8.89	1.3
Transportation, Communication, and Utilities[d]	44.54	6.3
Governmental and Institutional	6.90	1.0
Recreational	10.30	1.5
Subtotal	148.58	21.2
Rural		
Agricultural and Related	342.45	48.9
Water	12.05	1.7
Wetlands	104.86	15.0
Woodlands	62.24	8.9
Unused and Other Open Lands	29.81	4.3
Subtotal	551.42	78.8
Total	700.00	100.0

[a]*As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b]*Prior to 2000, detailed land use data are not available for the portions of the watershed outside the Southeastern Wisconsin Region.*

[c]*This represents the entire watershed, including those portions in Dodge, Fond du Lac, and Sheboygan Counties.*

[d]*Off-street parking of more than 10 spaces is included with the associated land use.*

Source: SEWRPC.

Figure 2-8. Land Use in the Milwaukee River Watershed

While urban development exists throughout much of the Milwaukee River watershed, it is especially concentrated in the southeastern portion of the watershed. Residential land represents about one half of the urban land use in the watershed. As of 2000, population in the watershed was approximately 480,000 persons. By 2020, the percentage of the watershed area made up of urban land uses is projected to increase to 25 percent. Projected year 2020 land use for the Milwaukee River Basin is shown in **Figure B.1** in Appendix B. **Figure 2-8** provides year 2000 land use information for the Milwaukee River watershed.

2.1.3.2 Hydrology

The Milwaukee River Watershed has diverse land uses and hydrology. The upper reaches of the Milwaukee River drain undeveloped portions of forest, agricultural, and developed rural lands. Runoff from barnyards, feedlots, and increasingly paved developments flow downstream. The river's lower reaches are substantially more urbanized. Runoff from highly developed lands increase flows and contribute to sediment and other pollutant loads.

The lower reaches of the Milwaukee River have been substantially modified from their natural condition over the past 150 years. Dams and other channel modifications have been constructed to address flooding concerns, altering flow patterns. Nearly 15 percent of the lower reach miles in this watershed are significantly modified. Many of these streams were straightened, enclosed or lined with concrete to facilitate water movement downstream to alleviate flooding concerns. The modifications have resulted in wide fluctuations in water levels over short periods of time, increasing channel scour, producing sediment issues, and providing little to no habitat for aquatic life. Sediments have built up behind dams and other obstructions trapping pollutants like heavy metals, organic chemicals, and nutrients in the silty layers.

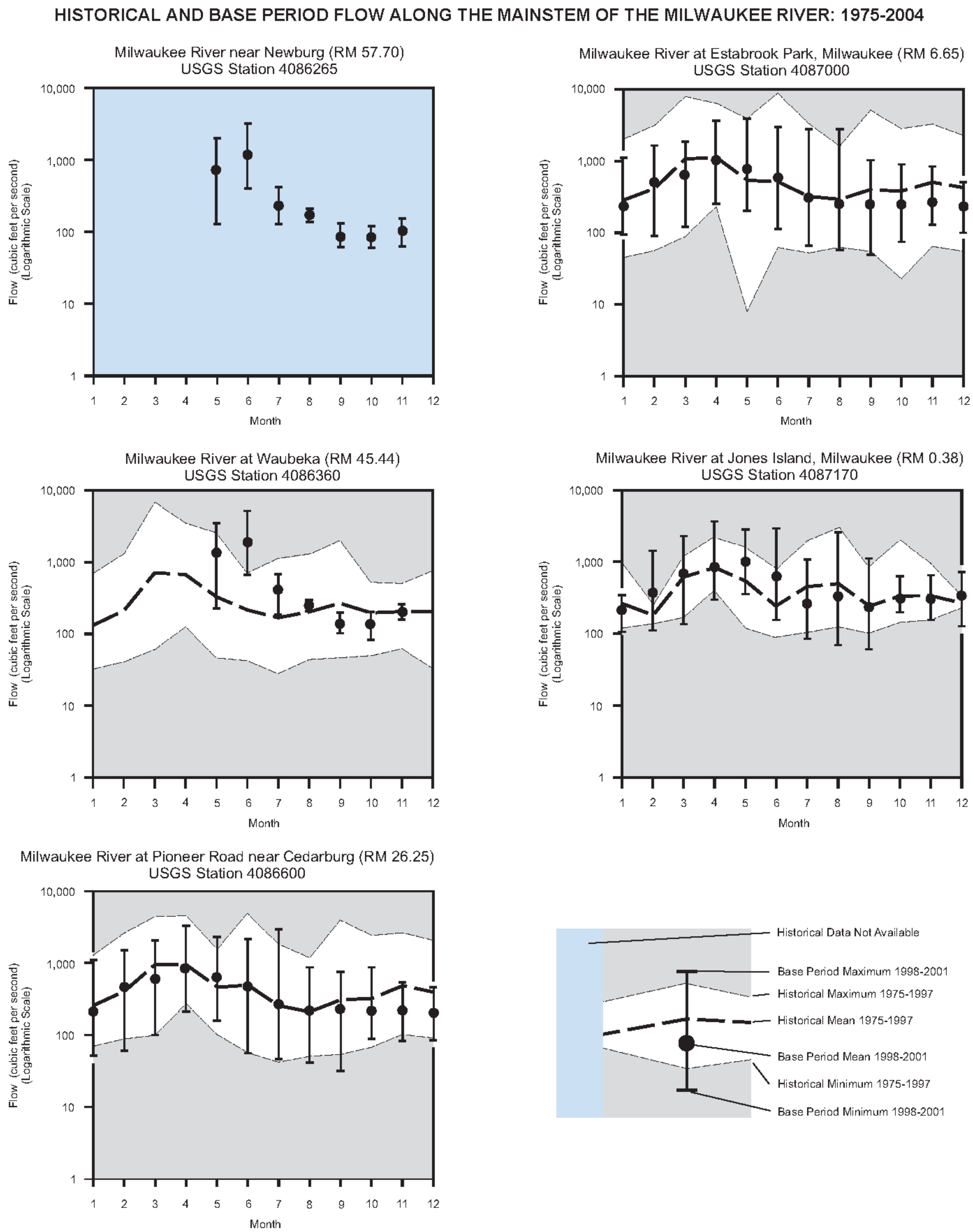
Since 1963, flow measurements have been recorded at a number of locations along the Milwaukee River and its tributaries. The period of record for some of these stations is rather short, with data collection occurring over periods ranging from about 4 months to about 14 months. Three USGS stations on the mainstem of the Milwaukee River at Pioneer Road, Estabrook Park, and Waubeka, have periods of record of about 23, 29, and 9 years, respectively. Three stations along tributaries, those on the East Branch Milwaukee River at New Fane, the North Branch Milwaukee River near Fillmore, and Cedar Creek at Cedarburg, have periods of record of 7, 7, and 27 years, respectively.

The Milwaukee River mainstem has the highest flows in the Milwaukee River Basin. Mean monthly streamflow within the watershed tends to reach a low point during the late summer or early fall, and remains reasonably constant through December. This is followed by a sharp increase during late winter and early spring associated with spring snowmelt and rains. Flows then decline through the spring and early summer to the late summer/early fall minimum. Considerable variability is associated with these patterns, but some of this variability is more likely attributed to sampling conditions rather than actual changes in discharge. Flow information from individual monitoring stations throughout the watershed is contained within the RWQMPU documentation. **Figure 2-9** provides streamflow information for the Milwaukee River watershed.

Recent projects undertaken by MMSD to improve hydrology and habitat include:

- Lincoln Creek: Serving as a national model for urban flood management, the $120 million Lincoln Creek Flood Management Project reduces the risk of flooding for more than 2,000 homes and businesses along a densely populated 9-mile-long creek. The waterway is substantially safer with improved water quality and habitat for fish, birds, and other wildlife. Lincoln Creek drains a 21-square-mile urban watershed, which is mostly located in the City of Milwaukee. Smaller portions are located in the Village of Brown Deer and the City of Glendale. Between 1960 and 1997, more than 4,000 separate flooding problems were reported along the creek. Correcting the problem required years of planning, ten separate projects, and the removal of more than 2.1 million cubic yards of earth. The final design resulted from input and suggestions from neighbors along the creek. A more open view along the creek provides improved security for residents and better access to an enhanced waterway. Construction began in late 1998. Where concrete once lined the creek, a more natural, meandering waterway now exists to keep the creek's flow within its banks during heavy rainstorms. Widening and deepening the creek required the removal of thick brush and overgrown shrubs. To keep peak stormwater runoff flows from spilling over creek banks, designers created two detention basins capable of storing more than 80 million gallons of water during a storm. Basin sites include: Havenwoods State Forest, 29 million gallons; and Green Tree Detention Basin, 52 million gallons. Although the project's main focus was to reduce the risk of flooding for homes and businesses from the 1% probability storm (commonly referred to as the 100-year storm), it also included measures to enhance the attractiveness of the corridor; improve water quality; restore, stabilize and protect eroding banks; and provide a suitable habitat for fish, birds and other wildlife.

- 30th Street Corridor: After $32 million of flood damage occurred in an industrial area on Milwaukee's north side, a solution was developed with extensive input from neighbors and nearby businesses. A project is underway to capture and store 40 million gallons of stormwater to reduce the risk of flooding when storms roll over the area. The plan calls for building three flood basins that will be dry most of the time until they are needed for heavy rain. All three basins will slowly drain to Lincoln Creek after the storms have passed. The East Basin will hold 1.7 million gallons and was designed to incorporate aesthetic, recreational, and safety concepts that neighbors desired, including usable green space. The North Basin will improve drainage and reduce flooding risks through construction of a 7.6-million-gallon storage basin. West Basin will consist of a 30-million-gallon flood basin providing increased protection for the area. The project will be constructed in two phases. The first work in 2016 includes building demolition and the removal of several feet of contaminated soil. The rest of the work will occur in subsequent years when the stormwater basin and new sewers are constructed.



Source: U.S. Geological Survey and SEWRPC.

Figure 2-9. Streamflow in the Milwaukee River Watershed

2.1.3.3 Sources

Sources of pollution in the Milwaukee River watershed include both point and nonpoint source contributions. Point sources include municipal wastewater treatment facilities (WWTFs) and industrial discharges, CSOs, and SSOs. Nonpoint sources include polluted runoff from urban, rural, and agricultural areas.

Point Sources

Twelve public and two private WWTFs currently discharge into streams in the Milwaukee River watershed. About 21 percent of the watershed is contained within planned sewer service areas: 8 percent within MMSD's planned service area, 3 percent within the sanitary sewer service areas of local municipalities that are connected to MMSD's conveyance and treatment systems, 4 percent within the City of West Bend's planned sewer service area, about 1 percent within each of the City of Cedarburg and Villages of Grafton and Jackson's planned sewer service areas, and less than 1 percent each within the City of Port Washington, the Villages of Adell, Campbellsport, Cascade, Fredonia, Kewaskum, Lomira, Saukville, Newburg, Random Lake, Slinger, and Waubeka's planned sewer service areas.

MMSD has 65 CSO outfalls that may discharge a combination of stormwater runoff and sanitary sewage from the combined sewer system during very large stormwater and snowmelt events. Prior to 1994, overflows from these sites typically occurred around 50 times per year. Since MMSD's ISS came online in 1994, the average number of CSOs per year has declined to fewer than three. Since 1995, SSOs have been reported at 54 locations: 15 within MMSD's system and 39 within local municipalities. The number of SSO events occurring per year has declined compared to the time period prior to completion of the MMSD Water Pollution Abatement Program facilities in 1993. At the rare times when they occur, overflows contribute phosphorus, TSS, and bacteria to waters in the watershed.

Stormwater regulated under the MS4 program is a significant source of phosphorus, TSS, and bacteria in the watershed, as discussed in Section 1.1. About two percent of the watershed is served by combined sanitary and storm sewers that convey sewage and stormwater to MMSD's sewage treatment facilities. Including combined sewer overflow, runoff tributary to the combined sewer system on an annual average is treated to a 98 percent reduction in total suspended solids, whereas runoff modeling completed under the MS4 program reports a median 32 percent reduction of total suspended solids from their respective storm sewer systems.

As of February 2016, 65 industrial dischargers and other point sources were permitted through the WPDES program to discharge wastewater to streams in the watershed. Approximately 62 percent of the permitted facilities discharge only non-contact cooling water, which may contain phosphorus.

Nonpoint Sources

Nonpoint sources of TP, TSS, and bacteria include polluted runoff from urban, rural, and agricultural areas not regulated by a WPDES permit. The Milwaukee River watershed is comprised of combinations of urban land uses and rural land uses. As of 2000, about 79 percent of the watershed was in rural and other open land uses. Runoff from these land uses can contain pet wastes, manure, fertilizer, and phosphorus-rich soil, as discussed in Section 1.1.1.

A major portion of the upstream watershed is rural in nature, and may utilize onsite sewage treatment systems. Failure of onsite sewage treatment systems is an issue of concern in these portions of the watershed, and can contain locally-high levels of phosphorus and bacteria.

2.1.4 Milwaukee Harbor Estuary

The Milwaukee Harbor Estuary is located in the southeastern portion of the Basin and is a tributary to Lake Michigan. The estuary is an open waterbody that includes the outer harbor area from the break wall to the shoreline, and the inner harbor area, which includes the lower reaches of the Milwaukee, Menomonee, and Kinnickinnic Rivers. Specifically, the inner harbor area includes the following river segments:

- The lower 2.2 miles of the Menomonee River downstream of the former Falk Corporation Dam
- The lower 2.4 miles of the Kinnickinnic River downstream of the Chase Avenue Bridge
- The lower 3.1 miles of the Milwaukee River downstream of the former North Avenue Dam

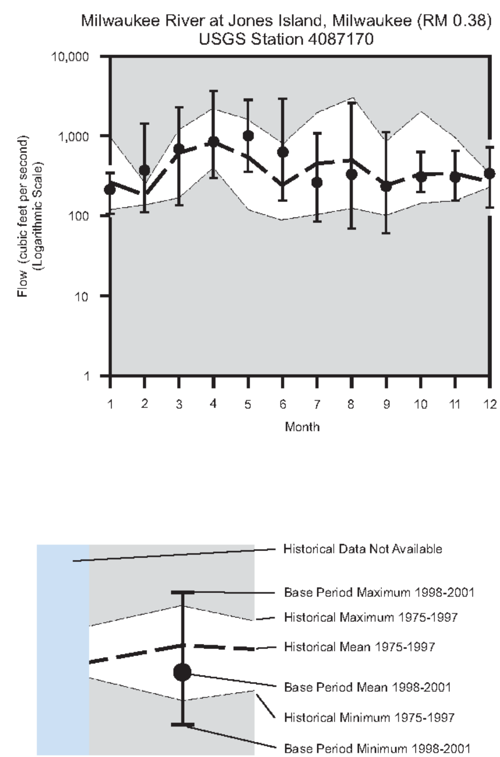
2.1.4.1 Land Use

The area directly tributary to the estuary is approximately 16 square miles and is dominated by urban land uses and some open space/park lands. Detailed land use data is not available as the various regional planning efforts developed land use for the Lake Michigan direct drainage area, which is a larger area than the estuary. The land use in the Estuary is essentially 100 percent developed urban land use.

2.1.4.2 Hydrology

The estuary behaves differently than the tributary river systems with respect to flow and conveyance of pollutant loads. Estuary "flow" is a combination of lake level and river flow and is very complex. Water quality is best evaluated at assessment points located throughout the estuary, rather than within defined river reaches. Assessment points that were established for the WQI are used in the TMDL analysis. This is explained in more detail in Section 5.4 of this report.

Since 1994, measurements of discharge have been taken at one location within the estuary, Jones Island at the mouth of the Milwaukee River. The period of record for this station is 42 months, with data collection occurring during two periods—April 1994 to October 1995 and November 2001 to September 2003. Historical and baseline period discharge for this station is shown in Figure 106 in Chapter VII of the RWQMPU (see opposite).



Source: U.S. Geological Survey and SEWRPC.

Figure 2-10. Streamflow in Milwaukee River at Jones Island, Milwaukee

For the RWQMPU, the relative contributions of discharge from the Kinnickinnic, Menomonee, and Milwaukee Rivers to the harbor were estimated. Flow fractions were calculated for the S. 11th Street station along the Kinnickinnic River, the 70th Street station along the Menomonee River, and the Estabrook Park station along the Milwaukee River relative to the discharge at the Jones Island station (procedure described in Chapter III of the RWQMPU). Several generalizations emerge from this analysis:

- The Milwaukee River is the dominant source of discharge to the harbor. Median discharge at the gauge at Estabrook Park represents about 75 percent of the median discharge at Jones Island.
- The Menomonee River accounts for much of the remaining discharge into the harbor. Median discharge at the gauge at 70th Street represents slightly more than 13 percent of the median discharge at Jones Island.
- The Kinnickinnic River contributes only a small portion of the discharge entering the harbor. Median discharge at S. 11th Street represents less than 3 percent of the median discharge at Jones Island.
- About 9 percent of the discharge at the gauge at Jones Island is not accounted for by discharge at the gauges on the three Rivers. This represents contributions entering the Rivers between their respective gauges and Jones Island gauge from at least one tributary, Woods Creek, as well as direct runoff.

MMSD is undertaking the following project in the Estuary:

- Burnham Canal: The purpose of this project is to transform the Burnham Canal into a productive and attractive wetland to improve water quality by removing pollutants from combined sewer overflows if they occur. Other project benefits include providing a low-cost opportunity to beneficially reuse fill from other projects, improving public awareness of the functions and values of wetlands in an area where wetlands are absent, improving fish and wildlife habitat, and improving access for recreation and education. The project scope is to cap contaminated sediment within the canal and to design and construct a wetland within the canal.

2.1.4.3 Sources

Point Sources

Sources of pollution in this tributary area include one municipal WWTF, industrial discharges, and CSOs. Pollution also enters the estuary from the Menomonee, Kinnickinnic, and Milwaukee Rivers. As discussed above, the Milwaukee River is the dominant source of discharge to the harbor. The Menomonee River contributes much of the remaining discharge, and the Kinnickinnic River provides a smaller portion. The area immediately adjacent to the estuary is highly urbanized and drains to the combined sewer system, which conveys sewage and stormwater to MMSD's sewage treatment facilities, resulting in a high degree of stormwater pollution control.

Nonpoint Sources

The land area tributary to the Milwaukee Harbor Estuary is dominated by urban land uses and open space/park lands. There are no nonpoint sources in this area. Therefore, runoff from rural and agricultural lands and failure of onsite sewage treatment systems is not an issue in this area.

2.2 Water Quality

Considerable phosphorus, suspended solids, and bacteria water quality data have been collected in the Basin since the 1960s, especially on the mainstems of the major rivers. The primary sources of data include MMSD, WDNR, USGS, and USEPA's STORET legacy and modern databases. This water quality information was analyzed as described in SEWRPC Technical Report No. 39 (TR-39), *Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds* (SEWRPC, 2007). In the TR-39 analysis, data from four time periods was examined: 1975-1986, 1987-1993, 1994-1997, and 1998-2004 (1998-2001 for the Kinnickinnic and Menomonee River watersheds). The four time periods were selected based upon full year sampling period (1975-1986); partial year sampling prior to the MMSD Inline Storage System (ISS) or Deep Tunnel construction (1987-1993); and as noted below. Bimonthly data records exist from several of MMSD's long-term monitoring stations beginning in 1975. After 1986, MMSD no longer conducted sampling during the winter months. In 1994 the Deep Tunnel came online. The remaining period from 1998-2001 or 2004 defines the baseline water quality conditions of the river systems for the assessment of water use objectives and to assess trends after the ISS came online. The data discussed in the following sections is summarized from TR-39 and organized by constituent and watershed. In the summaries, the estuary portion of each watershed is included in the discussion of that watershed; water quality for the estuary is not discussed in a separate subsection.

Throughout the data record analyzed for TR-39, TSS concentrations showed strong positive correlations with total phosphorus concentrations, reflecting the fact that total phosphorus concentrations include a large particulate fraction. TSS concentrations were also positively correlated with concentrations of fecal coliform bacteria (see Table C-3 in Appendix C of the RWQMPU TR-39).

Menomonee River

From 1998 to 2001, the Menomonee River only partially met water quality criteria supporting its designated uses of primary contact recreation and fish and aquatic life. Concentrations of fecal coliform bacteria in the estuary portion of the Menomonee River often exceeded the special variance standard of 1,000 cells per 100 mL, which applies to the estuary. Similarly, in the vast majority of samples collected from the section of the River upstream of the estuary, the concentrations of fecal coliform bacteria exceed the standard of 200 cells per 100 mL as shown in Section 1.3.3. The rate of exceedance with this standard varies among reaches. Attainment of the numeric criteria for total phosphorus also varies among reaches. The number of samples showing total phosphorus exceeding 0.1 mg/L ranges from a low of about 33 percent to a high of about 68 percent depending upon the reach.

Kinnickinnic River

From the same period described above, the Kinnickinnic River only partially met the water quality criteria supporting its designated uses of primary contact recreation and fish and aquatic life. Concentrations of fecal coliform bacteria in the Kinnickinnic River often exceed the special variance standard of 1,000 cells per 100 mL, which applies to the River. The rate of exceedance with this standard decreased from upstream to downstream. Attainment of the numeric criteria for total phosphorus follow the same pattern: the number of samples showing total phosphorus exceeding the 0.1 mg/L standard decreases from upstream to downstream from a low of about 21 percent to a high of about 70 percent.

Milwaukee River

From 1998 to 2004, the Milwaukee River partially met the water quality criteria supporting its designated uses of primary contact recreation and fish and aquatic life. In the estuary, concentrations of fecal coliform bacteria in the Milwaukee River were usually less than or equal to the variance standard of 1,000 cells per 100 mL. While the rate of exceedance varied among stations, it was generally between 65 percent and 77 percent. In the section of the River upstream from the estuary, concentrations of fecal coliform bacteria usually exceeded the recreational use standard of 200 cells per 100 mL. Depending upon the station, the percentage of samples in this section of the River that exceeded the numeric criteria ranged between about 20 and 55 percent. Attainment of the numeric criteria for total phosphorus is low with the number of samples showing total phosphorus exceeding 0.1 mg/L ranging from 21 to 63 percent at stations along the mainstem. At most stations along the mainstem of the River, concentrations of total phosphorus were above the standard in about 55 percent to 63 percent of the samples. The exception to this generalization occurred at the downstream stations nearest to the confluence with Lake Michigan and the three stations furthest upstream.

2.2.1 Total Phosphorus

For this study, phosphorus is expressed as total phosphorus (TP), including both dissolved and particulate forms of phosphorus. In Wisconsin, the total phosphorus criterion specified in ch. NR 102, Wis. Adm. Code, is 0.075 mg/L for streams and 0.1 mg/L for rivers, expressed as a median of monthly samples collected between May and October. More discussion of these targets is included in Section 3.

2.2.1.1 Menomonee River Watershed

The mean concentration of total phosphorus in the Menomonee River during the period of record, 1998 through 2004, was 0.116 mg/L. Concentrations varied over four orders of magnitude, ranging from 0.0015 to 3.000 mg/L. At most sampling sites, the data showed moderate variability.

According to TR-39, the annual average load of total phosphorus to streams of the Menomonee River watershed is estimated to be 53,120 pounds per year. Combined sewer overflows and sanitary sewer overflows contribute about 3.5 percent and 1.1 percent, respectively, of this load. Industrial discharges contribute about 33.0 percent of this load. The rest of total phosphorus loadings to streams in the watershed, about 62.4 percent, are contributed by runoff, with 54.7 percent coming from urban MS4, both permitted and non-permitted sources, and 7.7 percent from rural sources.

2.2.1.2 Kinnickinnic River Watershed

The mean concentration of total phosphorus in the Kinnickinnic River during the period of record was 0.095 mg/L. Concentrations varied over four orders of magnitude, ranging from 0.005 to 2.780 mg/L. At most sampling sites, the data showed moderate variability.

According to TR-39, the annual average load of total phosphorus to streams of the Kinnickinnic River watershed is estimated to be 12,750 pounds per year. Combined sewer overflows and sanitary sewer overflows contribute about 3.8 percent and 7.0 percent, respectively, of this load. Industrial discharges contribute about 11.3 percent of this load. The rest of total phosphorus loadings to streams in the watershed, about 77.9 percent, are contributed by urban runoff sources.

2.2.1.3 Milwaukee River Watershed

The mean concentration of total phosphorus in the Milwaukee River during the period of record was 0.129 mg/L. Concentrations varied over four orders of magnitude, ranging from 0.004 to 1.920 mg/L. At most sampling sites, the data showed moderate variability.

According to TR-39, the annual average load of total phosphorus to streams of the Milwaukee River watershed is estimated to be 274,500 pounds per year. Industrial discharges and municipal sewage treatment plants contribute about 34.2 percent and 18.8 percent, respectively, of this load. Combined sewer overflows and separate sanitary sewer overflows contribute about 0.7 percent and 0.3 percent, respectively. The rest of total phosphorus loadings to streams in the watershed, about 46.0 percent, are contributed by runoff, with 29.5 percent coming from rural sources and 16.5 percent from urban sources.

2.2.1.4 Milwaukee Harbor Estuary

The mean concentration of total phosphorus in the Milwaukee Harbor Estuary during the period of record was 0.115 mg/L. Total phosphorus concentrations varied over four orders of magnitude, ranging from 0.002 to 3.000 mg/L. The mean concentrations of total phosphorus during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 0.092 mg/L, 0.117 mg/L, and 0.126 mg/L, respectively. Total phosphorus concentrations varied over four orders of magnitude, ranging from below the limit of detection to 3.880 mg/L.

2.2.2 Total Suspended Solids

Total suspended solids (TSS) can include many different materials: soil, biological solids, decaying organic matter, and other particulates. TSS can carry with it other pollutants that have adsorbed to the particles as a result of physical and chemical interactions. There are currently no existing or proposed numeric criteria for TSS concentrations in Wisconsin. A target concentration of 12 mg/L expressed as a median of monthly samples collected between May and October, the growing season, was established by WDNR for this TMDL analysis. More discussion of this target is included in Section 3.

2.2.2.1 Menomonee River Watershed

The mean value for TSS concentrations in the Menomonee River during the period of record was 21.4 mg/L. Considerable variability was associated with this mean, with values ranging from 1.6 to 727.0 mg/L. At most sampling stations, baseline period monthly mean TSS concentrations generally tend to be near historical means. During the spring, there is a distinct tendency at several stations for baseline period monthly mean TSS concentrations to be higher than historical means.

The annual average load of TSS to streams of the Menomonee River watershed is estimated to be 18 million pounds (9,000 tons) per year. Combined sewer overflows and separate sewer overflows contribute about 1.0 percent and 0.2 percent, respectively, of this load. Industrial discharges contribute about 0.3 percent. The rest of TSS loadings to streams in the watershed, about 98.5 percent, are contributed by runoff, with 87.6 percent coming from urban sources and 10.9 percent from rural sources.

2.2.2.2 Kinnickinnic River Watershed

The mean value for TSS concentrations in the Kinnickinnic River over the period of record was 20.5 mg/L. Considerable variability was associated with this mean, with values ranging from below the limit of detection to 1,400 mg/L. The amount of variability was related to the locations of the sample sites, with variability decreasing from upstream to downstream. Baseline period monthly mean TSS concentrations generally tend to be near historical means. However, during the month of May there is a distinct tendency for monthly mean TSS concentrations from the baseline period to be higher than historical means at upstream sampling stations.

The annual average load of TSS to streams of the Kinnickinnic River watershed is estimated to be 5,300,000 pounds (2,650 tons) per year. Combined sewer overflows and separate sewer overflows contribute about 0.8 percent and 1.0 percent, respectively, of this load. Industrial discharges contribute about 0.2 percent of this load. The rest of TSS loadings to streams in the watershed, about 98.0 percent, are contributed by urban runoff.

2.2.2.3 Milwaukee River Watershed

The mean value for TSS concentrations in the Milwaukee River over the period of record, 1998 through 2004, was 25.1 mg/L. Considerable variability was associated with this mean, with values ranging from 1.2 to 892.0 mg/L during runoff events. TSS concentrations at most stations along the mainstem of the river have increased over time.

The annual average load of TSS to streams of the Milwaukee River watershed is estimated to be 58,400,000 pounds (29,200 tons) per year. Sewage treatment plants, combined sewer overflows, separate sanitary sewer overflows, and industrial discharges contribute 0.5 percent, 0.3 percent, less than 0.1 percent, and 0.8 percent, respectively, of this load. The rest of the TSS load to streams in the watershed, about 98.4 percent, is contributed by runoff, with 68.1 percent coming from rural sources and 30.3 percent from urban sources.

2.2.2.4 Milwaukee Harbor Estuary

The mean value for TSS concentration in the Milwaukee Harbor Estuary over the period of record was 22.1 mg/L. Considerable variability was associated with this mean, with values ranging from 1.0 to 892 mg/L. The mean concentrations of TSS during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 18.6 mg/L, 19.8 mg/L, and 25.7 mg/L, respectively. During all periods, the mean concentrations of TSS in the Milwaukee River portion of the estuary were higher than the mean concentrations in the Kinnickinnic River and Menomonee River portions of the estuary. Most sampling stations in the Menomonee River and Milwaukee River portions of the estuary showed trends toward increasing TSS concentration over time. Most sampling stations in the Kinnickinnic River portion of the Estuary showed trends toward decreasing TSS concentrations.

2.2.3 Bacteria

For this study, fecal coliform and *E. coli* concentrations are expressed as cells per 100 mL. Wisconsin water quality standards require that a river's fecal coliform concentration may not exceed 200 colony forming units (cfu) per 100 mL as a geometric mean, nor exceed 400 cfu per 100 mL in more than 10 percent of all samples during any month. As noted in Section 3.2.3, environmental and public health agencies are moving towards monitoring for *E. coli* as a more appropriate indicator bacteria to identify the presence of fecal contamination in waterbodies. More discussion of these standards is included in Section 3.

2.2.3.1 Menomonee River Watershed

Median concentrations of fecal coliform bacteria in the Menomonee River have ranged from about 2,000 to 20,000 cells per 100 mL. Fecal coliform cell counts varied over seven orders of magnitude ranging from as low as one cell per 100 mL to over two million cells per 100 mL. Cell counts in most samples exceed the standard for full recreational use.

The annual average load of fecal coliform bacteria to streams of the Menomonee River watershed is estimated to be 16,900 trillion cells per year. Combined sewer overflows and sanitary sewer overflows contribute about 10.2 percent and 3.8 percent, respectively, of this annual load. The rest of the fecal coliform bacteria loadings to streams in the watershed, about 86.0 percent, are contributed by runoff, with 83.7 percent coming from urban sources and 2.3 percent from rural sources.

Regular sampling for *E. coli* in the Menomonee River began at four sampling stations along the mainstem in 2000. During the years 2001 and 2002, the counts ranged from undetectable to 160,000 cells per 100 mL.

2.2.3.2 Kinnickinnic River Watershed

Median concentrations of fecal coliform bacteria in the Kinnickinnic River range from about 200 to 2,300 cells per 100 mL. Fecal coliform counts varied over seven orders of magnitude, ranging from as low as one cell per 100 mL to over one million cells per 100 mL. Counts in most samples exceed the standard for full recreational use.

The annual average load of fecal coliform bacteria to streams of the Kinnickinnic River watershed is estimated to be 4,900 trillion cells per year. Combined sewer overflows and separate sewer overflows contribute about 11.3 percent and 20.0 percent, respectively, of this load. The rest of fecal coliform bacteria loadings to streams in the watershed, about 68.7 percent, are contributed by runoff.

Regular sampling for *E. coli* in the Kinnickinnic River began at three long-term sampling stations along the mainstem in 2000. During the years 2001 and 2002, the counts ranged from 0.5 cells per 100 mL to 160,000 cells per 100 mL.

2.2.3.3 Milwaukee River Watershed

Median concentrations of fecal coliform bacteria in the Milwaukee River during the period of record ranged from about 50 to 2,300 cells per 100 mL. Fecal coliform counts varied over seven orders of magnitude, ranging from as low as one cell per 100 mL to over 1,100,000 cells per 100 mL. Counts in most samples exceed the standard for full recreational use.

According to TR-39, the annual average load of fecal coliform bacteria to streams of the Milwaukee River watershed is estimated to be 41,000 trillion cells per year. Combined sewer overflows, sewage treatment plants, and separate sanitary sewer overflows contribute 4.6 percent, 0.1 percent and about 1.1 percent, respectively, of this annual load. Industrial discharges contribute less than 0.1 percent of this load. The rest of the fecal coliform bacteria load to streams in the watershed, about 94.2 percent, is contributed by runoff, with 35.2 percent coming from rural sources and 59.0 percent from urban sources.

MMSD began regular sampling for *E. coli* in the Milwaukee River at six long-term sampling stations along the mainstem and two sampling stations along Lincoln Creek in 2000. In addition, the USGS and WDNR have conducted some sampling for *E. coli* in the Milwaukee River watershed. Concentrations of *E. coli* ranged from 0.5 cells per 100 mL to 130,000 cells per 100 mL.

2.2.3.4 Milwaukee Harbor Estuary

The median concentration of fecal coliform bacteria in the Milwaukee Harbor Estuary during the period of record was 930 cells per 100 mL. The median concentrations of fecal coliform bacteria in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 430 cells per 100 mL, 930 cells per 100 mL, and 930 cells per 100 mL, respectively. Fecal coliform counts in the estuary varied over seven orders of magnitude, ranging from about one cell per 100 mL to over 2,400,000 cells per 100 mL. Counts in most samples in the estuary exceeded the standard for full recreational use.

MMSD began regular sampling for *E. coli* at sampling stations in the estuary and outer harbor in 2000. The median concentration of *E. coli* in the estuary during the period of 2000-2002 was 410 per 100 mL. The median concentrations of *E. coli* during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 290 cells per 100 mL, 520 cells per 100 mL, and 410 cells per 100 mL, respectively. Counts of *E. coli* in the estuary varied over six orders of magnitude, ranging from about 0.5 cells per 100 mL to 240,000 cells per 100 mL.

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Section 3
Applicable Water Quality Standards

3.1 Designated Uses

Chapter NR 102, Wis. Adm. Code, defines designated uses for Wisconsin waterbodies. Waterbodies in the Milwaukee River Basin are designated for fish and other aquatic life and recreational uses.

3.1.1 Fish and Other Aquatic Life Uses

The department classifies all surface waters into one of the fish and other aquatic life subcategories described in s. NR 102.04 (3), Wis. Adm. Code (excerpted below). Only those use subcategories identified in paragraphs (a) to (c) shall be considered suitable for the protection and propagation of a balanced fish and other aquatic life community as provided in the federal water pollution control act amendments of 1972, P.L. 92-500; 33 USC 1251 et. Seq.

(a) Cold water communities. This subcategory includes surface waters capable of supporting a community of cold water fish and aquatic life, or serving as a spawning area for cold water fish species. This subcategory includes, but is not restricted to, surface waters identified as trout water by the Department of Natural Resources (Wisconsin Trout Streams, publication 6-3600 (80)).

(b) Warm water sport fish communities. This subcategory includes surface waters capable of supporting a community of warm water sport fish or serving as a spawning area for warm water sport fish.

(c) Warm water forage fish communities. This subcategory includes surface waters capable of supporting an abundant diverse community of forage fish and other aquatic life.

(d) Limited forage fish communities. (Intermediate surface waters). This subcategory includes surface waters of limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of forage fish and other aquatic life.

(e) Limited aquatic life. (Marginal surface waters). This subcategory includes surface waters of severely limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of aquatic life.

3.1.2 Recreational Uses

Subsection NR 102.04 (5) states that all surface waters shall be suitable for supporting recreational use and shall meet the criteria specified in subsection (6) (discussed below in 3.2.3). A sanitary survey or evaluation, or both to assure protection from fecal contamination is the chief criterion for determining the suitability of a water for recreational use. Exceptions include whenever the department determines, in accordance with the procedures specified in s. NR 210.06 (3), that wastewater disinfection is not required to protect recreational uses, the recreational criteria and requirements in chs. NR 103 and 104, Wis. Adm. Code, do not apply.

At the time of this publication, Wisconsin had not yet adopted an *E. coli* standard.

Table 1-1 in Section 1 presents the current and designated uses for the impaired waterbodies in the Basin.

3.2 Water Quality Criteria

Wisconsin has both narrative and numeric water quality criteria. Both are contained in chapter NR 102, Wisconsin Administrative Code.

All waters of the State of Wisconsin are subject to the following narrative water quality standard, as defined in s. NR 102.04(1), Wis. Adm. Code:

> "To preserve and enhance the quality of waters, surface water uses and criteria are established to govern water management decisions. Practices attributable to municipal, industrial, commercial, domestic, agricultural, land development or other activities shall be controlled so that all surface waters including the mixing zone meet the following conditions at all times and under all flow and water level conditions: (a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water, shall not be present in such amounts as to interfere with public rights in waters of the state. (b) Floating or submerged debris, oil, scum or other material shall not be present in such amounts as to interfere with public rights in waters of the state. (c) Materials producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the state. (d) Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life."

Excessive phosphorus loading causes algal blooms, which can be characterized as floating scum, producing a green color, a strong odor, and an unsightly condition. Sometimes these algal blooms contain toxins which limit recreational uses of the waterbodies. Excessive sediments are considered objectionable deposits, causing habitat impairments which inhibit the propagation of fish and aquatic life. Because of low dissolved oxygen and degraded habitat caused by TP and TSS, many designated fish and aquatic life uses are impaired in the waters covered by this TMDL study.

3.2.1 Total Phosphorus

Section NR 102.06, Wis. Adm. Code, sets total phosphorus criteria for surface waterbodies (0.1 mg/L for rivers and 0.075 mg/L for streams). According to s. NR 102.06(3)(a), Wis. Adm. Code, the 0.1 mg/L TP criteria applies to the following waterbodies within the Basin:

- Menomonee River from the confluence with Little Menomonee River downstream to the estuary
- Kinnickinnic River from the confluence with Wilson Park Creek downstream to the estuary
- Milwaukee River from the confluence with Cedar Creek downstream to the estuary
- Inner and outer harbor areas of the estuary

The 0.075 mg/L TP criteria, also specified in s. NR 102.06, applies to all other surface waters exhibiting unidirectional flow in the Basin that are not listed as limited aquatic life systems pursuant to s. NR 102.06.

Lake and reservoir criteria are also established in s. NR 102.06, Wis. Adm. Code. There are 20 lakes with a surface area of 50 acres or more in the Milwaukee River watershed. Of these 20 lakes, 19 were included in the model used to generate flows for the TMDLs; therefore, their effects are represented in the TMDL reach flows. Green Lake in Washington County was not included because it is a seepage lake and not hydraulically connected to the rest of the system. None of the lakes are listed on the CWA 303(d) impaired waters list and individual allocations were not developed for each lake. **Table 3-1** presents the TMDL reach encompassing each of the 19 lakes and the phosphorus criterion for each lake. **Figure B.2** of Appendix B shows the locations of the 19 lakes. For impoundments that are not reservoirs, the criterion is the same as that of the inflowing stream or river. The TMDL study area does not include Lake Michigan beyond the Milwaukee Harbor breakwall; therefore, the Lake Michigan TP criterion was not considered in the analysis.

Table 3-1. Total Phosphorus Water Quality Criteria for Lakes in Milwaukee River Watershed

Lake	TMDL Reach Encompassing Lake	Waterbody ID Code	Type	Total Phosphorus Criterion (mg/L)
Auburn (Fifteen)	MI-02	42400	Deep Lowland	0.03
Barton Pond	MI-06	35400	Shallow Lowland	0.04
Big Cedar	MI-18	25300	Two-Story Fishery	0.015
Crooked	MI-05	37900	Deep Seepage	0.02
Ellen	MI-10	32500	Deep Headwater	0.03
Forest	MI-05	8900	Deep Seepage	0.02
Kettle Moraine	MI-01	43900	Deep Seepage	0.02
Little Cedar	MI-18	25100	Deep Lowland	0.03
Long	MI-05	38700	Deep Lowland	0.03
Lucas	MI-06	35900	Shallow Headwater	0.04
Mauthe	MI-05	38200	Deep Lowland	0.03
Mud (Fond du Lac County)	MI-01	43700	Deep Lowland	0.03
Mud (Ozaukee County)	MI-24	22100	Shallow Seepage	0.04
Random	MI-14	30300	Shallow Headwater	0.04
Silver	MI-06	36200	Deep Headwater	0.03
Smith (Drickens)	MI-06	36700	Shallow Seepage	0.04
Spring	MI-14	30500	Deep Seepage	0.02
Twelve	MI-13	29700	Deep Headwater	0.03
Wallace	MI-13	28300	Deep Headwater	0.03

3.2.2 Total Suspended Solids

There are currently no numeric criteria for TSS in Wisconsin; however, there are narrative criteria in s. NR 102.04, Wis. Adm. Code, which can be applied to TSS as described above. Because a numeric target is needed for TMDL analysis, one was developed for this study area. Although USEPA has not published guidance on setting water quality criteria for TSS in flowing streams and rivers, USEPA's Science Advisory Board guidance for nutrient criteria provides a framework that can be applied to TSS. That guidance emphasizes use of multiple lines of evidence, relating concentrations to biotic impacts, using strong and supportable correlations between causal and response parameters. A target concentration of 12 mg/L TSS was derived by WDNR for use in this TMDL to address the sediment impacts, based on the same approach and data used to develop Wisconsin's phosphorus criteria. This numeric target is intended to meet the narrative criteria in s. NR 102.04, Wis. Adm. Code.

U.S. Geological Survey Professional Paper 1754, *Nutrient Concentrations and Their Relations to the Biotic Integrity of Nonwadeable Rivers in Wisconsin* by Dale M. Robertson, Brian M. Weigel, and David J. Graczyk (USGS, 2008) provides data and statistical results that allow identification of TSS targets, as supplemented by unpublished analysis by Dale Robertson. On Tables 11 and 15 of the paper, a strong correlation, based on the Spearman rank correlation coefficients, was noted for a number of indices, including macroinvertebrate species, % of individuals from the order Ephemeroptera, Mean Pollution Tolerance Value, Hilsenhoff Biotic Index, % intolerant fish species, % lithophillic spawners, % suckers, and fish index of biotic integrity. Subsequent breakpoint analysis by Dale Robertson preliminarily showed a weighted breakpoint of between 10 and 15 mg/L.

The TSS target based on Wisconsin non-wadeable streams and river data is preferred over earlier and broader analyses for a variety of reasons, including:

- All data was collected using a defined protocol and during the same year, while other studies are based on available data collected using a variety of protocols over a number of years.
- All of the 42 non-wadeable rivers and streams are of similar size, stream order, etc., while other studies used a wide range of streams and rivers.
- Correlation to biotic impacts is considered as a stronger and more appropriate basis than a calculated pre-settlement reference condition.

Based on weighting strategies similar to what was used in the development of the phosphorus criteria, WDNR arrived at a TSS target value of 12 mg/L, expressed as the median of monthly samples collected during the growing season between May and October. The expression of the TSS target matches how the samples were collected and are intended to be used.

The 12 mg/L target is designed to address both sedimentation and impacts caused by TSS that remains in the water column. In translating the 12 mg/L target, it is important to note that it will be expressed as a monthly median concentration meaning higher than 12 mg/L may occur at times in the receiving waters.

Since standard wastewater treatment processes such as grit removal and primary and secondary clarification, which are necessary to reduce wastewater TSS levels to 12 mg/L, will have removed settable material that would contribute to sedimentation, wastewater discharges at or below 12 mg/L will not contribute to sediment impairments. Contributions to turbidity, a condition that is related to concentration and not mass, would also be absent at 12 mg/L effluent concentrations. Therefore, wastewater dischargers will not be required to meet effluent limits lower than 12 mg/L (including equivalent mass limits) in order to comply with the water quality targets developed for this TMDL.

3.2.3 Bacteria

Chapter NR 104, Wis. Adm. Code, lists variances to designated uses. Section NR 104.06, specifies variances applicable to this TMDL area. For waterbodies that are allowed a variance under s. NR 104.06 (a), "the membrane filter fecal coliform count exceed 1,000 per 100 mL as a monthly geometric mean based on not less than 5 samples per month nor exceed 2,000 per 100 mL in more than 10% of all samples during any month." This variance includes the following waterbodies:

- Honey Creek in Milwaukee County
- Indian Creek in Milwaukee County
- Kinnickinnic River in Milwaukee County
- Lincoln Creek in Milwaukee County
- Menomonee River in Milwaukee County below the confluence with Honey Creek
- Underwood Creek in Milwaukee and Waukesha Counties below Juneau Boulevard

For waterbodies that are allowed a variance under s. NR 104.06 (b), "the membrane filter fecal coliform count cannot exceed 1,000 per 100 mL as a monthly geometric mean based on not less than 5 samples per month":

- Burnham Canal in Milwaukee County
- Milwaukee River in Milwaukee County downstream from the former North Avenue dam
- South Menomonee Canal in Milwaukee County

As stated above, compliance with the fecal coliform criteria is determined in two ways: 1) the fecal coliform count may not exceed 200 cfu per 100 mL as a geometric mean, and 2) the count may not exceed 400 cfu per 100 mL in more than 10 percent of all samples during any month. The fecal coliform data was evaluated and it was found that the 10 percent not to exceed 400 cfu per 100 mL threshold was exceeded more frequently than the geometric mean threshold, making the 10 percent not to exceed 400 cfu per 100 mL threshold more restrictive than the geometric mean threshold. To develop TMDLs for fecal coliform in this study, the 10 percent not to exceed 400 cfu per 100 mL portion of the criteria was used for the TMDL calculations. While the TMDL will focus on the geometric mean portion of the water quality standard, WDNR requires that both parts of the water quality standard be met.

USEPA has promulgated recreational water quality criteria (40 CFR 131.41) for open water Lake Michigan areas and the outer harbor area of the Milwaukee Harbor Estuary (Figure 1-16). The criteria promulgated in 2004 were based on USEPA's 1986 Ambient Water Quality Criteria for Bacteria include an *E. coli* geometric mean standard of 126 cfu per 100 mL and single sample maximum value of 235 cfu per 100 mL for designated bathing (swimming) areas.

The variance criteria within ch. NR 104, Wis. Adm. Code, were evaluated as part of this study. Each waterbody with a variance standard is upstream of a waterbody with a more restrictive (non-variance) standard. Waters downstream of the variance waters are required to meet their respective *E. coli* or fecal coliform standards to protect their designated uses. The loading allowed by the variance criteria in the NR 104.06-listed waters would not allow for the water quality criteria to be met in the downstream waters; therefore, the variance criteria could not be used within the TMDL calculations. For these waters, the non-variance criteria (an *E. coli* geometric mean standard of 126 cfu per 100 mL and statistical threshold value of 410 cfu per 100 mL for the outer harbor area of the Milwaukee Estuary, and 200 fecal coliform cfu per 100 mL as a geometric mean and not to exceed 400 cfu per 100 mL in more than 10 percent of all samples during any month for all other waters in the basin) were used.

Most of the historical bacteriological data is for fecal coliform and the upstream watershed models were calibrated for this organism. The water quality standard for the outer harbor and nearshore area of Lake Michigan is based on *E. coli* concentrations; therefore, a translator was developed to convert the fecal coliform loadings to *E. coli* loadings for use in evaluating impacts to the outer harbor area. The translator was developed based on concurrent fecal coliform and *E. coli* samples collected in the TMDL study area and analyzed by the McLellan lab at the UWM School of Freshwater Sciences. A fecal coliform to *E. coli* relationship was developed for this study so that calculated fecal coliform loading capacities and resulting instream concentrations could be translated to *E. coli* for the outer harbor area. See Section 5 and Appendix E for more information on the development and use of the translator.

Section 4
Source Assessment

4.1 Spatial Framework

The methods used to calculate baseline pollutant loading for each source category is described within this section. Baseline loading values assist with understanding the relative contribution of each source to each TMDL reach, and set a foundation for the allocation of allowable pollutant loads.

Baseline loads for total phosphorus, total suspended solids, and fecal coliform are presented in Appendix A. Appendix A contains tables for each TMDL watershed and the Milwaukee Harbor Estuary, numbered in the same sequence for consistency between the four sets of tables. Kinnickinnic River watershed tables are denoted as (KK), for example, **Table A.1** (KK). Menomonee River watershed tables are denoted as (MN). Milwaukee River watershed tables are denoted as (MI). Milwaukee Harbor Estuary tables are denoted as (Estuary). Appendix A, **Tables A.1** through **A.3** present baseline loads for nonpoint sources. **Tables A.4** through **A.6** present baseline loads for MS4s. **Table A.7** presents baseline loads for other individually permitted point sources and non-contact cooling water sources covered by general permits.

In addition to the baseline loads presented in Tables A.1 through A.7, Appendix A includes tables presenting flows, allocations, and percent reductions from baseline. Specifically, **Tables A.8** and **A.9** present the flows used for calculation of the allowable loads, **Tables A.10** through **A.27** present allocations, and **Tables A.29** through **A.30** present percent reductions for each TMDL reach. Corresponding baseline loads, flows, and allocations for the Milwaukee Harbor Estuary are listed by assessment point rather than by reach because of how the calculations for the estuary are performed. **Tables A.A** through **A.C** (concentrations at the assessment points) are unique to the Estuary and not included for the watersheds.

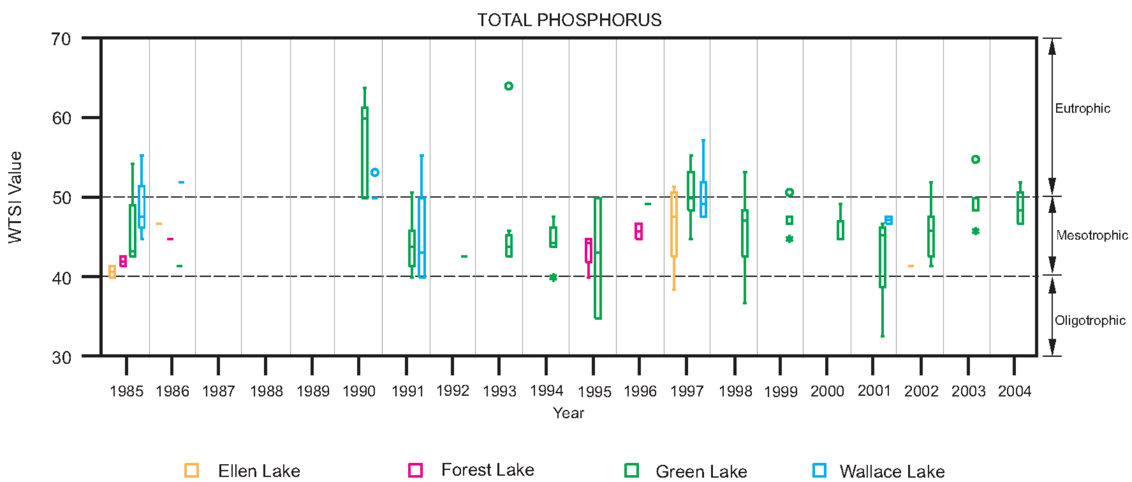
4.2 Analysis Framework

The river and stream network in the Basin was divided into unique reaches and subwatersheds for the purposes of TMDL analysis. These are referred to as TMDL reaches and TMDL subbasins. The watershed models developed for the Water Quality Initiative (WQI) served as the source of flow and baseline nonpoint source loading information for the TMDL calculations, so the WQI model reaches served as the basis for the TMDL reaches. Each TMDL reach contains several WQI model reaches. Several hundred model reaches were combined into larger reaches for TMDL analysis and to allow more flexibility and opportunities for TMDL implementation (for example, water quality trading). TMDL reaches were delineated based on 303(d) listed segments, changes in water quality standards, point source locations, and significant changes in flow (for example, at a major tributary confluence). The TMDL reaches are the spatial basis for all calculations and allocations. A total of 55 TMDL reaches were delineated to represent the Basin (Figure B.2 in Appendix B). The flow from the most downstream WQI model reach defines the flow for the TMDL reach. Loads from the tributary WQI model subbasins were aggregated to calculate baseline loads from each TMDL subbasin.

As discussed in Section 3.2, there are 20 lakes with a surface area of 50 acres or more in the Milwaukee River watershed. None of these lakes are listed as impaired for phosphorus, sediment, or bacteria. In addition, these lakes have specific phosphorus criteria, so calculating allocations for each individual lake would require additional modeling and delineation work. Ultimately, the TMDL Development Team decided that allocations will not be calculated for the individual lakes (see Decision Memorandum in Appendix C). Since these lakes are currently not impaired and the TMDL allocations will reduce overall watershed loadings, it is believed that the lakes will be adequately protected. If monitoring shows that additional work is needed to protect the lakes, lake management plans could be drafted to address specific issues.

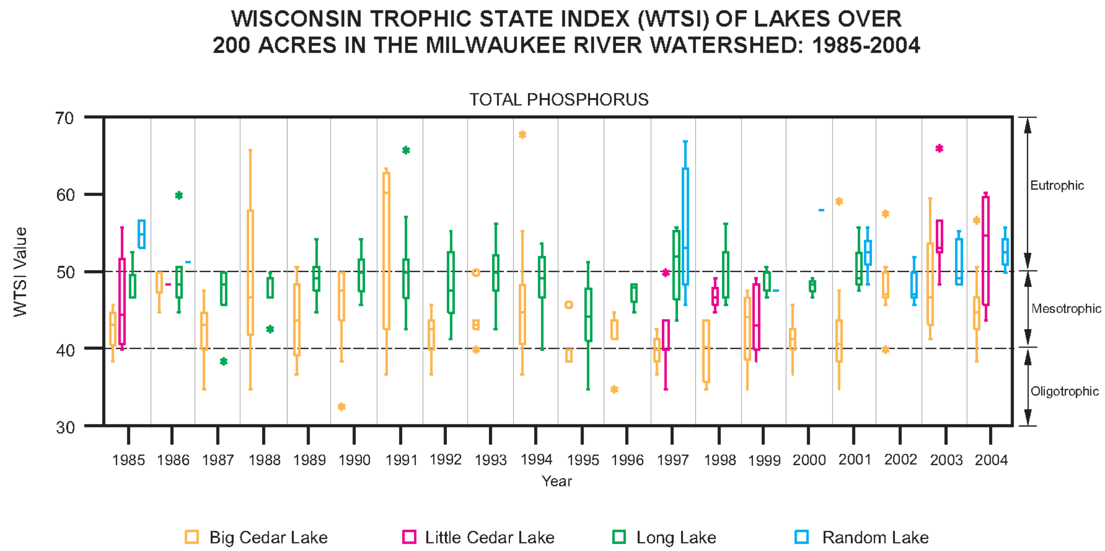
The Regional Water Quality Management Plan Update summarizes the degree of nutrient enrichment, or trophic status, for lakes in the Greater Milwaukee area based on Secchi-disk transparency, chlorophyll-*a*, and total phosphorus concentrations. This methodology was modified by WDNR using data from 184 lakes throughout the state. The resulting Wisconsin State Trophic Index (WSTI) numeric ratings for lakes in the Milwaukee River watershed are presented below. Mesotrophic lakes do not usually exhibit the nuisance growths of algae associated with eutrophic lakes, and typically support productive fisheries with opportunities for recreational activities.

WISCONSIN TROPHIC STATE INDEX (WTSI) OF LAKES UNDER 200 ACRES IN THE MILWAUKEE RIVER WATERSHED: 1985-2004



Source: Wisconsin Department of Natural Resources and SEWRPC.

CDM Smith



Source: Wisconsin Department of Natural Resources and SEWRPC.

Because the estuary is more of an open waterbody than a stream network, water quality concentrations are calculated at selected assessment points located throughout the estuary, rather than within defined river reaches as in the Menomonee, Kinnickinnic, and Milwaukee River watersheds. The open water nature of the estuary requires more complex analysis tools (as described in Section 4.2.1 below) and a different allocation methodology (described in Section 5.4).

4.2.1 Water Quality Models

Water quality models developed and calibrated as part of the WQI were used to analyze flow and baseline nonpoint source loading conditions in the Basin. WQI watershed flow models were developed using Hydrological Simulation Program–Fortran (HSPF) and Loading Simulation Program in C++ (LSPC), which includes HSPF algorithms but uses a Microsoft Access database structure. Both are public domain models developed for the USEPA and have been used throughout the country for TMDL development. HSPF was used to represent the Menomonee and Kinnickinnic River watersheds and LSPC was used to represent the Milwaukee River watershed.

Both models apply a series of algorithms to watershed characteristics and meteorological data to simulate hydrologic (flow) and pollutant transport processes. HSPF is a comprehensive watershed and receiving water quality model that was originally developed in the mid-1970s. The LSPC modeling system includes HSPF algorithms for simulating hydrology, sediment, and general water quality on land as well as in the water column. One key advantage of using LSPC is that, unlike HSPF, it has no inherent limitations in terms of modeling size or model operations. Thus, larger watersheds like the Milwaukee River watershed can be handled in one model setup, rather than being split into a number of smaller input datasets. More information about the WQI models, including model calibration and validation, is provided in Chapter V of PR-50.

Land cover classifications are defined in the models to simulate surface runoff, flow routing, and pollutant loading. These land cover classifications are characterized as impervious, or as combinations of Natural Resource Conservation Service hydrologic soil group (A, B, C, or D) and land use/land cover for pervious areas. The HSPF models for the Kinnickinnic and Menomonee River watersheds use 17 land use classifications (six impervious and eleven pervious). The Milwaukee River watershed LSPC model uses 26 land use classifications (six impervious and twenty pervious). The distribution of these classifications for each of the model subbasins was determined during the WQI model development using GIS overlay techniques and SEWRPC year 2020 planned land use data (see **Figure B.1** in Appendix B for land use map).

Initial unit-loading parameters (pollutant buildup rate and maximum pollutant buildup) for these land cover classifications and each modeled constituent were derived to produce loads consistent with Source Loading and Management Model (SLAMM) and Soil and Water Assessment Tool (SWAT) models, where possible. SLAMM is designed to estimate urban loads and is preferred by WDNR for assessing compliance with WPDES urban storm water pollutant regulations. SWAT is more often used to compute loads from rural watersheds. Initial loading parameters for fecal coliform from background, agricultural, and urban pervious areas were adopted from other successful modeling applications and approaches. Fecal coliform loading rates from urban impervious areas were adjusted to replicate loads estimated by SLAMM. The derived loading parameter values were refined during model calibration to improve the correlation between observed and simulated water quality conditions.

To model the dynamics in the Milwaukee Harbor Estuary, specialized hydrodynamic and water quality models were developed for the WQI. The Estuarine Coastal and Ocean Model (ECOM) simulates complex hydrodynamic processes and water temperature. The Row-Column AESOP (Advanced Ecological Simulation Program), or RCA model, simulates water quality processes, including interaction with sediment. The ECOM/RCA model extends from the inner harbor area to the interface between Lake Michigan and the modeled near shore area between Fox Point to the north and Wind Point to the south. While the model includes near shore areas of Lake Michigan, the TMDL study extends only as far as the outer harbor.

Boundary conditions at the upstream boundaries of the estuary model were input from the HSPF and LSPC models of the watershed systems. The estuary model does not directly simulate runoff and pollutant loadings from the land surface, therefore runoff volume and pollutant loading time series from the LSPC and HSPF models were input directly to the ECOM/RCA model. Meteorological data and point source data were also included as inputs to the model.

The watershed and estuary models were calibrated during the WQI by comparing observed data and simulated values and adjusting the input parameters of the model as necessary. The hydrologic and hydraulic portions of the models were calibrated first since the simulation of pollutant transport mechanisms is based on accurate simulation of hydrologic and hydraulic processes.

For the watershed models, the calibration period of the hydrologic and hydraulic elements was 1995 through 1998. Input parameters were adjusted until the modeled runoff volumes and flow rates adequately matched those from data recorded at selected USGS flow gauges. In some instances, adjustments were made to the meteorological datasets themselves, particularly precipitation, if it appeared that the data were not representative of conditions over the area being represented.

The comparisons were done using both graphical and statistical means. Graphical procedures included time series plots, scatter plots, and flow-duration plots. Statistical comparisons used the relative error method and the following tolerances were used to evaluate the model fit to observed data:

- Total runoff volume: ± 10 percent

- Seasonal runoff volume: ± 20 percent
- Highest 10 percent flow volume: ± 15 percent
- Lowest 50 percent flow volume: ± 10 percent
- Error in storm volumes: ±20 percent

These tolerances are consistent with, and in some cases more stringent than, those recommended by the USGS for calibration of the HSPF model (USGS, 1994).

In general, the hydrologic calibration and validation results indicate acceptable agreement between observed and modeled streamflows. Some limitations in the calibration and validation of the Milwaukee LSPC model were noted. In particular, the model was found to generally under predict flows during the spring months. Much of the meteorological data for the Milwaukee LSPC model was clustered in the downstream portion of the watershed. A single rain gauge covers a large area of the upper watershed where precipitation and other meteorological inputs vary significantly. The only rain gauge with decades (70 years) of reliable information is the gauge at General Mitchell International Airport. In prior modeling and study efforts, using the many years of data available from this site was thought to take care of the geographical bias. In addition, the WQI modeling team concluded that the discrepancies may be due to poor representation of certain snowmelt events and a limited ability to simulate the hydrologic impacts of numerous small lakes and wetlands. Agreement between observed and modeled flows was stronger for the Menomonee and Kinnickinnic watershed models.

The calibration period of the water quality portions of the watershed models was 1994 through 1998. Input parameters were adjusted until the modeled water quality indicators adequately matched data collected by MMSD under its bi-weekly sampling program. The model validation period was 1999 through 2001. Both graphical and statistical procedures were used to evaluate the model results. A "weight of evidence approach" was used where no one absolute criterion was used to determine model acceptance or rejection. Graphical methods included time series plots, concentration exceedance plots, and plots of load versus flow and flow exceedance. Statistical methods included Student's *t*-tests to evaluate equality of means, and standard deviation.

Calibration of the water quality components of the models was conducted in a specific sequence in terms of water quality indicators. For example, absorbed pollutant transport depends on the simulation of sediment so the sediment portion of the model was calibrated before the simulation of particle-reactive pollutants, including phosphorus and fecal coliform. The complete calibration sequence followed:

1. Calibration of sediment
2. Calibration of water temperature
3. Initial calibration of gross nutrient transport
4. Initial calibration of carbonaceous biochemical oxygen demand and dissolved oxygen (DO)
5. Calibration of algae
6. Final calibration of nutrient species and DO
7. Calibration of fecal coliform
8. Calibration of metals

The results of the water quality portions of the models were compared with measured concentrations at locations throughout the watershed. Because load is not observed directly, estimates of observed load are made by multiplying concentration by the average daily flow. For the calibration, model predicted loads were compared with observations in reaches where both flow and concentration data were available. It should be noted that the concentrations are from a specific point in time, while the flow data is generally a daily average; therefore, a primary goal of water quality model calibration was to obtain general agreement between simulated and the estimated observed loads.

Statistical tests were applied to both simulated concentrations and estimated loads. The primary test is the Student's *t*-test of equality of means. Model performance is considered acceptable unless the statistical analysis indicates otherwise. For both concentrations and loads over the calibration and validation periods, the models met the *t*-test criteria in a majority of cases.

Watershed model validation was done for the period of 1999 through 2002 to test the calibrated model using input from a different time period with no further adjustment of input parameters. The calibration and verification performed for the WQI was determined acceptable with no need for additional calibration or validation of the models for use in the TMDL analysis.

For the estuary model, the calibration period of the hydrodynamic portion was 1995 through 1998. Model results were compared to measured water levels in the harbor, flow at the mouth of the rivers, and vertical water temperature profiles from various water quality sampling stations in the three rivers, harbor area, and Lake Michigan. Input parameters such as horizontal and vertical mixing coefficients were adjusted until the model results adequately matched observed data. Graphical comparison procedures included time series plots and temperature profile plots. Statistical comparisons included root mean square error and relative root mean square error.

In general, the hydrodynamic calibration and validation results indicate reasonable agreement between observed and modeled data. Root mean square error was calculated to provide a measure of the error between the model and observed data.

The calibration period of the water quality portion of the estuary model was 1995 through 1998. Input parameters were adjusted until the modeled water quality conditions adequately matched observed data. The model validation period was 1999 through 2002. The model results were compared to observed conditions through graphical time series comparisons and model error analyses. Similar to the watershed models, a "weight of evidence approach" was used where no one absolute criterion was used to determine model acceptance or rejection.

For the estuary model, an error analysis was conducted at eight monitoring stations representing the three rivers entering the harbor, the confluence of the three rivers, and the outer harbor. The qualitative and quantitative comparisons between modeled and observed data were reasonable given the complex nature of the Milwaukee Harbor Estuary system.

The WQI models were prepared under the guidance of a technical advisory committee that included representatives of the WDNR and USEPA. The models were accepted by WDNR for TMDL study use.

Further details on the calibration and validation of the model are provided in PR-50 and two technical memoranda prepared for the 2020 Facilities Plan project (Tetra Tech, 2007).

4.2.2 Model Simulation Period

The WQI models were run for the period of 1988 through 1997 to compile the flow and baseline nonpoint source loading dataset for the TMDL calculations. The TMDL Development Team selected this 10-year period because it contains a wide range of flow conditions representative of the available 63-year period of record, and the models are considered well calibrated for this period.

4.2.3 Fecal Coliform Load Duration Curve

For developing the TMDLs for fecal coliform, the Load Duration Curve (LDC) process was used. The LDC method considers how streamflow conditions relate to a variety of pollutant sources (point and nonpoint sources), and can be used to make rough determinations as to what flow conditions result in exceedances of the water quality standards. The LDC method assimilates flow and pollutant (fecal coliform) data across stream flow regimes, and provides allowable loads to meet water quality standards. Additional explanation of the LDC approach is provided in Section 5.3.2.

4.3 Analysis of Phosphorus, Sediment, and Fecal Coliform Loading

4.3.1 Nonpoint Source Loading

Baseline flow and loads for phosphorus, total suspended solids, and fecal coliform from nonpoint sources were generated from the WQI models. Natural or background sources of stormwater runoff loads from woodland, wetland, and other natural areas (background loads) were estimated from the forest and wetland land covers in the models. Baseline agricultural loads were calculated from the crop and pasture land covers in the WQI models. Baseline loads for non-permitted urban areas were calculated from the non-background and non-agricultural land covers based on the proportion of the TMDL subbasin area that was outside of a permitted MS4 municipal boundary. The phosphorus loads from the WQI were adjusted to reflect the statewide fertilizer ban that took effect in April 2010. Baseline total phosphorus loads from the grass land covers were reduced by 20% per the Kinnickinnic and Menomonee Watershed Restoration Plans (MMSD, 2010).

Percent reductions for agricultural sources stipulated in the TMDL are calculated from the baseline agricultural conditions simulated in the WQI models. The baseline conditions reflect watershed averages and do not address variation in individual fields. Refer to PR-50 and the SWAT (Soil and Water Assessment Tool) model that was developed for details on the baseline and loading conditions assumed for agricultural lands.

4.3.2 Point Source Loading

Baseline flows and loads for individual and general (non-contact cooling water) permittees are listed in **Table 4-1** and shown on **Figure B.3** in Appendix B (map numbers in the table correspond to point labels on the figure). The following sections outline the approaches used for these sources.

4.3.2.1 Individual Permits

The phosphorus and total suspended solids baseline loads for wastewater point sources covered by an individual WPDES permit with specified limits was based on the concentration limit and design flow (annual average design flow for POTWs; highest average annual flow over three years for industrial dischargers). If a permitted limit did not exist, measured data from the facility was used in place of the concentration limit to determine the baseline load. To be representative of ch. NR 217, Wis. Adm. Code technology-based effluent limits (TBELs) for phosphorus, all wastewater point source baseline TP loads were set to an effluent concentration limit of 1.0 mg/L unless the individual permittee's TBEL was less than 1.0 mg/L, in which case the lower TP permitted effluent limit was used. Baseline TSS loads for municipal wastewater discharges were set to the TBEL concentration limit of 30 mg/L, unless the individual permittee's TBEL was less than 30 mg/L, in which case the lower permitted effluent limit was used. Baseline TSS loads for non-municipal wastewater discharges were set to their actual discharge amount. If no TSS data was available for an industrial discharge, estimations based upon the type of discharge were made to determine a baseline concentration where needed. Baseline fecal coliform loads for municipal wastewater discharges were based on the plant's design flow and a concentration of 400 cfu/100 mL during the months of May through September to reflect seasonal disinfection limits. Baseline fecal coliform loads for non-municipal wastewater discharges were set to zero, because industrial wastewater discharges are not expected to contain bacteria.

Based on a SEWRPC analysis of estimated 2035 wastewater flows for POTWs, which used population projections developed under the 2035 SEWRPC Regional Land Use Plan, there are two facilities in the Basin projected to have significant flow increases by 2035. These facilities are the City of Cedarburg POTW and the Village of Newburg POTW. The projected flow rates for these two facilities are used in the TMDL calculations.

Table 4-1 provides a summary of permits including special notes regarding the dischargers. In some cases, baseline loads have not been assigned; however, that does not imply that no discharge is allowed. Discharges from these facilities are laid out in specific conditions contained within the permits. The baseline load for these facilities is included in the MS4 baseline load if the discharge is located within an MS4 boundary or the set-aside for general permits if the discharge is located outside of an MS4 area. For example, General Mitchell International Airport has an individual permit to cover deicing and other procedures; however, discharges from the airport are more similar to those covered under the general industrial stormwater permit, rather than those from a traditional point source discharger (i.e., discharges occur as runoff during storm or melting events).

4.3.2.2 General Permits

Baseline loads for general permittees located within an MS4 boundary were included in the MS4 baseline load. Baseline loads for general permittees located outside of MS4 areas were included as 5% of the non-permitted urban baseline load for TP and TSS. There was no baseline load assumed for bacteria from general permits because bacteria are not expected to be in general permit (industrial wastewater) discharges.

Non-contact cooling water (NCCW) facilities were evaluated to determine whether individual allocations were necessary to meet TP goals in the TMDL area, but this was not done for TSS or fecal coliform. Total suspended solids in NCCW general permits will be addressed similarly to other general permits, through the MS4 allocation for NCCW discharges within the MS4 area and through the general permit set-aside load for sources outside of the MS4 area. During the allocation process, the set-aside load for general permits is subtracted from the overall assimilative capacity of the receiving water. Fecal coliform loads for NCCW discharges were set to zero because they are not expected to contain bacteria.

4.3.2.3 Non-Contact Cooling Water General Permits (phosphorus only)

Most NCCW discharges are covered by the NCCW general permit (WI-0044938). This general permit does not currently contain TBELs for phosphorus, because these permittees discharged less than the TBEL thresholds set in ch. NR 217, Subchapter II, Wis. Adm. Code, at the time of the last reissuance. However, water quality-based effluent limits (WQBEL) would be necessary for some permittees covered under this general permit if the permittee discharges phosphorus at levels high enough to trigger WQBELs, as required in s. NR 217.13, Wis. Adm. Code.

Elevated phosphorus concentrations are often present in these discharges, due to the use of additives to control lead in municipal water supplies. Phosphorus WQBELs that are imposed as a result of this TMDL, or according to s. NR 217.13, Wis. Adm. Code, do not intend to suggest that additives in finished drinking water are not needed or should not be used. In the case of lead, additives are often needed to ensure healthy and safe drinking water. However, alternatives may need to be explored to reduce phosphorus inputs into receiving waters.

During TMDL development, NCCW discharges were evaluated independent of other general permitted sources, for the purposes of determining whether individual WLAs for phosphorus were needed to meet TMDL goals. For facilities that add phosphorus to their discharge or that use water from a public water supply that adds phosphorus, design flows (highest average annual flow over three years, like that used for individually permitted industrial dischargers) and discharge concentrations were used to determine individual WLAs. The baseline discharge concentration used was either phosphorus monitoring supplied by the discharger or an assumed value based on the concentration of phosphorus in the water supply. For dischargers using City of Milwaukee water, a TP concentration of 0.515 mg/L was used (based on discussions with Milwaukee Water Works).

For pass through systems (i.e., facilities with surface water intake structures) where phosphorus is not added and the water is withdrawn from and discharged to the same waterbody, the baseline condition for the allocation process utilized actual discharge flows with TP concentrations set to zero to reflect that no net addition of phosphorus is occurring. This would result in an allocation of zero, but allow the facility to discharge the pass through phosphorus load.

Evaluation of NCCW facilities was necessary due to the large number of NCCW general permittees in some reaches and the large volumes of water (and potentially TP mass load) that they may discharge. However, once this evaluation was completed, it became clear that these discharges do not contribute a significant mass when compared to the total phosphorus load discharged to these receiving waters. The total load of TP from all NCCW general permittees is 2,178 pounds per year. The sum of TP from all individual permits is 259,796 pounds per year, meaning that the NCCW contribution is 0.83 percent of the total point source load.

Since it was determined that individual WLAs were not necessary to achieve TMDL goals, a single mass allocation has been assigned to all NCCW general permits. To aid in implementation, this allocation will be grouped and tracked by watershed to ensure that the total allocation for NCCW is not exceeded.

Currently, NCCW facilities covered under the general permit are only required to submit annual monitoring of their effluent quality. In watersheds with TMDLs, this requirement will be increased to quarterly effluent sampling. The sampling will be used to track the total mass allocation used by NCCW facilities in each watershed. If through the increased monitoring and tracking it is determined that sufficient allocation has not been set aside for NNCW facilities, facilities may be switched to individual permits with discharge requirements placed in the permit sufficient to meet TMDL allocations. These discharge requirements would likely be similar to the individual mass allocations for NCCW facilities already listed in the TMDL.

In addition to increased sampling frequency, NCCW facilities covered under the general permit and located in a TMDL watershed will be required to optimize their processes to limit the phosphorus in their discharge.

4.3.2.4 Municipal Separate Storm Sewer Systems (MS4s)

There are 37 cities, villages, and townships within the Basin that are regulated under the MS4 permit program. These areas are listed in **Table 4-2** and shown in **Figure B.4** in Appendix B. Baseline MS4 loads were determined from the non-background and non-agricultural land covers in the WQI models. The MS4 portion of the load from these land covers was determined based on the proportion of the TMDL subbasin area that lies within a permitted municipal boundary.

In addition to the 37 listed municipalities, there are six counties (Fond du Lac, Ozaukee, Sheboygan, Washington, Milwaukee, and Waukesha) and two special units of government (Southeast Wisconsin Professional Baseball Park District and Wisconsin State Fair Park) that are regulated MS4s. These entities will not receive individual allocations. Instead, they are accounted for in the portions of each city, village, or town MS4 that they discharge to or lie within; however, these regulated MS4s that are not given specific allocations will still be expected to achieve the applicable identified reductions within their portion of their jurisdictional area. While Fond du Lac and Sheboygan Counties' jurisdictional limits lie within the Basin, neither county has permitted area within the Basin. The permitted area is determined by the US Census Bureau's mapped Urbanized Area, adjacent developed areas, or areas that are connected or will connect to other municipal separate storm sewer systems regulated under subchapter I of ch. NR 216, Wis. Adm. Code.

The WQI Year 2020 condition models were used to establish the MS4 baseline load, with some adjustments. The WQI models included consideration of full implementation of the ch. NR 151, Wis. Adm. Code, runoff management performance standards for non-agricultural facilities to achieve water quality standards required by ss. 281.16(2) and (3), Wis. Stats. One of the rules reflected in the models called for an annual average TSS reduction of 40% from existing development constructed prior to October 1, 2004. In 2011, Wisconsin Act 32 amended s.281.16(2), Wis. Stats., to require only a 20% reduction from existing development (there was no change to the requirements for new and re-development areas). With no revisions, the WQI models would overestimate the level of TSS control from existing development, which would result in lower baseline loads and allocations for the MS4 municipalities. In order to rectify this, the models needed to be revised to reflect the statute change. The adjustment factors used to reflect the original 40% TSS reduction were revised to reflect the newer 20% TSS reduction requirement; therefore, the baseline MS4 loads calculated by the revised models assume municipalities have achieved the 20% reduction required.

There are MS4s in the Basin that have implemented practices and reported annual average percent TSS reductions from their systems greater than 20%. While these individual modeled results have not been included in the TMDL analysis, these above-baseline condition reductions will be credited towards meeting water quality targets established in the WPDES permits regulating these municipalities.

During the WQI model development, a baseline concentration of fecal coliform was simulated, and in part, accounts for contributions of fecal coliform loadings from unknown urban sources. These loadings are presumed to be from illicit connections to the storm sewer system, leaking sewer and private laterals, and other unidentified sources that are not flow-dependent. Direct additions of bacteria through wildlife, waterfowl and domestic animals were also included. This baseline concentration was adjusted in the WQI model development by specifying seasonally varying concentrations based on individual monitoring location data to obtain good agreement with observed dry-weather conditions. Modeling of build-up and wash-off rates of fecal coliform loading were initially adjusted to be consistent with rates produced by WinSLAMM during the simulation period. A calibration factor was then applied to obtain good agreement with observed data in downstream segments with higher levels of imperviousness.

Municipalities are addressing illicit connections with the assistance of MMSD, Milwaukee Riverkeeper, and the UWM School of Freshwater Sciences (see the Milwaukee Riverkeeper web site for recent information on this issue), as well as through the MS4 permit by effectively prohibiting non-stormwater discharges into and from the municipal storm sewer system. Fecal coliform loads were incorporated into the impervious land cover loadings within the WQI models to represent these unnamed sources and are therefore included in the baseline MS4 loads used for the allocation calculations.

Wisconsin Department of Transportation (WisDOT) land areas are not currently covered by a WPDES permit. These areas are considered to be regulated through the conditions of a memorandum of understanding with WDNR. The WisDOT baseline load was considered to be within the baseline load for each MS4 with WisDOT area.

Loads from the Combined Sewer Service Area are not considered part of the MS4 area because runoff within this area does not discharge to surface water, but instead is conveyed to the Jones Island Water Reclamation Facility for treatment. The Combined Sewer Service Area is shown on **Figure B.4** in Appendix B.

Table 4-1. Permitted Point Sources in the Milwaukee River Basin TMDLs

Facility Name	Permit Number	Outfall Number	Permit Type	TMDL Reach	Baseline Flow (MGD)	Baseline TP Concentration (mg/L)	Baseline TP Load (lbs/month)	Baseline TSS Concentration (mg/L)	Baseline TSS Load (lbs/month)	Baseline FC Concentration (cells/100 mL)	Baseline FC Load (cells/month)	Notes	Map Number
Menomonee River Watershed													
A O Smith Corporation	0044938	001	General - NCCW	MN-06	0.013	0.535	1.76	0	0	0	0		100
Advanced Metal Treating Inc*	0044938	001	General - NCCW	MN-10	0.007	0.450	0.799	0	0	0	0	Permit discontinued 06/16/2014.	101
American Concrete Pipe Co Milwaukee*	0044938	001	General - NCCW	MN-06	0.001	0.512	0.130	0	0	0	0	Permit discontinued 03/03/2014.	102
Avoca Bioprocessing Corp*	0044938	001	General - NCCW	MN-05	0.002	0.450	0.228	0	0	0	0		103
Avoca Bioprocessing Corp	0044938	003	General - NCCW	MN-05	0.012	0.705	2.15	0	0	0	0		104
Avoca Bioprocessing Corp	0044938	004	General - NCCW	MN-05	0.006	0.457	0.696	0	0	0	0	Permit for Outfall 001 discontinued as of 03/02/2014.	105
Badger Alloys Inc	0044938	001	General - NCCW	MN-16	0.008	1.065	2.16	0	0	0	0		106
Blue Mound Golf & Country Club	0044938	001	General - NCCW	MN-10	0.027	0.022	0.151	0	0	0	0		107
Brenntag Great Lakes LLC - Milsolv Facility	0044938	001	General - NCCW	MN-07	0.005	0.515	0.653	0	0	0	0	Phosphorus concentrations represent average residual concentration of water supply per WDNR.	108
Briggs Stratton Corp Wauwatosa	0026514	002	Individual	MN-10	0.500	0.120	15.2	0	0	0	0	NCCW is discharged to one of two 3.2 million gallon stormwater ponds. . . Source water for NCCW is private well water whjch is chlorinated and treated with orthophosphate. Sampling is done at the overflow from one of the ponds (north). Current permit does not require TSS sampling.	109
Briggs Stratton Corp Wauwatosa	0026514	003	Individual	MN-10	0.010	0.550	1.40	0	0	0	0	Discharge contains NCCW w/o additives. Storm sewer to Menomonee River.	110
Cambridge Major Laboratories Inc	0044938	001	General - NCCW	MN-05	0.006	0.019	0.029	0	0	0	0		111
Cambridge Major Laboratories Inc - Grant Drive	0044938	001	General - NCCW	MN-05	0.042	2.30	24.5	0	0	0	0		112
Canadian Pacific Railway	0064351	001	Individual	MN-16	0.001	0.118	0.030	20	5.07	0	0	Oil/water separator. Stormwater runoff near engine fueling site. Discharge is rainfall dominated.	113
Charter Wire Division	0044938	001	General - NCCW	MN-16	0.0005	0.140	0.018	0	0	0	0		114
Chr Hansen Inc	0044938	001	General - NCCW	MN-15	0.009	0.410	0.936	0	0	0	0		115
Chr Hansen Inc	0044938	002	General - NCCW	MN-15	0.009	1.33	3.03	0	0	0	0		116
Dana Sealing Products LLC*	0044938	001	General - NCCW	MN-09	0.030	0.390	2.97	0	0	0	0	Permit discontinued 11/30/2012.	117
Derco Repair Service	0044938	001	General - NCCW	MN-09	0.001	0.486	0.123	0	0	0	0		118
D. R. Diedrich & Co LTD	0044938	004	General - NCCW	MN-16	0.016	0.740	3.00	0	0	0	0		119
D. R. Diedrich & Co LTD	0044938	006	General - NCCW	MN-16	0.028	0.700	4.97	0	0	0	0		120
Froedtert Memorial Lutheran Hospital	0044938	001	General - NCCW	MN-15	0.019	0.856	4.13	0	0	0	0		121
Gallos Metal Solutions Inc	0044938	001	General - NCCW	MN-09	0.004	0.593	0.602	0	0	0	0		122
GE Healthcare	0044938	001	General - NCCW	MN-09	0.002	0.605	0.307	0	0	0	0		123

Facility Name	Permit Number	Outfall Number	Permit Type	TMDL Reach	Baseline Flow (MGD)	Baseline TP Concentration (mg/L)	Baseline TP Load (lbs/month)	Baseline TSS Concentration (mg/L)	Baseline TSS Load (lbs/month)	Baseline FC Concentration (cells/100 mL)	Baseline FC Load (cells/month)	Notes	Map Number
GEHL Guernsey Farms Inc*	0044938	001	General - NCCW	MN-01	0.190	0.432	20.8	0	0	0	0	Permit discontinued	124
Gkn Sinter Metals	0044938	001	General - NCCW	MN-01	0.006	0.205	0.312	0	0	0	0		125
Gkn Sinter Metals	0044938	001a	General - NCCW	MN-05	0.010	1.14	2.88	0	0	0	0		126
Gkn Sinter Metals	0044938	001b	General - NCCW	MN-05	0.010	0.566	1.44	0	0	0	0		127
Grede LLC - Liberty Foundry	0044938	001	General - NCCW	MN-16	0.089	0.532	12.0	0	0	0	0		128
Grede LLC - Liberty Foundry	0044938	002	General - NCCW	MN-16	0.028	0.256	1.82	0	0	0	0		129
Hampel Corp	0044938	001	General - NCCW	MN-03	0.120	0.040	1.22	0	0	0	0		130
Harley Davidson Motor Company Operations	0044938	001	General - NCCW	MN-05	0.003	1.16	0.884	0	0	0	0		131
Harley Davidson Motor Company PDC	0044938	001	General - NCCW	MN-10	0.007	0.193	0.343	0	0	0	0		132
Harley Davidson Motor Company PDC	0044938	002	General - NCCW	MN-10	0.003	1.39	1.06	0	0	0	0		133
Hellermann Tyton	0044938	001	General - NCCW	MN-09	0.067	1.57	26.7	0	0	0	0	WDNR Facility ID No. 26159	134
Helwig Carbon Products Inc	0044938	001	General - NCCW	MN-09	0.004	0.515	0.523	0	0	0	0	Phosphorus concentrations represent average residual concentration of water supply per WDNR.	135
Hentzen Coatings Inc Milwaukee	0044938	002	General - NCCW	MN-09	0.016	0.573	2.33	0	0	0	0		136
Hentzen Coatings Inc Milwaukee	0044938	003	General - NCCW	MN-09	0.016	0.566	2.30	0	0	0	0		137
Joy Global Surface Mining Inc	0025321	001	Individual	MN-16	0.285	0.500	36.1	15	1.08E+03	0	0	NCCW, heat treat quench water, boiler blowdown.	138
Krete Industries Inc	0044938	001	General - NCCW	MN-10	0.001	0.915	0.232	0	0	0	0		139
Masterson Co	0044938	001	General - NCCW	MN-16	0.045	0.593	6.77	0	0	0	0		140
Masterson Co	0044938	002	General - NCCW	MN-16	0.051	0.548	7.09	0	0	0	0		141
Mayfair Mall	0062260	001	Individual	MN-12	0.0085 (Mar-Nov)	1.70 (Mar-Nov)	3.67 (Mar-Nov)	20 (Mar-Nov)	43 (Mar-Nov)	0	0	Cooling tower blowdown w/ additives, operates March through November.	142
Midwestern Anodizing Corporation	0044938	001	General - NCCW	MN-09	0.004	0.643	0.652	0	0	0	0		143
Millercoors LLC	0000744	001	Individual	MN-16	0.190	0.300	14.5	10	482	0	0	Cooling water	144
Millercoors LLC	0000744	004	Individual	MN-16	0.320	0.800	64.9	20	1.62E+03	0	0	Filter backwash	145
Milwaukee County Power Plant	0044938	001	General - NCCW	MN-14	0.133	1.06	35.8	0	0	0	0		146
Milwaukee Logistic Center	0044938	001	General - NCCW	MN-05	0.00001	8.34	0.021	0	0	0	0		147
Motor Castings Co Plt 1 West Allis	0044938	004	General - NCCW	MN-16	0.003	0.247	0.188	0	0	0	0		148
Motor Castings Co Plt 1 West Allis	0044938	005	General - NCCW	MN-16	0.006	0.582	0.886	0	0	0	0		149
Motor Castings Co Plt 1 West Allis	0044938	007	General - NCCW	MN-16	0.003	0.470	0.358	0	0	0	0		150
Neubauer Fabrications Inc	0044938	001	General - NCCW	MN-01	0.0002	0	0	0	0	0	0	Facility is located in Germantown. The Village of Germantown does not add phosphorus to its water supply per WDNR.	151
Perlick Corp	0044938	001	General - NCCW	MN-09	0.024	0.245	1.49	0	0	0	0		152
Pettit National Ice Center	0044938	001	General - NCCW	MN-15	0.005	0.515	0.653	0	0	0	0	Phosphorus concentrations represent average residual concentration of water supply per WDNR.	153
Phoenix Metal Treating	0044938	001	General - NCCW	MN-01	0.014	0.032	0.114	0	0	0	0		154
Rexnord Industries Inc	0044938	001	General - NCCW	MN-16	0.133	0.500	16.9	0	0	0	0		155

Facility Name	Permit Number	Outfall Number	Permit Type	TMDL Reach	Baseline Flow (MGD)	Baseline TP Concentration (mg/L)	Baseline TP Load (lbs/month)	Baseline TSS Concentration (mg/L)	Baseline TSS Load (lbs/month)	Baseline FC Concentration (cells/100 mL)	Baseline FC Load (cells/month)	Notes	Map Number
Rexnord Industries Inc	0044938	004	General - NCCW	MN-16	0.0005	1.20	0.163	0	0	0	0		156
Rexnord Industries Inc	0044938	009	General - NCCW	MN-16	0.034	0.670	5.85	0	0	0	0		157
Rexnord Industries LLC -Falk	0044938	005	General - NCCW	MN-16	0.030	0.480	3.65	0	0	0	0		158
Sun Chemical Kohl & Madden	0044938	004	General - NCCW	MN-05	0.001	0.620	0.157	0	0	0	0		159
Super Steel LLC	0044938	001	General - NCCW	MN-09	0.002	0.362	0.184	0	0	0	0		160
Super Steel LLC	0044938	002	General - NCCW	MN-09	0.002	0.677	0.343	0	0	0	0		161
Thiele Tanning Co	0044938	001	General - NCCW	MN-16	0.0009	0.515	0.118	0	0	0	0	Phosphorus concentrations represent average residual concentration of water supply per WDNR.	162
Toshiba International Corp	0044938	001	General - NCCW	MN-16	0.0086	0.427	0.933	0	0	0	0		163
Toshiba International Corp	0044938	002	General - NCCW	MN-16	0.0014	0.692	0.246	0	0	0	0		164
US Food Service	0044938	001	General - NCCW	MN-05	0.003	5.16	3.93	0	0	0	0		165
Waste Management of Omega Hills Landfill	0049514	001	Individual	MN-05	0.080	0.020	0.406	20	406	0	0	Baseline flow based on design flow in permit.	166
We Energies Germantown	0042757	001	Individual	MN-01	0.005 (May-Oct)	0.197 (May-Oct)	0.250 (May-Oct)	10 (May-Oct)	13 (May-Oct)	0	0	Intermittent discharge, operates May through November. Oil/water separator. Flow from permit application. Source water private well.	167
We Energies Germantown	0042757	002	Individual	MN-01	0.008 (May-Oct)	0.202 (May-Oct)	0.410 (May-Oct)	20 (May-Oct)	41 (May-Oct)	0	0	Intermittent discharge, operates May through November. Condenser blowdown, cooling coil condensate, ice water storage tanks. Flow from permit application. Source water private well.	168
We Energies Germantown	0042757	003	Individual	MN-01	0	0	0	0	0	0	0	Portable demineralizer tanks. No discharge.	169
We Energies Milwaukee Heating Plant	0044938	003	General - NCCW	MN-16	0.024	0.380	2.31	0	0	0	0		170
West Allis Memorial Hospital	0044938	001	General - NCCW	MN-15	0.017	0.555	2.39	0	0	0	0		171
Xymox Technologies Inc	0044938	001	General - NCCW	MN-09	0.001	0.712	0.181	0	0	0	0		172
Kinnickinnic River Watershed													
Acme Galvanizing Inc	0044938	003	General - NCCW	KK-7	0.003	0.400	0.304	0	0	0	0		200
Apiscent Labs	0044938	001	General - NCCW	KK-4	0.124	1.04	32.7	0	0	0	0		201
Associated Spring	0044938	001	General - NCCW	KK-5	0.0001	1.62	0.041	0	0	0	0		202
Campbell Soup Supply Co LLC	0044938	001	General - NCCW	KK-5	0.090	0.720	16.4	0	0	0	0		203
Elite Finishing	0044938	001	General - NCCW	KK-7	0.010	0.630	1.60	0	0	0	0		204
General Electric Medical Tube Manufacturing	0044938	001	General - NCCW	KK-3	0.070	0.610	10.8	0	0	0	0		205
General Electric Medical Tube Manufacturing	0044938	002	General - NCCW	KK-3	0.093	0.892	21.0	0	0	0	0		206
General Mitchell International Airport	0046477	001	Individual	KK-5	0.06	0.780	11.9	45	685	0	0	Non-continuous deicing discharge. Outfall 003 discharges to Oak Creek. Flows are max annual average from permit application. P concentration from P point source load summary table. TSS is average from Mar 2006 - Jan 2015.	207
General Mitchell International Airport	0046477	007	Individual	KK-4	3.14	0.780	621	60	4.78E+04	0	0		208
Great Lakes Water Institute	0045942	001	Individual	KK-7	0.260	0.500	33.0	10	660	0	0		209

Facility Name	Permit Number	Outfall Number	Permit Type	TMDL Reach	Baseline Flow (MGD)	Baseline TP Concentration (mg/L)	Baseline TP Load (lbs/month)	Baseline TSS Concentration (mg/L)	Baseline TSS Load (lbs/month)	Baseline FC Concentration (cells/100 mL)	Baseline FC Load (cells/month)	Notes	Map Number
Great Lakes Water Institute	0045942	002	Individual	KK-7	0.260	0.500	33.0	10	660	0	0		210
Grebes Bakery	0044938	001	General - NCCW	KK-2	0.0003	0.515	0.039	0	0	0	0	Phosphorus concentrations represent average residual concentration of water supply per WDNR.	211
Grebes Bakery	0044938	002	General - NCCW	KK-2	0.002	0.515	0.261	0	0	0	0		212
Grebes Bakery	0044938	003	General - NCCW	KK-3	0.006	0.515	0.784	0	0	0	0		213
Joy Mark Inc*	0044938	001	General - NCCW	KK-4	0.000006	0.515	0.001	0	0	0	0	Permit discontinued as of 03/13/2015. Phosphorus concentrations represent average residual concentration of water supply per WDNR.	214
Ladish Forging LLC	0000728	040	Individual	KK-4	0.23	0.400	23.3	10	583	0	0	Outfall 040 is the combined discharge of Ladish Outfalls 002 and 003 (NCCW discharges). Flow is estimated and reported on Discharge Monitoring Report; no other monitoring done at this outfall.	215
Malteurop North America Inc.	0044938	001	General - NCCW	KK-3	0.025	0.810	5.14	0	0	0	0		216
Maynard Steel Casting Co*	0000272	002	Individual	KK-7	0.012	0.197	0.601	0	0	0	0	Permit discontinued March 2016.	217
Patrick Cudahy Inc	0044938	001	General - NCCW	KK-4	0.060	0	0	0	0	0	0	Source water does not contain phosphorus per WDNR.	218
Reliable Plating Works Inc	0044938	001	General - NCCW	KK-5	0.022	0.564	3.15	0	0	0	0		219
Rexnord/Stearns Division	0044938	001	General - NCCW	KK-4	0.026	0.238	1.57	0	0	0	0		220
St Luke's Medical Center	0044938	008	General - NCCW	KK-7	0.009	0.302	0.689	0	0	0	0		221
St Luke's Medical Center	0044938	009	General - NCCW	KK-4	0.029	0.488	3.59	0	0	0	0		222
St Luke's Medical Center	0044938	011	General - NCCW	KK-7	0.019	0.600	2.89	0	0	0	0		223
St Luke's Medical Center	0044938	016	General - NCCW	KK-7	0.0007	0.240	0.043	0	0	0	0		224
Unit Drop Forge Co Inc	0044938	001	General - NCCW	KK-3	0.027	0.478	3.27	0	0	0	0		225
Milwaukee River Watershed													
Airsan Corp*	0044938	001	General - NCCW	MI-31	0.000012	0.500	0.002	0	0	0	0	Permit discontinued 10/21/2011.	300
Amcor Flexibles Inc	0044938	002	General - NCCW	MI-31	0.022	0.302	1.69	0	0	0	0		301
Arkema Inc	0027731	001	Individual	MI-16	0.870	0	0	0	0	0	0	Water supply is from a groundwater source per WDNR. Background TP and TSS are present in effluent from source water. Point source is not contributing TP or TSS beyond that which is present in the water supply. For these reasons, no TP or TSS reductions are necessary to meet TMDL targets.	302
Badger Meter Inc	0033529	001	Individual	MI-28	0.2255	0.350	20.0	0	0	0	0	Meter test stand water is discharged to stormwater pond..Samples are collected at overflow structure to storm sewer to Beaver Creek. Source water for test stand water is municipal water supply. Current permit does not require TSS sampling.	303
Badger Meter Inc*	0033529	002	Individual	MI-28	--	--	--	--	--	--	--	WLAs will not be assigned. Outfall 002 abandoned per WDNR.	304
Brady USA Inc Coated Products Div	0044938	001	General - NCCW	MI-31	0.028	0.570	4.05	0	0	0	0		305

Facility Name	Permit Number	Outfall Number	Permit Type	TMDL Reach	Baseline Flow (MGD)	Baseline TP Concentration (mg/L)	Baseline TP Load (lbs/month)	Baseline TSS Concentration (mg/L)	Baseline TSS Load (lbs/month)	Baseline FC Concentration (cells/100 mL)	Baseline FC Load (cells/month)	Notes	Map Number
Brewery Works Inc	0044938	001	General - NCCW	MI-32	5.90	0	0	0	0	0	0	Water supply is surface water per WDNR. Background TP is present in effluent from source water. Point source is not contributing TP beyond that which is present in the water supply. For these reasons, no TP reductions are necessary to meet TMDL targets.	306
C & D Technologies	0063258	006	Individual	MI-32	0.010	0.600	1.52	20	50.7	0	0	NCCW, boiler blowdown	307
Campbellsport Wastewater Treatment Facility	0020818	001	Individual	MI-01	0.470	1.00	119	10.0	1.19E+03	400 (May-Sept)	2.16E+11 (May-Sept)	Baseline TP concentrations for all POTWs is set at 1 mg/L to reflect compliance with NR 217.	308
Cascade Wastewater Treatment Facility	0031372	001	Individual	MI-08	0.130	1.00	33.0	60.0	1.98E+03	400 (May-Sept)	5.98E+10 (May-Sept)	Baseline TP concentrations for all POTWs is set at 1 mg/L to reflect compliance with NR 217.	309
Cedarburg Wastewater Treatment Facility	0020222	001	Individual	MI-24	3.07	1.00	779	15.0	1.17E+04	400 (May-Sept)	1.41E+12 (May-Sept)	Baseline TP concentrations for all POTWs is set at 1 mg/L to reflect compliance with NR 217. Baseline flow set at Planned 2035 Flow per SEWRPC.	310
Charter Steel Div Of Charter Mfg Co	0044938	002	General - NCCW	MI-16	0.239	0.030	1.82	0	0	0	0		311
Charter Steel Div Of Charter Mfg Co	0044938	003	General - NCCW	MI-16	0.027	0.040	0.274	0	0	0	0		312
Charter Steel Div Of Charter Mfg Co	0044938	005	General - NCCW	MI-16	0.011	0.070	0.195	0	0	0	0		313
Chicago Faucets	0044938	001	General - NCCW	MI-31	0.004	0.563	0.571	0	0	0	0		314
Compass Properties	0044938	001	General - NCCW	MI-32	0.177	0	0	0	0	0	0	Water supply is surface water per WDNR. Background TP is present in the surface water intake. Point source is not contributing TP beyond that which is present in the water supply. For these reasons, no TP reductions are necessary to meet TMDL targets.	315
DRS Power & Control Technologies Inc	0062723	002	Individual	MI-31	0.032	0.584	4.76	0	0	0	0	HVAC cooling water discharge to Storm Sewer to Lincoln CreekFlow and baseline TP load for former Outfall 001 added to flow and baseline TP load for Outfall 002. Outfall 001 no longer active.	316
DRS Power & Control Technologies Inc	0062723	003	Individual	MI-31	0.0001	1.80	0.046	20	0.51	0	0	Cooling tower blowdown, discharge is once per year.	317
DRS Power & Control Technologies Inc	0062723	009	Individual	MI-31	0.048	2.30	28.0	0	0	0	0	Heat Exchanger; Point source is not contributing TSS beyond that which is present in the water supply. Discharge is once through city water. For these reasons, no TSS reductions are necessary to meet TMDL targets.	318
Electron Beam Fusion Corp	0044938	001	General - NCCW	MI-31	0.003	0.780	0.594	0	0	0	0		319
Franchise Mailing Systems*	0044938	001	General - NCCW	MI-32	0.0001	0.515	0.013	0	0	0	0	Permit discontinued 2/20/2014.	320
Fred Usinger Inc	0044938	001	General - NCCW	MI-32	0.005	0.515	0.653	0	0	0	0	Phosphorus concentration represents average residual concentration of water supply per WDNR.	321
Fredonia Municipal Sewer and Water Utility	0020800	001	Individual	MI-15	0.600	1.00	152	30	4.57E+03	400 (May-Sept)	2.76E+11 (May-Sept)		322
Fromm Family Pet Food	0044938	001	General - NCCW	MI-26	0.008	0.100	0.203	0	0	0	0		323
Grafton Village Water & Wastewater Utility	0020184	001	Individual	MI-17	2.50	1.00	634	30	1.90E+04	400 (May-Sept)	1.15E+12 (May-Sept)		324

Facility Name	Permit Number	Outfall Number	Permit Type	TMDL Reach	Baseline Flow (MGD)	Baseline TP Concentration (mg/L)	Baseline TP Load (lbs/month)	Baseline TSS Concentration (mg/L)	Baseline TSS Load (lbs/month)	Baseline FC Concentration (cells/100 mL)	Baseline FC Load (cells/month)	Notes	Map Number
Hellermann Tyton	0044938	001	General - NCCW	MI-31	0.0005	0.515	0.065	0	0	0	0	WDNR Facility ID No. 50265. Phosphorus concentration represents average residual concentration of water supply per WDNR.	325
Hub Milwaukee Center Properties LLC	0044938	001	General - NCCW	MI-32	3.56	0	0	0	0	0	0	Water supply is surface water per WDNR. Background TP is present in the surface water intake. Point source is not contributing TP beyond that which is present in the water supply. For these reasons, no TP reductions are necessary	326
Hydrite Chemical Company	0044938	001	General - NCCW	MI-29	0.054	1.49	20.4	0	0	0	0		327
Hydro Platers Inc	0044938	001	General - NCCW	MI-31	0.005	0.650	0.824	0	0	0	0		328
Hydro Platers Inc	0044938	002	General - NCCW	MI-31	0.005	0.633	0.803	0	0	0	0		329
Jackson (Village) Wastewater Treatment Plant	0021806	001	Individual	MI-21	1.69	1.00	429	12	5.14E+03	400 (May-Sept)	7.78E+11 (May-Sept)		330
Johnson Controls Inc	0000108	001	Individual	MI-31	0.004 (Mar-Nov)	1.70 (Mar-Nov)	1.51 (Mar-Nov)	20 (Mar-Nov)	17.8 (Mar-Nov)	0	0	Cooling tower blowdown, operates March through November.	331
Kewaskum Village	0021733	001	Individual	MI-02	0.750	1.00	190	10 (May-Oct) 18 (Nov-Apr)	1.90E+03 (May-Oct) 3.42E+03 (Nov-Apr)	400 (May-Sept)	3.45E+11 (May-Sept)		332
Kracor Inc	0044938	001	General - NCCW	MI-31	0.0004	1.16	0.118	0	0	0	0		333
Kracor Inc	0044938	002	General - NCCW	MI-31	0.0008	1.16	0.235	0	0	0	0		334
Krier Foods Inc Random Lake	0049204	001	Individual	MI-14	0.082	0.18	3.74	0	0	0	0	NCCW, reverse osmosis reject	335
Lallemand Specialities Inc	0044938	001	General - NCCW	MI-31	0.020	0.677	3.43	0	0	0	0		336
Mid City Foundry United Division*	0044938	001	General - NCCW	MI-17	0.011	0.240	0.670	0	0	0	0	Permit discontinued March 2015.	337
Milk Specialties Global Adell	0001236	001	Individual	MI-09	1.39	0.740	261	10	3.53E+03	0	0		338
Milwaukee Gear Co Inc	0044938	001	General - NCCW	MI-27	0.183	0.160	7.43	0	0	0	0		339
Molecular Biology Resources Inc	0044938	001	General - NCCW	MI-31	0.014	0.632	2.24	0	0	0	0		340
Newburg Village	0024911	001	Individual	MI-07	0.200	1.00	50.7	30	1.52E+03	400 (May-Sept)	9.21E+10 (May-Sept)	Baseline TP concentrations for all POTWs is set at 1 mg/L to reflect compliance with NR 217. Baseline flow set at Planned 2035 Flow per SEWRPC.	341
Norstar Aluminum Molds Inc	0044938	002	General - NCCW	MI-24	0.001	0.345	0.088	0	0	0	0	Phosphorus concentration represents average residual concentration of water supply per WDNR (Cedarburg).	342
Norstar Aluminum Molds Inc	0044938	003	General - NCCW	MI-24	0.0006	0.345	0.053	0	0	0	0	Phosphorus concentration represents average residual concentration of water supply per WDNR (Cedarburg).	343
Novozymes Bioag Inc	0044938	001	General - NCCW	MI-31	0.014	0.700	2.49	0	0	0	0		344
Pentair Residential Filtration LLC	0044938	002	General - NCCW	MI-27	0.0015	0.515	0.196	0	0	0	0	Phosphorus concentration represents average residual concentration of water supply per WDNR. Previous individual permit discontinued 6/30/2015 (that discharge is now covered by Hydrostatic Test Water General Permit.)	345

Facility Name	Permit Number	Outfall Number	Permit Type	TMDL Reach	Baseline Flow (MGD)	Baseline TP Concentration (mg/L)	Baseline TP Load (lbs/month)	Baseline TSS Concentration (mg/L)	Baseline TSS Load (lbs/month)	Baseline FC Concentration (cells/100 mL)	Baseline FC Load (cells/month)	Notes	Map Number
Pereles Bros	0044938	001	General - NCCW	MI-31	0.202	0.892	45.7	0	0	0	0		346
Random Lake Village	0021415	001	Individual	MI-14	0.449	1.00	114	20	2.28E+03	400 (May-Sept)	2.07E+11 (May-Sept)		347
Regal Beloit America	0044938	001	General - NCCW	MI-27	0.046	0.173	2.02	0	0	0	0		348
Regal Ware Inc	0044938	001	General - NCCW	MI-06	0.067	0.322	5.47	0	0	0	0		349
Ritus Rubber Corporation	0044938	001	General - NCCW	MI-29	0.074	0.515	9.67	0	0	0	0	P Per letter from facility on 06/23/2016, facility uses closed loop system now. No discharge. Permit discontinued.	350
Riveredge Nature Center	0044938	001	General - NCCW	MI-07	0.014	0	0	0	0	0	0	Water supply is from a well source per WDNR.	351
Saukville Village Sewer Utility	0021555	001	Individual	MI-16	1.61	1.00	408	30	1.23E+04	400 (May-Sept)	7.41E+11 (May-Sept)		352
Schreiber Foods Inc - West Bend	0026751	001	Individual	MI-24	0.476	1.00	121	10 (May-Oct) 19 (Nov-Apr)	1.21E+03 (May-Oct) 2.29E+03 (Nov-Apr)	0	0		353
Signicast LLC - Milwaukee	0044938	002	General - NCCW	MI-28	0.024	0.607	3.70	0	0	0	0		354
Signicast LLC - Milwaukee	0044938	003	General - NCCW	MI-28	0.004	0.580	0.589	0	0	0	0		355
Solines, LLC	0044938	007	General - NCCW	MI-31	0.162	1.76	72.1	0	0	0	0		356
Solines, LLC	0044938	014	General - NCCW	MI-31	0.002	0.646	0.328	0	0	0	0		357
Stainless Foundry Engineering Inc	0044938	002	General - NCCW	MI-31	0.040	0.800	8.12	0	0	0	0		358
Stainless Foundry Engineering Inc	0044938	004	General - NCCW	MI-31	0.112	0.585	16.6	0	0	0	0		359
Super Steel LLC Calumet*	0044938	001	General - NCCW	MI-29	0.002	0.480	0.244	0	0	0	0	Permit discontinued June 2015.	360
Sysco Food Service Of Eastern Wisconsin	0063231	001	Individual	MI-18	0.002	0.370	0.188	0	0	0	0	Wastewater component is cooling tower blowdown (not a "pass-through" NCCW), operates April through October.	361
Universal Strap Inc	0044938	001	General - NCCW	MI-20	0.0004	0	0	0	0	0	0	The facility is located in Village of Jackson which uses orthophosphate for corrosion control in water supply distribution system. Average concentration is 0.43 mg/L orthophosphate, or 0.14 mg/L TP.	362
We Energies Milwaukee Heating Plant	0044938	001	General - NCCW	MI-32	0.002	0.144	0.073	0	0	0	0		363
We Energies Milwaukee Heating Plant	0044938	002	General - NCCW	MI-32	0.0002	0.065	0.003	0	0	0	0		364
We Energies Milwaukee Heating Plant	0044938	004	General - NCCW	MI-32	0.007	0.410	0.728	0	0	0	0		365
We Energies Milwaukee Heating Plant	0044938	006	General - NCCW	MI-32	0.006	0.090	0.137	0	0	0	0		366
West Bend City	0025763	001	Individual	MI-06	9.00	1.00	2.28E+03	10	2.28E+04	400 (May-Sept)	4.14E+12 (May-Sept)		367
WDNR Kettle Moraine Springs Fish Hatchery	0026255	001	Individual	MI-11	1.20	0.060	18.3	10	3.04E+03	0	0		368
Wisconsin Thermoset Molding Inc	0042218	005	Individual	MI-32	0.0002	1.650	0.084	0	0	0	0	Cooling tower blowdown	369

Facility Name	Permit Number	Outfall Number	Permit Type	TMDL Reach	Baseline Flow (MGD)	Baseline TP Concentration (mg/L)	Baseline TP Load (lbs/month)	Baseline TSS Concentration (mg/L)	Baseline TSS Load (lbs/month)	Baseline FC Concentration (cells/100 mL)	Baseline FC Load (cells/month)	Notes	Map Number
Milwaukee Harbor Estuary													
Aldrich Chemical Co Inc Emmber	0044938	001	General - NCCW	Estuary	0.009	0.530	1.21	0	0	0	0		400
Discovery World at Pier Wisconsin	0044938	001	General - NCCW	Estuary	2.44	0	0	0	0	0	0	Water supply is surface water per WDNR.	401
Miller Compressing Mainyard Recycle AP	0044938	003	General - NCCW	Estuary	0.003	0.820	0.624	0	0	0	0		402
Milwaukee Art Museum	0044938	001	General - NCCW	Estuary	1.44	0	0	0	0	0	0	Water supply is surface water per WDNR.	403
Milwaukee Metropolitan Sewerage District - Jones Island	0036820	002	Individual	Estuary	123.0	0.660	2.06E+04	30	9.36E+05	400	5.66E+13		404
Milwaukee Metropolitan Sewerage District - Jones Island	0036820	003	Individual	Estuary	2.40	0	0	0	0	0	0	Water supply is surface water per WDNR. Flow is based on highest 7-day averages from 1/2006 through 5/2011 and phosphorus values from 8/2011 thru 8/2012.	405
We Energies Valley Power Plant	0000931	001	Individual	Estuary	79.2	0	0	0	0	0	0	Process wastewater discharged to MMSD for treatment. Water supply for remainder of discharge is surface water per WDNR.	406
We Energies Valley Power Plant	0000931	002	Individual	Estuary	54.9	0	0	0	0	0	0	Water supply is surface water per WDNR.	407

*An asterisk (*) behind a facility name indicates that the discharge has been discontinued. Baseline and draft wasteload allocation amounts were calculated for this outfall during TMDL development. Since the discharge was discontinued prior to TMDL approval, a final individual wasteload allocation was not assigned to this outfall. Instead, the draft WLA portion will be set aside as additional reserve capacity for the reach.

Table 4-2. Municipal Separate Storm Sewer Systems in the Milwaukee River Basin

Municipality	TMDL Subbasin	Area (acres)
Village of Bayside	MI-30	245
City of Brookfield	MN-08	2,540
City of Brookfield	MN-10	555
City of Brookfield	MN-11	4,172
City of Brookfield	MN-12	526
City of Brookfield	MN-13	831
Town of Brookfield	MN-11	113
Village of Brown Deer	MI-27	373
Village of Brown Deer	MI-28	1,222
Village of Brown Deer	MI-29	1,066
Village of Brown Deer	MI-31	160
Village of Butler	MN-06	58
Village of Butler	MN-08	13
Village of Butler	MN-10	446
City of Cedarburg	MI-24	2,849
City of Cedarburg	MI-25	74
City of Cedarburg	MI-26	195
Town of Cedarburg	MI-17	1,617
Town of Cedarburg	MI-21	425
Town of Cedarburg	MI-22	2,753
Town of Cedarburg	MI-24	9,548
Town of Cedarburg	MI-26	1,596
City of Cudahy	KK-4	953
Village of Elm Grove	MN-11	435
Village of Elm Grove	MN-12	1,649
Village of Elm Grove	MN-13	15
Village of Fox Point	MI-27	73
Village of Fox Point	MI-30	959
Village of Germantown	MN-01	11,578
Village of Germantown	MN-02	1,119
Village of Germantown	MN-03	1,664
Village of Germantown	MN-04	2,149
Village of Germantown	MN-05	1,909
Village of Germantown	MN-06	134
Village of Germantown	MN-09	249
Village of Germantown	MI-21	3,279
City of Glendale	MI-27	2,737
City of Glendale	MI-30	121
City of Glendale	MI-31	430
City of Glendale	MI-32	492
Town of Grafton	MI-16	5

CDM Smith

Municipality	TMDL Subbasin	Area (acres)
Town of Grafton	MI-17	3,397
Town of Grafton	MI-24	312
Town of Grafton	MI-25	5,975
Village of Grafton	MI-17	2,029
Village of Grafton	MI-24	413
Village of Grafton	MI-25	797
Village of Greendale	MN-15	73
City of Greenfield	KK-1	108
City of Greenfield	KK-2	111
City of Greenfield	KK-4	649
City of Greenfield	KK-6	556
City of Greenfield	MN-15	1,840
Village of Jackson	MI-18	142
Village of Jackson	MI-20	710
Village of Jackson	MI-21	846
Village of Jackson	MI-22	241
Village of Kewaskum	MI-02	773
Village of Kewaskum	MI-03	44
Village of Kewaskum	MI-04	593
Village of Kewaskum	MI-05	90
Town of Lisbon	MN-04	196
Village of Menomonee Falls	MN-01	2,170
Village of Menomonee Falls	MN-04	539
Village of Menomonee Falls	MN-05	376
Village of Menomonee Falls	MN-06	4,031
Village of Menomonee Falls	MN-07	3,640
Village of Menomonee Falls	MN-08	1,070
Village of Menomonee Falls	MN-10	13
City of Mequon	MN-01	547
City of Mequon	MN-05	420
City of Mequon	MN-06	92
City of Mequon	MN-09	6,399
City of Mequon	MI-21	41
City of Mequon	MI-24	524
City of Mequon	MI-25	8,821
City of Mequon	MI-26	5,328
City of Mequon	MI-27	5,397
City of Mequon	MI-28	28
City of Milwaukee	KK-1	745
City of Milwaukee	KK-2	1,218
City of Milwaukee	KK-3	60
City of Milwaukee	KK-4	3,671

Municipality	TMDL Subbasin	Area (acres)
City of Milwaukee	KK-5	1,099
City of Milwaukee	MN-06	2,124
City of Milwaukee	KK-6	59
City of Milwaukee	KK-7	2,536
City of Milwaukee	MN-09	7,305
City of Milwaukee	MN-10	2,501
City of Milwaukee	MN-12	53
City of Milwaukee	MN-13	198
City of Milwaukee	MN-14	67
City of Milwaukee	MN-15	2,185
City of Milwaukee	MN-16	2,002
City of Milwaukee	MI-27	1,162
City of Milwaukee	MI-28	924
City of Milwaukee	MI-29	771
City of Milwaukee	MI-31	12,084
City of Milwaukee	MI-32	901
City of New Berlin	MN-13	431
City of Port Washington	MI-16	92
City of Port Washington	MI-25	105
Village of Richfield	MN-02	98
Village of Richfield	MN-03	28
Village of Richfield	MN-04	860
Village of Richfield	MI-21	3,638
Village of River Hills	MI-27	2,044
Village of River Hills	MI-29	30
Village of River Hills	MI-30	660
Village of Saukville	MI-16	1,961
Village of Saukville	MI-17	312
Village of Shorewood	MI-32	461
Village of Slinger	MI-18	64
Village of Slinger	MI-19	4
Village of Slinger	MI-21	710
City of St. Francis	KK-4	66
Village of Thiensville	MI-25	196
Village of Thiensville	MI-26	417
Village of Thiensville	MI-27	67
City of Wauwatosa	MN-10	2,236
City of Wauwatosa	MN-12	2,445
City of Wauwatosa	MN-13	101
City of Wauwatosa	MN-14	705
City of Wauwatosa	MN-15	150
City of Wauwatosa	MN-16	2,827

Municipality	TMDL Subbasin	Area (acres)
City of West Allis	KK-2	340
City of West Allis	KK-3	734
City of West Allis	MN-13	1,766
City of West Allis	MN-15	2,258
City of West Allis	MN-16	316
City of West Bend	MI-02	12
City of West Bend	MI-06	8,433
City of West Bend	MI-07	816
City of West Bend	MI-13	3
City of West Bend	MI-23	90
Town of West Bend	MI-06	4,961
Town of West Bend	MI-18	5,093
Town of West Bend	MI-22	17
Town of West Bend	MI-23	164
Village of West Milwaukee	KK-3	304
Village of West Milwaukee	MN-16	413
Village of Whitefish Bay	MI-27	68
Village of Whitefish Bay	MI-32	414

4.3.2.5 Combined Sewer Overflows

Combined sewers serve central Milwaukee and a portion of Shorewood. Overflows from these sewers are regulated under section 4.7 of WPDES Permit WI-0036820-03-01 issued to MMSD. The permit implements the USEPA Combined Sewer Overflow Policy (59 *Fed. Reg.* 18688, April 19, 1994), which requires a Long-Term Control Plan (LTCP). MMSD has fully implemented its LTCP and has complied with all permit requirements for controlling CSOs.

CSOs occur an average of only three times per year. They occur only during extreme wet weather, when receiving water flows are high. At the flow conditions (see Section 5.2) that are the basis for load allocations, CSOs are a limited source of the three pollutants that are the subject of this TMDL. For this TMDL study, CSO wasteload allocations for all three pollutants are set at zero. The allocation of zero is not intended to translate into an immediate requirement for zero discharge, but rather, continued compliance with the approved MMSD Long-Term CSO Control Plan and WPDES permits, which are ultimately aimed at long-term goals for CSO abatement (discussed further in Section 6.4.5.).

4.3.2.6 Sanitary Sewer Overflows

Baseline SSO loads for all three pollutants were not calculated because SSOs are not permitted and cannot receive TMDL allocations. SSO flows and loads in the WQI models were set to zero.

4.3.2.7 Concentrated Animal Feeding Operations

CAFOs are operations defined and regulated under the NPDES program. There are 12 regulated CAFOs in the Basin (**Table 4-3** and **Figure B.5** in Appendix B; map numbers in the table correspond to point labels on the figure). WPDES permits for these facilities require no discharge of pollutants from the production area, unless caused by an extreme storm event (24-hour storm duration exceeding the 25-year recurrence interval). Baseline CAFO loads were set as zero, as discharges from the production area of the CAFO are prohibited. Manure from CAFO operations used for agronomic purposes in the watershed is considered a nonpoint source of bacteria and phosphorus. Manure spreading loads are included in the modeled nonpoint source loads used for the TMDL calculations.

Table 4-3. CAFOs in the Milwaukee River Basin

Facility Name	Permit Number	TMDL Reach	Map Number
BECK DAIRY FARM	0064599	MI-3	1
CLOVER HILL DAIRY*	0061689	MI-3	2
GOLDEN E DAIRY FARM	0064602	MI-13	3
HICKORY LAWN DAIRY FARM	0064611	MI-10	4
KETTLE MORAINE EGG RANCH, LLC	0056677	MI-13	5
MELICHAR BROAD ACRES	0064866	MI-16	6
MURPH-KO FARMS INC**	0062740	MI-1	7
OPITZ DAIRY FARM	0062600	MI-16	8
PAULUS DAIRY (APP RECEIVED)	0065927	MI-16	9
ROCKLAND DAIRY	0061786	MI-14	10
SECOND LOOK HOLSTEINS LLC	0062987	MI-1	11
VOLM FARMS	0064700	MI-3	12

*Clover Hill Dairy main farm is located in the Rock River basin. Outfalls 004, 005, 008, and 009 associated with the "Heifer Farm Site" are located in the Milwaukee River basin.
**Murph-KO Farms Inc. 2010 production area expansion into Milwaukee River basin.

4.4 Seasonality

Loading of TP, TSS, and fecal coliform varies substantially among different months. This variation is primarily driven by seasonal patterns in precipitation and vegetative cover that influence runoff and erosion rates. These same seasonal patterns also affect streamflow, which drive a waterbody's loading capacity. To account for these patterns, calculations of loading capacity are based on monthly streamflow, and baseline loads were compiled for each month in the 10-year model simulation period.

Section 5
Pollutant Loading Capacity

Pollutant loading capacity is the allowable load of a pollutant that a waterbody can receive from both point and nonpoint sources and still meet water quality standards or targets. The terms loading capacity, allowable load, and TMDL have this same general meaning. The term "allowable load" will be used primarily in this section. It is important to note that due to the open water nature of the estuary, the allowable load and allocation calculation methodologies differ between the watersheds and the estuary. These differences are described in Sections 5.3 and 5.4 below.

5.1 Linking Pollutant Loading to Concentration

Water quality criteria are expressed as concentrations [mg/L for TP and TSS, colony forming units (cfu) or cells per 100 mL for fecal coliform]. The allowable load, or TMDL, is expressed as a pollutant mass over a period of time (pounds per day for TP and TSS, billion cells per day for fecal coliform). The approach for linking these measurements is described in this section.

5.1.1 Movement of Phosphorus, Sediment, and Fecal Coliform

For this TMDL analysis, the total mass loads of TP, TSS, and fecal coliform are assumed to move conservatively through the stream network, which means that the dynamic retention (reductions) or growth (increases) of these parameters from instream processes was not considered. This conservative transport assumption provides an implicit margin of safety for the allocations, as described further in Section 6.5.

5.2 Critical Conditions

The variability in flow and loading conditions over time must be considered when developing allowable loads. Seasonal changes and wet weather events cause considerable variability in streamflow, pollutant loading, and resulting instream concentrations. Determining conditions to base the allowable load upon (i.e., critical conditions) is important for targeting when water quality is most vulnerable. TMDL studies typically rely upon low-flow conditions to determine allowable loads of pollutants, based on the assumption that such conditions result in the lowest assimilative capacity in receiving waters.

5.2.1 Critical Conditions for Total Phosphorus and Total Suspended Solids

To develop allowable loads for TP and TSS, the dynamics of the sources must be considered. Phosphorus and TSS enter waterways through two primary means: either as a point source discharge (such as treatment plant effluent or as an MS4 illicit discharge), or as rainfall-dependent wash-off (stormwater, including MS4 runoff, agricultural runoff, etc.). Note that in this context, even though an MS4 discharge is given a wasteload allocation at a "point of discharge," it is evaluated in a similar manner as nonpoint source runoff because it occurs as rainfall-dependent wash-off over broad geographic areas. Using a low-flow condition to calculate point source discharge loading is appropriate since dominant sources such as wastewater effluent are likely to occur regardless of rainfall or instream flow conditions, and will have the most significant impact on water quality during low-flow conditions. However, using the same low-flow criteria to represent rainfall-dependent runoff (including MS4 runoff) is not appropriate, since runoff contributes a higher load during wet weather when instream flows are inherently higher and have a more significant impact on water quality at those times. An appropriate balance must be found that acknowledges the disparity in the types of conditions that are considered most critical for the two different types of loads.

The critical condition for TP and TSS related impairments was set at a flow condition that would represent dry weather periods but still account for impacts from wet weather events. The fourth lowest flow for each calendar month (out of the ten annual values from the model simulation period of 1988-1997) was used to develop the allowable loads for TP and TSS throughout the Basin. The fourth lowest flow is near the lower end of the flow regime, and is therefore an appropriate benchmark for critical conditions associated with continuous point source discharges, without being overly conservative. For example, the lowest flow in the 10-year period may be close to zero for some reaches, which means virtually no assimilative capacity. Moreover, at very low-flow conditions, one can expect no runoff and no nonpoint source pollution. However, when flow begins to climb above minimum levels, the cause will almost always be rainfall and/or snowmelt, and the runoff will carry with it attendant phosphorus and TSS loads. The benchmark of the fourth lowest flow is reasonable because loading from both point and nonpoint sources can be expected under these conditions. It is neither too lenient for point sources nor too conservative for nonpoint sources. This methodology is consistent with other TMDLs developed for TP and TSS in Wisconsin.

For each reach in the Menomonee and Kinnickinnic River watersheds, monthly average flows for each year in the 10-year modeling period were compiled from the WQI models. For each reach and month, the fourth lowest flow value out of the ten years was determined. For the Milwaukee River watershed, flows equivalent to the fourth lowest flows for each reach and calendar month were calculated parametrically as the $33.\overline{3}$ (33.333…) percentile flows from the modeled flow data. The $33.\overline{3}$ percentile is equivalent to the fourth lowest out of ten values. The parametric calculation approach was used for the Milwaukee River watershed calculations to allow for the application of adjustment factors to the flows to address limitations in the WQI flow model calibration. In the end, use of these adjustment factors was not incorporated.

The TMDL calculations aim to represent expected monthly values for the selected fourth lowest flow condition. To cancel out some of the “noise” in the flow statistics from month to month, the flows used to calculate the allowable loads for TP and TSS were smoothed using a three-month moving average (e.g., the flow value used for June is the average of May, June, and July flows). The noise is random variation introduced from the use of modeled data (it can be introduced by the model data inputs and the model itself) and is not indicative of actual trends in month-to-month variation. The data smoothing approach has been previously used in other TMDLs, for example the Rock River TMDL in Wisconsin (WDNR, 2011), and the Lemhi River Watershed TMDL in Idaho (Idaho DEQ, 1999). Because the flows for the Milwaukee River watershed calculations were parametrically estimated and therefore not as prone to noise as the fourth lowest flows for the Menomonee and Kinnickinnic River watershed calculations, the smoothing procedure was not applied to the Milwaukee River watershed flows.

Table A.8 in Appendix A presents the fourth lowest streamflow used for calculating allowable TP and TSS loads by month and TMDL reach.

5.2.2 Critical Conditions for Fecal Coliform

A load duration curve approach was used to develop the fecal coliform TMDLs as discussed in Section 4.2.3 above. The load duration curve (LDC) method considers how streamflow conditions relate to a variety of pollutant sources, and can be used to make rough determinations as to what flow conditions result in exceedances of the water quality standards. The LDC method incorporates flow and pollutant (fecal coliform) data across stream flow regimes, and provides allowable loads to meet water quality standards.

As noted in Section 4.2.1, the flow values were generated in the WQI model, and adjusted as needed to correlate with observed flows. Typically, LDCs are developed using daily flows over a period of years. This was initially pursued for the Milwaukee Basin, but the flow curves showed significant negative variability. The Milwaukee Basin has had significant flow alteration over the last century, and it is possible the numerous dams, channels, culverts, impervious cover, etc., have reduced the effectiveness of the "typical" LDC process. Therefore, the TMDL Team decided to use the WQI model flow outputs to develop the LDCs.

Flow regimes to establish the load duration curve were defined by the 5th, 25th, 50th, 75th, and 95th percentiles based on USEPA guidance, *An Approach for Using Load Duration Curves in the Development of TMDLs* (USEPA, 2007). The USEPA guidance defines these percentiles as representing low-, dry-, mid-, moist-, and high-flow conditions, respectively. With this method, allowable load increases as a function of flow to satisfy state standards for instream concentration; the greater the assimilative capacity in the receiving water, the higher the allowable load. Because the recreation season of May through September is the critical period for protection of human health (and the recreational use designation), monthly flow values from this period were used to develop the load duration curves and allocations.

For the Menomonee and Kinnickinnic River watersheds, the 5th, 25th, 50th, 75th, and 95th percentile flows were calculated using a rank-order percentile calculation from modeled flows for the months of May through September over the 10-year modeling period. For the Milwaukee River watershed, the various percentile flows were calculated parametrically for each TMDL reach from the modeled flows. The load duration curves for each Milwaukee River TMDL reach are based on the 5th, 25th, 50th, 75th, and 95th percentile flows plus flows for the 1st and 99th percentiles (to define the far ends of the curve).

Table A.9 in Appendix A presents the flows used for calculating allowable fecal coliform loads by TMDL reach.

5.3 Allowable Watershed Loads

Because of the different critical conditions discussed above, two approaches were used to develop the allowable loads for each TMDL reach, one approach for TP and TSS, and a separate approach for fecal coliform. Each approach is described below.

5.3.1 Phosphorus and Total Suspended Solids Allowable Loads

The allowable load for TP and TSS was determined for each TMDL reach using the critical condition described above. To calculate the maximum allowable load at the target flow condition, the fourth lowest flow was multiplied by the TP water quality standard or TSS target and necessary unit conversion factors. The fourth lowest flows used in the allowable TP and TSS load calculation are cumulative flows, meaning that they increase from one reach to the next moving downstream through the reach network. In order to define the allowable load for just the local TMDL subbasin contributing to each reach (an "incremental" allowable load), the allowable load for all upstream reaches is subtracted from the allowable load calculated with the cumulative flows. These incremental allowable loads are then allocated to the various sources in the subbasin.

An allowable load for each reach was determined for each month of the year to account for seasonal and other flow variations that affect allowable load in those reaches. Daily loads were calculated by dividing the monthly load by 30.4 days per month.

Allowable loads for TP and TSS are presented in Appendix A. Appendix A, **Tables A.10** and **A.11** present daily and monthly allowable loads for TP for each TMDL reach. **Tables A.12** and **A.13** present daily and monthly allowable loads for TSS for each TMDL reach.

5.3.1.1 Allowable Loads in Reaches with Higher Phosphorus Criterion

As discussed in Section 3.2.1, s. NR 102.06, Wis. Adm. Code sets TP criteria of 0.100 mg/L for rivers and other specified waterbodies and 0.075 mg/L for streams. The 0.100 mg/L TP criterion applies to the downstream mainstem reaches of the Menomonee, Kinnickinnic, and Milwaukee River watersheds. The higher water quality criterion allows for a larger amount of phosphorus load to be allocated to these reaches—not only due to the allowable load associated with the incremental flows from the local TMDL subbasin, but also due to a "differential load" associated with the flows coming in from the upstream 0.075 mg/L criterion reaches. The differential load is the difference between the two criteria applied to the flow contributed by the reaches with the 0.075 mg/L criterion.

To account for the additional allowable load in the TMDL calculations, the differential load was added to the allowable load calculated for the individual 0.100 mg/L reach. To optimize equity among the 0.100 mg/L reaches, the differential load is calculated using the total flow contributed by the 0.075 mg/L reaches and proportioned to the 0.100 mg/L reaches according to each reach's incremental flow contribution. The TP concentrations based on these allowable loads are then calculated to verify that they increase as expected when moving downstream and that they do not exceed the 0.100 mg/L criterion.

5.3.2 Fecal Coliform Allowable Loads

The allowable load for fecal coliform was determined for each TMDL reach using the load duration curve methodology. To develop a load duration curve, a flow duration curve is first established by calculating the non-exceedance probability of each monthly flow record in the 10-year period for a given reach. Non-exceedance probability is synonymous with percentile and defines the value below which a given percentage of the observations (in this case modeled flow values) fall. For example, 75 percent of the flow values are less than (or equal to) the 75th percentile flow value.

The flows used for the fecal coliform load duration curves are incremental flows from the local TMDL subbasin only. These incremental flows are calculated by taking the cumulative flows for a given reach and subtracting the cumulative flows for reaches directly upstream.

The flow records are then multiplied by the numeric water quality standard (not to exceed 400 cfu/100 mL for more than 10% of all samples during any month) and necessary unit conversion factors to calculate the allowable loads. These loads are then plotted versus the non-exceedance probabilities. The resulting curve shows the allowable pollutant load (in this case fecal coliform load)

CDM Smith

for any given flow condition. An example load duration curve is shown in **Figure 5-1**. Because the flow duration curve values were simply multiplied by the constant water quality standard, the load and flow curve shapes are the same. From the curve, an allowable load can be defined for a given flow condition, and therefore, the load duration curve *is* the TMDL. As shown in the figure, the allowable daily fecal coliform load for Reach MN-8 during a mid-range flow condition (defined by the 50^{th} percentile) is approximately $4x10^{10}$ or 40 billion cells per day.

Appendix A, **Tables A.14** and **A.15** present daily and monthly allowable loads for fecal coliform for each TMDL reach based on the midpoint of each flow regime. Appendix D presents the fecal coliform load duration curves for each TMDL reach. Modeled baseline fecal coliform data is presented in the figures to indicate the order of magnitude difference between the modeled baseline data and the calculated allowable load curve. The magnitude of the modeled baseline loads is fairly constant over the range of non-exceedance probabilities/percentiles. This is not surprising given that the modeled loads are nonpoint loadings, which are modeled using the build-up/wash-off method. This method allows an amount of load to build-up on the land surface and then wash-off during wet weather so the represented loadings will be fairly consistent. There are no point source fecal coliform loadings for this example reach in the Menomonee River watershed, and even when there are (like from POTWs in the Milwaukee River watershed), they are represented as constant values in the calculations (given permitted flow and concentration limits). In addition, wet weather loadings, such as from CSOs, are not included in the TMDL baseline. For all of these reasons, little variability is expected in the modeled fecal coliform load across the flow regimes. To estimate what percent reduction of loads would be necessary to meet the water quality standard, flow-coupled fecal coliform sample data would be required. To calculate a percent reduction, the measured load could be compared to the TMDL load given the flow condition during which the sample was collected.

Because WPDES fecal coliform discharge permit limits are specified for the recreation season of May through September, monthly flow values from this period were used to develop the load duration curves and allocations. As discussed in Section 3.2.3, the 10 percent not to exceed 400 cfu per 100 mL threshold of the fecal coliform water quality standard was more restrictive than the geometric mean threshold. To develop TMDLs for fecal coliform, 400 cfu per 100 mL was used to calculate the fecal coliform load duration curves. It should be noted, however, that both portions of the standard (the geometric mean and the not to exceed value) apply.

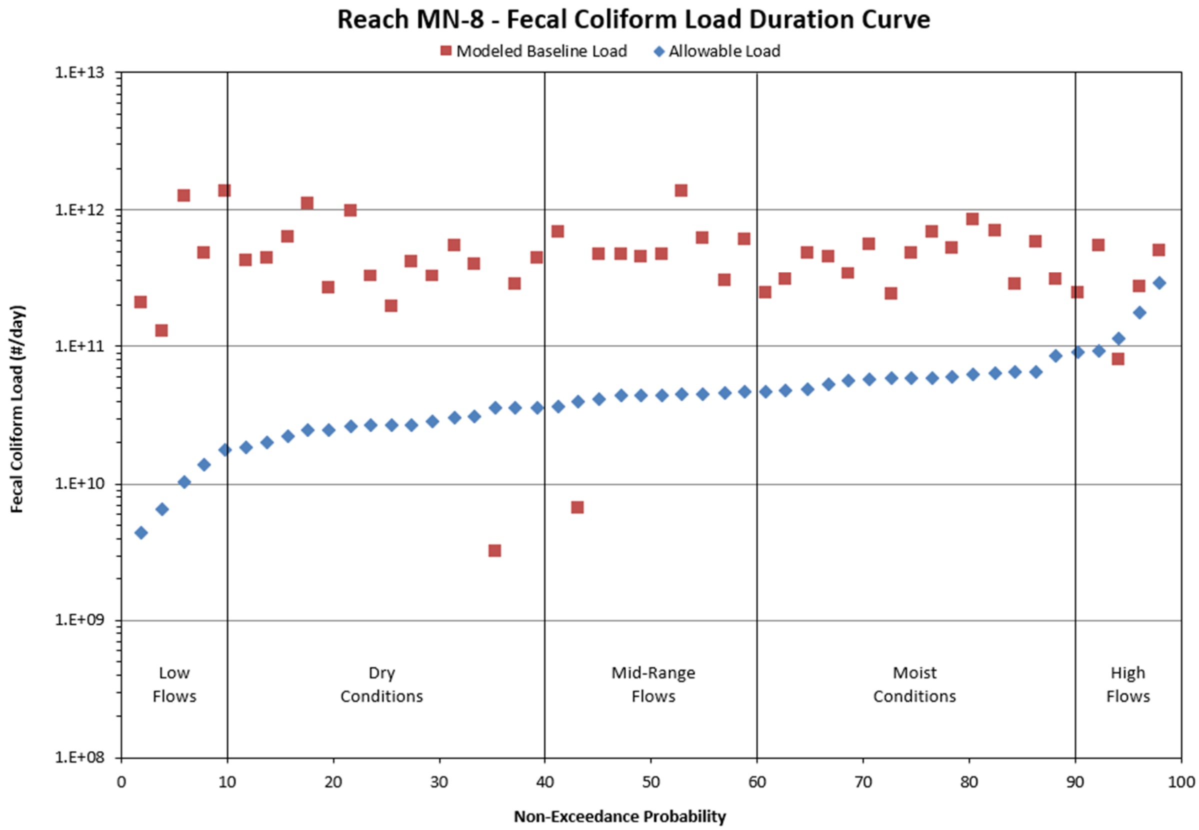


Figure 5-1. Example Bacteria Load Duration Curve for Reach MN-8

5.4 Allowable Estuary Loads

5.4.1 Estuary TMDL Calculation Methodology

As noted above, due to the open water nature of the estuary, the allowable load and allocation calculation methodologies differ between the watersheds and the estuary. Unlike the watershed loads, the estuary loads for the three pollutants were not calculated for a single flow condition. Instead, the estuary model (see Section 4.2.1) was run for the 10-year simulation period with river inputs set at water quality standards/targets and the local point sources set at their baseline loads. The point sources included in the estuary model, as listed in **Table 4-1**, are those that drain to the estuary outside of the WQI watershed model domains. Concentration output at ten estuary assessment points established in the RWQMPU (shown on Figure B.2 in Appendix B) was examined to determine if reductions from each point source's baseline load were required. Growing season median TP and TSS concentrations, as well as fecal coliform concentrations at the ten assessment points indicated that water quality standards were being met, thus further reductions in the riverine and estuary loads were not required. Tables A.A and A.B present the growing season median TP and TSS concentrations, respectively, for each estuary assessment point based on the TMDL loads and model simulated flows for 1988 through 1997.

To provide an assessment of fecal coliform concentrations in the estuary, the estuary model output at each estuary assessment point was evaluated. There were no exceedances of the water quality standard. **Table A.C** presents the recreation season fecal coliform geometric mean concentrations for each estuary assessment point. For comparative purposes, the 30-day geometric mean standard is included in the table; however, the simulated concentration values provided in the table were calculated over the entire recreation season. The outer harbor assessment points have an *E. coli* geometric mean standard of 126 cells per 100 mL. Using the translator approach described below, the *E. coli* standard was translated to a fecal coliform standard of 210 cells per 100 mL.

5.4.2 Allowable Bacteria Loads in the Outer Harbor

Wisconsin Administrative Code, section NR 102.04(5)(a), sets bacteriological criteria for waters designated with full recreational uses. Under these criteria, the membrane filter fecal coliform count may not exceed 200 colony forming units (cfu) per 100 mL as a geometric mean, and may not exceed 400 cfu per 100 mL in more than 10 percent of all samples during any month. For waterbodies that are subject to a variance under s. NR 104.06, the membrane filter fecal coliform count may not exceed 1,000 cfu per 100 mL as a monthly geometric mean. This includes the following waterbodies:

- Burnham Canal in Milwaukee County
- Honey Creek in Milwaukee County
- Indian Creek in Milwaukee County
- Kinnickinnic River in Milwaukee County
- Lincoln Creek in Milwaukee County
- Menomonee River in Milwaukee County below the confluence with Honey Creek
- Milwaukee River in Milwaukee County downstream from the former North Avenue dam
- South Menomonee Canal in Milwaukee County
- Underwood Creek in Milwaukee and Waukesha Counties below Juneau Boulevard

In addition, the following waterbodies may not exceed 2,000 cfu per 100 mL in more than 10 percent of all samples during any month:

- Honey Creek in Milwaukee County
- Indian Creek in Milwaukee County
- Kinnickinnic River in Milwaukee County
- Lincoln Creek in Milwaukee County
- Menomonee River in Milwaukee County below the confluence with Honey Creek
- Underwood Creek in Milwaukee and Waukesha Counties below Juneau Boulevard

As stated above, compliance with the fecal coliform criteria is determined in two ways: 1) the fecal coliform count may not exceed 200 cfu per 100 mL as a geometric mean, and 2) the count may not exceed 400 cfu per 100 mL in more than 10 percent of all samples during any month. The fecal coliform data was evaluated and it was found that the 10 percent not to exceed 400 cfu per 100 mL threshold was exceeded more frequently than the geometric mean threshold, making the 10 percent not to exceed 400 cfu per 100 mL threshold more restrictive than the geometric mean threshold. To develop TMDLs for fecal coliform in this study, the 10 percent not to exceed 400 cfu per 100 mL portion of the criteria was used for the TMDL calculations. While the TMDL will focus on the geometric mean portion of the water quality standard, WDNR requires that both parts of the water quality standard be met.

USEPA has promulgated recreational water quality criteria (40 CFR 131.41) for open water Lake Michigan areas and the outer harbor area of the Milwaukee Harbor Estuary (Figure 1-16). The criteria promulgated in 2004 were based on USEPA's 1986 Ambient Water Quality Criteria for Bacteria include an *E. coli* geometric mean standard of 126 cfu per 100 mL and single sample maximum value of 235 cfu per 100 mL for designated bathing areas.

The variance criteria within ch. NR 104, Wis. Adm. Code, were considered within this study. Each waterbody with a variance standard is upstream of a waterbody with a more restrictive (non-variance) standard. Waters downstream of the variance waters are required to meet their respective *E. coli* or fecal coliform standards to protect their designated uses. The loading allowed by the variance criteria in the variance waters would not allow for the water quality criteria to be met in the downstream waters; therefore, the variance criteria could not be used within the TMDL calculations. For these waters, the non-variance criteria (an *E. coli* geometric mean standard of 126 cfu per 100 mL and statistical threshold value of 410 cfu per 100 mL for the outer harbor area of the Milwaukee Estuary, and 200 fecal coliform cfu per 100 mL as a geometric mean and not to exceed 400 cfu per 100 mL in more than 10 percent of all samples during any month for all other waters in the basin) were used.

Most of the historical bacteriological data is for fecal coliform and the upstream watershed models were calibrated for this organism. The water quality standard for the outer harbor and nearshore area of Lake Michigan is based on *E. coli* concentrations; therefore a translator was developed to convert the fecal coliform loadings to *E. coli* loadings for use in evaluating impacts to the outer harbor area. The translator was developed based on concurrent fecal coliform and *E. coli* samples collected in the TMDL study area and analyzed by the McLellan lab at the UWM School of Freshwater Sciences. A fecal coliform to *E. coli* relationship was developed for this study so that calculated fecal coliform loading capacities and resulting instream concentrations could be translated to *E. coli* for the outer harbor area. See Section 5 and Appendix E for more information on the development and use of the translator.

Section 6
Pollutant Load Allocations

The allowable load of pollutants for each TMDL reach is allocated to the pollutant sources in the tributary area to that reach. These sources include point sources (Wasteload Allocation or WLA), and nonpoint sources (Load Allocation or LA), which include both anthropogenic and natural background sources of a given pollutant.

The load allocation is the portion of the waterbody's total loading capacity attributed to existing and future nonpoint sources, including natural background sources. The wasteload allocation is the portion of the waterbody's total loading capacity that is allocated to point sources (for example, municipal or industrial wastewater facilities).

TMDLs must also include a margin of safety (MOS) to account for the uncertainty in predicting how well pollutant reduction will result in meeting water quality standards, and account for seasonal variations. A reserve load capacity may be included in a TMDL to account for future discharges, changes in discharges, and other sources not defined through the TMDL study.

6.1 TMDL Equation

The TMDL calculation is:

TMDL = ΣWLA + ΣLA + MOS + RC

Where,

ΣWLA = the sum of wasteload allocations (point sources)

ΣLA = the sum of load allocations (nonpoint sources)

MOS = the margin of safety, and

RC = the reserve capacity.

6.2 Load Allocation Approach

Load and wasteload allocations were developed for the following sources in the Basin.

Load allocations were developed for:

- Background sources (woodland, wetland, and natural areas)
- Agricultural sources
- Non-permitted urban areas

Wasteload allocations were developed for:

- Individual WPDES wastewater permittees

- General WPDES wastewater permittees
- Municipal Separate Storm Sewer System (MS4s) permittees

Several existing sources were given a wasteload allocation of zero as discussed below:

- Combined Sewer Overflows (CSOs)
- Sanitary Sewer Overflows (SSOs)
- Concentrated Animal Feeding Operations (CAFOs)

The allowable load for each TMDL reach was allocated proportionally to each source according to the relative contribution of that source to the established baseline load.

Before allocating loads to each source, the natural background load and a load assigned to general permits were subtracted from the total allowable load to set aside the loads that cannot be reduced further. Other than NCCW discharges, baseline loads from the numerous general permitted sources in the Basin could not be individually determined; therefore, individual wasteload allocations could not be calculated. Allocations for background and general permits were set equal to each of their baseline loads.

Allocations must not exceed established permits and regulations. Therefore, CSOs, SSOs and CAFOs received a WLA of zero, as these discharges are not permitted. See Section 6.4.5 for a discussion of the CSO wasteload allocations.

Allocations were calculated separately for each source or source type in each TMDL reach for each month, as both monthly loads and daily loads (per month). The allocations are presented in Appendix A. Appendix A contains tables for each TMDL watershed and the Milwaukee Harbor Estuary, numbered in the same sequence for consistency between the four sets of tables. Kinnickinnic River Watershed tables are denoted as (KK), for example, Table A.1 (KK). Menomonee River watershed tables are denoted as (MN). Milwaukee River watershed tables are denoted as (MI). Milwaukee Harbor Estuary tables are denoted as (Estuary). Appendix A **Tables A.10** and **A.11** present daily and monthly allocations for TP for each TMDL reach. **Tables A.12** and **A.13** present daily and monthly allocations for TSS for each TMDL reach. **Tables A.14** and **A.15** present daily and monthly allocations for fecal coliform for each TMDL reach.

In addition to allocations, Appendix A includes tables presenting baseline loads, flows, and percent reductions from baseline. Specifically, **Tables A.1** through **A.7** present baseline loads, **Tables A.8** and **A.9** present the flows used for calculation of the allowable loads, and **Tables A.29** through **A.30** present percent reductions for each TMDL reach. Corresponding baseline loads, flows, and allocations for the Milwaukee Harbor Estuary are listed by assessment point rather than by reach because of how the calculations for the estuary are performed. **Tables A.A** through **A.C** (concentrations at the assessment points) are unique to the Estuary and not included for the watersheds.

Appendix F presents an example allocation calculation.

6.3 Load Allocations

6.3.1 Background Sources

Baseline background loads (woodland, wetland, and natural area loads) were estimated from the forest and wetland land covers in the WQI models. Allocations for background sources are equal to the baseline background load for that TMDL reach and month (no load reduction from baseline). Background TP and TSS loads for the Menomonee and Kinnickinnic River watershed allocations were defined by determining the monthly total background load associated with the fourth lowest flow month. Background fecal coliform loads were determined by performing regressions of background load versus incremental reach flow from the WQI model output and then solving for the background load given the incremental 5th, 25th, 50th, 75th, and 95th percentile flows.

Because of the parametric calculation method used for the Milwaukee River watershed fourth lowest flows, background loads for all three pollutants (TP, TSS, and fecal coliform) were calculated by performing regressions of background load versus incremental reach flow from the WQI model output and then solving for the background load given the parametrically estimated incremental fourth lowest flow for TP and TSS and the incremental 5th, 25th, 50th, 75th, and 95th percentile flows for fecal coliform.

6.3.2 Agricultural Sources

Baseline agricultural loads were calculated from the crop and pasture land covers in the WQI models. Agricultural sources received allocations proportional to their contribution to the total baseline load. **Table A.30** presents percent reduction of agricultural TP and TSS by reach. These percent reductions were calculated as the average of the monthly percent reductions from the baseline agricultural load.

6.3.3 Non-Permitted Urban Areas

Baseline loads for non-permitted urban areas were calculated from the non-background and non-agricultural land covers outside of a permitted MS4 municipal boundary. Non-permitted urban sources received allocations proportional to their contribution to the total baseline load. **Table A.30** presents percent reduction of non-permitted urban TP and TSS by reach. These percent reductions were calculated as the average of the monthly percent reductions from the baseline non-permitted urban load.

6.4 Wasteload Allocations

6.4.1 Permitted Point Source Dischargers

The baseline load for wastewater point sources covered by an individual WPDES permit with specified limits was based on the concentration limit and design flow (annual average design flow for municipal POTWs; highest average annual flow over a three-year period for industrial dischargers). These permits typically contain a discharge concentration limit, but do not typically contain a load limit. If a permitted concentration limit did not exist, measured facility data from Discharge Monitoring Reports was used to determine the baseline load. To be representative of the technology-based effluent limit required by ch. NR 217, Wis. Adm. Code, all baseline TP loads were set to an effluent concentration limit of 1.0 mg/L unless the limit was less than 1.0 mg/L, in which case the lower TP effluent limit was used. Individually permitted point source dischargers received allocations proportional to their contribution to the total baseline load.

Daily wasteload allocations (WLA_d) for permitted dischargers were calculated from monthly wasteload allocations (WLA_m) with the following equation, as recommended by EPA guidance (USEPA, 2007b). (n is the number of days in the month.)

$$WLA_d = 2.39 \cdot (WLA_m / n)$$

Tables A.16 and **A.17** present daily and monthly allocations for TP for permitted point sources.

Tables A.18 and **A.19** present daily and monthly allocations for TSS for permitted point sources.

For phosphorus, the mass allocation contained in the TMDL will be expressed as a mass limit. In many cases, discharges will also receive a concentration limit for P, based on the TBEL requirements in ch. NR 217, Wis. Adm. Code.

For solids, the mass allocation contained in the TMDL will be expressed as a mass limit for TSS, unless the equivalent concentration is ≤ 12 mg/L. In those cases, the limit will be expressed as a monthly average concentration of 12 mg/L TSS. See Section 3.2.2 for more information.

For bacteria, no reductions will be required for municipal wastewater dischargers that already employ disinfection. Limits for fecal coliform will continue to be expressed as 400 cfu/100 mL from May through September, in order to provide protection from human health impacts during the recreation season.

Tables A.20 and **A.21** present daily and monthly allocations for fecal coliform for permitted point sources.

6.4.2 General Permitted Dischargers

General permitted dischargers in an MS4 area are included within the WLA for the MS4 (see Section 4.3.2.2). General permitted sources outside of the MS4 area received a WLA equal to 5% of the baseline non-permitted urban load for TP and TSS. The assumption of 5% was based on the number and typical types of facilities present within the watersheds and best professional judgment of the TMDL Development Team. This general permit load was set aside from the loading capacity with no reduction. Similar to the background loads, the set-aside general permit loads for the Menomonee and Kinnickinnic River watershed allocations were defined by determining the monthly total non-permitted urban load associated with the fourth lowest flow month, then calculating 5% of that load. Because of the different calculation method used for the Milwaukee River watershed fourth lowest flows, general permit loads for the Milwaukee watershed were calculated by performing regressions of non-permitted urban load versus incremental reach flow from the WQI model output, solving for the non-permitted urban load given the parametrically estimated incremental fourth lowest flow, and then calculating 5% of that load. There were no allocations (WLA = 0) given for bacteria loads from general permitted sources as bacteria is not expected in general permitted discharges, unless it is present in the source water in pass-through systems.

Non-contact cooling water general permittees were evaluated during TMDL development, independent of other general permitted sources, to determine whether individual WLAs for phosphorus were needed to meet TMDL goals. For facilities that add phosphorus to their discharge or that use water from a public water supply that adds phosphorus, design flows (highest average annual flow over three years, like that used for individually permitted industrial dischargers) and discharge concentrations were used to determine what potential individual WLAs might be. The baseline discharge concentration used was either phosphorus monitoring supplied by the discharger or an assumed value based on the concentration of phosphorus in the water supply. For dischargers using City of Milwaukee water, a TP concentration of 0.515 mg/L was used (based on discussions with Milwaukee Water Works).

For pass through systems (i.e., facilities with surface water intake structures) where phosphorus is not added and the water is withdrawn from and discharged to the same waterbody, the baseline condition for the allocation process utilized actual discharge flows with TP concentrations set to zero to reflect that no net addition of phosphorus is occurring. This would result in an allocation of zero, but allow the facility to discharge the pass through phosphorus load.

Evaluation of NCCW facilities was necessary due to the large number of NCCW general permittees in some reaches and the large volumes of water (and potentially TP mass load) that they may discharge. However, once this evaluation was completed, it became clear that these discharges do not contribute a significant mass when compared to the total phosphorus load discharged to these receiving waters. The total load of TP from NCCW general permittees is 2,178 pounds per year. The sum of TP from all individual permits is 259,796 pounds per year meaning that the NCCW contribution is 0.83 percent of the total load from point sources.

An individual mass allocation has been assigned to NCCW general permits. To aid in implementation, this allocation will be grouped and tracked by watershed to ensure that the total watershed allocation for NCCW is not exceeded.

Currently, NCCW facilities covered under the general permit are only required to submit annual monitoring of their effluent quality. In watersheds with TMDLs, this requirement will be increased to quarterly effluent sampling. The sampling will be used to track the total mass allocation used by NCCW facilities in each watershed. If through the increased monitoring and tracking it is determined that sufficient allocation has not been set aside for NCCW facilities, facilities may be switched to individual permits with discharge requirements placed in the permit sufficient to meet TMDL allocations. These discharge requirements will likely be similar to the individual mass allocations for NCCW facilities already listed in the TMDL.

In addition to increased sampling frequency, NCCW facilities covered under the general permit and located in a TMDL watershed will be required to optimize their processes to limit the phosphorus in their discharge.

NCCW dischargers covered by the general permit (WI-0044938) did not receive individual allocations for TSS. Instead, they were addressed similarly to other general permit holders, through the MS4 allocation for NCCW discharges within the MS4 area and through the general permit set-aside load for sources outside of the MS4 area. During the allocation process, the set-aside load for general permits was subtracted from the overall assimilative capacity of the receiving water.

6.4.3 Noncontinuous Point Source Discharges

Section 40 CFR 122.45 (d) specifies that unless impracticable, permit effluent limits must be expressed as weekly and monthly averages for publicly owned treatment works and as daily maximums and monthly averages for all other continuous discharges. A continuous discharge is a discharge which occurs without interruption throughout the operating hours of the facility, except for infrequent shutdowns for maintenance, process changes, or other similar activities (s. 40 CFR 122.2).

For non-continuous discharges, methods for converting WLAs into permit limits should be determined on a case-by-case basis. For example, many non-contact cooling water discharges do not occur continuously and often vary from year to year, depending on weather conditions (generally, more cooling water is used in warmer months) or production levels. In these cases, it may be appropriate to express limits by season or as a total annual amount (by adding up monthly WLAs during the expected season of discharge). In many cases, using shorter term limits (daily, monthly) might have the effect of unduly limiting operational flexibility and, since TMDLs are required to be protective of critical conditions, a seasonal or annual limit would be consistent with the TMDL and protective of water quality.

The discharge from General Mitchell International Airport (GMIA) would be another example of a noncontinuous and unique point source discharge situation. GMIA has an individual permit to cover discharges from deicing and other practices; however, discharges from the airport are more similar to stormwater, than to those from a traditional point source discharger (i.e., discharges occur as runoff during storm or melting events). Permit limits in this case would be more appropriately expressed as a percent reduction, rather than as a monthly or annual mass load, since compliance would be achieved via best management practices and determined via modeling, similar to methods used for other storm event-related discharges.

6.4.4 Municipal Separate Storm Sewer System Permittees

Baseline MS4 loads were determined based on loadings from the non-background and non-agricultural land covers in the WQI models. The MS4 portion of the load from these land covers was defined based on the proportion of the TMDL reach subbasin area that lies within a permitted municipal boundary. MS4 permittees received allocations proportional to their contribution to the total baseline load for each TMDL reach to which they discharge.

The six counties (Fond du Lac, Ozaukee, Sheboygan, Washington, Milwaukee, and Waukesha) and two special units of government (Southeast Wisconsin Professional Baseball Park District and Wisconsin State Fair Park) covered by a WPDES MS4 permit will not receive individual allocations. Instead, they are accounted for in the portions of each city, village, or town MS4 that they discharge to or lie within; however, these regulated MS4s that are not given specific allocations will still be expected to achieve the applicable identified reductions within their portion of their jurisdictional area. While Fond du Lac and Sheboygan Counties' jurisdictional limits lie within the Basin, neither county has permitted area within the Basin. The permitted area is determined by the US Census Bureau's mapped Urbanized Area, adjacent developed areas, or areas that are connected or will connect to other municipal separate storm sewer systems regulated under subch. I of NR 216, Wis. Adm. Code. As discussed in Section 4.3.2.4, fecal coliform loadings from an unknown urban source were identified during the WQI model development. These loadings are presumed to be from illicit connections to the storm sewer system, leaking sewers, and other unidentified sources. Loads were incorporated in the WQI models during model development to represent these unnamed sources so these loads are included in the baseline loads and therefore implicit in the allocations.

Wisconsin Department of Transportation (WisDOT) land areas are not currently covered by a WPDES permit. These areas are considered to be regulated through the conditions of a memorandum of understanding with WDNR. The WisDOT allowable load is considered to be included in the allowable load for each MS4 with WisDOT area.

Tables A.22 and **A.23** present daily and monthly allocations for TP for each MS4. **Tables A.24** and A.25 present daily and monthly allocations for TSS for each MS4. **Tables A.26** and **A.27** present daily and monthly allocations for fecal coliform for each MS4. **Tables A.28** and **A.29** present percent reduction of TP and TSS for each MS4. **Table A.28** is organized by reach then municipality, and **Table A.29** is organized by municipality then reach. These percent reductions were calculated as the average of the monthly percent reductions from the baseline MS4 load for that reach and municipality. MS4s discharging into the same reach are assigned the same percent reduction. This is because the baseline build-up and wash-off rates for pollutants are land cover based and assumed to be the same for all MS4s in the WQI models.

Municipalities that are co-permittees under a group or watershed-based MS4 permit are assigned individual allocations, however implementation of the TMDL and demonstration of collective compliance for these permit groups may be done on a per reach basis, instead of reporting by municipality.

6.4.5 Sanitary Sewer Overflows

Baseline sanitary sewer overflow loads were set to zero as discharges from SSOs are not permitted. Likewise, SSOs received a WLA of zero.

6.4.6 Combined Sewer Overflows

In 1977, MMSD commenced the $2.8 billion Water Pollution Abatement Program (WPAP), which upgraded the Jones Island and South Shore water reclamation facilities and expanded the regional sewer system. Completed in 1994, the WPAP also included construction of the Inline Storage System (ISS) which was originally a 405-million-gallon centralized wastewater storage facility to reduce both SSOs and CSOs. Commonly referred to as the Deep Tunnel, it initially consisted of 19.4 miles of tunnels located in bedrock 200 to 300 feet below ground and ranging in size from 17 to 32 feet in diameter.

By 2002, MMSD began work on the $1.0 billion Overflow Reduction Plan, which made further improvements to the regional sewer and wastewater storage systems. Completed in 2010, projects included a two-mile extension of the Deep Tunnel, which added 27 million gallons to increase the total volume to 432 million gallons. Another project constructed a 7.1-mile storage tunnel on the northwest side of Milwaukee County to provide 89 million gallons of storage for excess sanitary sewer flows. Total wastewater storage volume in the MMSD system is now 521 million gallons.

Prior to the Deep Tunnel going online in 1994, the Milwaukee area experienced more than 50 sewer overflows a year on average. From 1994 through 2013, the ISS has reduced overflows to an average of 2.5 per year and helped capture and clean 98.3% of all the water that entered MMSD's regional sewers. It has prevented more than 99 billion gallons of pollution from reaching our rivers and Lake Michigan. The existing CSO permit condition allows up to six CSO events in any calendar year or the capture, delivery and treatment at either the Jones Island or South Shore WRF of no less than 85% by volume of the combined sewage collected in the CSS as the result of a precipitation events in a calendar year. MMSD has achieved an average of only three CSOs per year and has complied with all requirements for implementation of a Long-Term Control Plan, as required by the U.S. Environmental Protection Agency. In response to these conditions, the TMDL does not calculate baseline CSO loads or establish CSO allocations.

For this TMDL study, CSO wasteload allocations for all three pollutants are set at zero. The allocation of zero is not intended to translate into an immediate requirement for zero discharge, but rather, continued compliance with the approved MMSD Long-Term CSO Control Plan and WPDES permits, which are ultimately aimed at long-term goals for CSO abatement.

6.4.7 Concentrated Animal Feeding Operations

Baseline CAFO loads were set to zero as discharges from CAFO production areas are not permitted, as consistent with WPDES permits. Likewise, CAFOs received a wasteload allocation of zero. Land spreading loads associated with CAFO operations are included in the nonpoint source loads.

6.5 Margin of Safety

A margin of safety (MOS) was considered when developing the total load allocation approach to account for uncertainty in predicting how a waterbody will respond to reductions in loadings and whether pollutant reduction will result in meeting water quality standards. A margin of safety may be explicit, expressed in the TMDL as a portion of the total allowable load, or implicit, for example through conservative assumptions in the analysis.

The WQI models used for the TMDL analysis are based on extensive, quality reviewed data and are well calibrated to represent actual conditions. Therefore, a minimal MOS was required based on the available data and tools used for the allocation calculations.

The TMDL Development Team evaluated the overall approach being used to calculate the TMDLs, and determined the MOS to be implicit within the calculation approach. The approach assumes conservative transport of pollutants with no accounting of load dynamics in the system (settling and uptake of TSS and TP, settling and die-off for bacteria). In reality, a portion of that load would be lost from the system. Given these system dynamics, if loads that equal the calculated allocations are delivered to the waterbody, instream concentrations would likely be lower than water quality standards.

For TSS, the WQI river models include routines for instream sediment scour and deposition for which rates vary by location, concentration, and flow conditions. Routines also are included for nutrient (phosphorus) uptake dynamics. These routines were included and adjusted during model calibration to match observed water quality conditions (Tetra Tech, 2007). The fraction of these parameters that is permanently deposited in bottom sediments or reduced via nutrient uptake processes was not accounted for in the allocation calculations.

As stated in USEPA's Protocol for Developing Pathogen TMDLs (USEPA, 2001), many different factors affect the survival and die-off of pathogens, including the physical condition of the water. These factors include, but are not limited to sunlight, temperature, nutrient deficiencies, predation, and other factors. Within the WQI river models, loss rates of 1.0 to 1.15 per day were used to fit water quality data for calibration (Tetra Tech, 2007). These dynamics and resulting loss rate, or instream load reductions were not accounted for in the allocation calculations for fecal coliform.

Similar dynamic processes of settling and uptake of TSS and TP, and bacterial die-off occur in the estuary water quality model, but since only permitted point sources received allocations in the estuary, and no reductions in loading were determined necessary to meet water quality targets at the estuary assessment points, no MOS was needed for the estuary TMDLs. The permitted point sources with estuary discharges are typically discharging well below their permitted concentration and load limits for TP, TSS, and bacteria parameters.

6.6 Reserve Capacity – Mass for the Future

Reserve capacity is intended to provide wasteload allocation for new or expanding industrial, CAFOs, or municipal WPDES permit holders. The reserve capacity is not intended to be applied to general permits, unless as discussed below, or permitted MS4s.

Reserve capacity can be used to cover discharges from general permits if it is determined that the wasteload allocation set aside for general permits, as specified in the TMDL, does not adequately cover existing, new, or expanding discharges from general permits. For this TMDL, reserve capacity is assigned for phosphorus and TSS/sediment. Reserve capacity is not required for bacteria. Bacteria allocations are expressed in permits as a concentration, not a mass.

Reserve capacity is calculated on a reach by reach basis with 5% of a reach's available loading capacity being set aside as reserve capacity. This provides adequate reserve capacity for potential new or expanding dischargers in headwater sections of the basin. In addition, reserve capacity accumulates from contributing reaches moving down through the basin making more available for dischargers located on larger downstream rivers. This approach affords dischargers greater flexibility in where they can locate or expand, minimizes impacts on existing dischargers, and is consistent with the observed practice of larger dischargers locating on larger bodies of water.

If a permitee wishes to commence a new discharge or expand an existing discharge of a pollutant covered by the TMDL and the discharge is within the area covered by the TMDL, the permittee must submit a written notice of interest along with a demonstration of need to the DNR. Interested dischargers will not be given reserve capacity unless they can demonstrate need.

A demonstration of need should include an evaluation of conservation measures, recycling measures, and other pollution minimization measures. New dischargers must evaluate current available treatment technologies and expanding dischargers should evaluate optimization of their existing treatment system and evaluation of alternative treatment technologies. In addition to evaluation of treatment options, an expanding discharger must demonstrate that the request for reserve capacity is due to increasing productions levels or industrial, commercial, or residential growth in the community.

If the department determines that a new or expanding discharger qualifies for reserve capacity, the reserve capacity, if available, will be distributed using the procedures outline below:

> New Discharger: For a new discharger, calculate the water quality based effluent limit (WQBEL) per NR 217 for phosphorus and NR 102 or NR 106 for other pollutants. If there is no water quality based effluent limit available for the pollutant apply the TMDL reductions, consistent with the applicable reach, to the baseline condition used in the TMDL. Baseline conditions, consisting of concentration and flows, are set for different pollutants and classes of dischargers and are summarized in Section 4. If the discharger can meet the resulting limit with available technology than the limit is translated into a mass and this mass becomes the amount of reserve capacity allocated to the discharger. If the discharger is unable to meet the limit with available technology than more reserve capacity, up to a maximum cap, can be allocated to the discharger. The maximum cap is calculated based on the facility's flow and the highest concentration for a similar type facility and treatment system.
>
> Determination of the wasteload allocation available to a new discharge will depend on the type and condition of the immediate receiving water. Limitations for new discharges to

Outstanding Resource Waters shall be based on NR 207.03(3). Limitations for new discharges to Exceptional Resource Waters which are not needed to prevent or correct either an existing surface or groundwater contamination situation, or a public health problem shall be based on NR 207.03(4)(b). For all other new discharge situations the following procedures apply to determine the appropriate mass allocation:

a) Determine the mass of reserve capacity that is available in the given reach.

b) Calculate the water quality based effluent limit (WQBEL) per NR 217.13(2)(a) and the associated mass limit per NR 217.14(3). Calculation should be based on current upstream water quality and for purposes of this calculation any other discharges within the given reach may be ignored.

c) Calculate the mass load associated with the baseline condition (see Section 4) for the class of the new discharger. Then apply the TMDL reductions, consistent with the applicable reach, to the baseline condition to determine the resultant mass.

d) Set the wasteload allocation equal to the most restrictive of the values determined by the above methods.

For a new discharge directly to a lake or reservoir, use the following procedure to determine the appropriate mass allocation:

a) Determine the amount of reserve capacity that is available for the lake or reservoir. This can include unassigned reserve capacity from contributory reaches located upstream of the lake or reservoir.

b) Calculate the WQBEL per 217.13(3) and associated mass limit per NR 217.14(3).

c) Set the wasteload allocation equal to the more restrictive of the values determined by the above methods.

Expanding Discharger: For an expanding discharger, reserve capacity will be allocated to cover the increased mass attributed to the facility expansion, measured as the increase in flow over the flow assumed in the TMDL baseline (see Section 4, Table 4-1), minus any reductions that can be realized through optimization or economically viable treatment technologies.

If a new or expanding discharger requires more mass than what was allocated through reserve capacity the difference between the mass discharged and their allocation can be made up through an off-set such as water quality trading. If there is not sufficient reserve capacity available, the discharge must be offset or the TMDL can be re-evaluated to determine if more assimilative capacity has become available since the original analysis.

Reserve capacity should be taken equally from all reaches upstream and in which the discharger is located. As additional demands are placed on available reserve capacity, it may become necessary to shift the location that previously assigned reserve capacity was taken, provided the total loading capacity for each reach is maintained. DNR will maintain a database system to track assigned reserve capacity and DNR will notify EPA in writing of reserve capacity assignments. Once reserve capacity reaches levels that it is no longer usable, the TMDL will need to be re-evaluated to see if additional assimilative capacity has become available since the original TMDL analysis due to changes in flow or implementation of the reductions prescribed in the TMDL.

Reserve capacity is not required for new or expanding permitted MS4s. For new or expanding permitted MS4s, the mass associated with the load allocation for the nonpermitted, undeveloped, or agricultural land, that is now part of the permitted MS4, is transferred to the wasteload allocation with a percent reduction in pollutant load assigned to the new or expanding permitted MS4 area consistent with the reductions stipulated in the TMDL for the reachshed. Refer to "TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance" and corresponding Addendums for process details. Visit http://dnr.wi.gov to view and obtain current guidance documents.

For CAFOs, the TMDL assigns the production area a wasteload allocation of zero; however, reserve capacity is available to cover a new or expanding continuous or intermittent surface water discharge resulting from a manure treatment system. If reserve capacity is not available, the mass resulting from a treatment system discharge must be off-set through water quality trading. This off-set can be generated through reductions in pollutant loads associated with modifications in manure applications to fields resulting from the treatment system or changes in the CAFO's operation. Fields receiving manure from the CAFO are covered by the nonpoint load allocation.

Pursuant to 40 CFR 122.41(g) and s. NR 205.07(1)(c), Wis. Adm. Code, a WPDES permit does not convey any property rights of any sort nor any exclusive privilege. Distribution of reserve capacity does not require re-opening of the TMDL; rather, the permit process can be used for reserve capacity assignments. All proposed reserve capacity assignments are subject to WDNR review and approval and must be consistent with applicable regulations. Reserve capacity decisions and related permit determinations are subject to public notice and participation procedures as well as opportunities for challenge at the time of permit modification, revocation and reissuance, or reissuance under chapter 283, Wis. Stats.

6.7 Seasonal Variation

Seasonal variation in loading was considered by calculating allowable loads on a monthly basis, and for various flow conditions. Fecal coliform allocations were calculated using a load duration curve approach. Flow regimes to establish the load duration curve were defined by the 5^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles (based on USEPA guidance) of the 10-year (1988-1997) flow dataset from the WQI models.

TP and TSS allocations were calculated for each month based on the fourth lowest flow for that month as calculated from the 10-year (1988-1997) flow dataset from the WQI models. By using this approach, allocations vary with the assimilative capacity of the TMDL reaches, and according to variation in the baseline loads from different sources. The approach allows load allocations to meet water quality standards but not be restrictive at times of the year when assimilative capacity is greater.

The use of the WQI models allowed for incorporating seasonal variations. The models operate on a 15-minute or hourly time step, but incorporate long-term seasonal patterns representative of variable conditions.

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Section 7
Implementation

7.1 Reasonable Assurance for Implementation

This section describes the programs and management measures that provide reasonable assurance, or a level of confidence that the load allocations developed for this TMDL can be achieved. TMDL implementation will occur through existing local, state, and federal regulatory programs, and other planned and existing activities. The following are some of the activities and programs that provide reasonable assurance for implementation.

7.2 Implementation Plan Development

Once the TMDL is approved, the TMDL Development Team will develop a plan that provides additional information to support the next steps of TMDL implementation. The implementation plan will include summaries of the TMDL development process and the allocation results, including a series of maps that present the baseline and allocated load data spatially. This mapping will assist with prioritization of future implementation efforts and show where there may be potential for partnerships. The implementation plan will also include recommendations for future monitoring to obtain additional information and track implementation progress.

The implementation plan will be coupled with other plans under development by SWWT. These plans will identify prioritized actions for load reductions to achieve the TMDL allocations.

The following sections provide an overview of the existing plans and federal, state, and local programs in place for implementation.

7.2.1 Regional Water Quality Management Plan and MMSD 2020 Facilities Plan

A joint planning effort designated as the "Water Quality Initiative" included the cooperative development of the MMSD facilities planning program and the SEWRPC Regional Water Quality Management Plan (RWQMP) updating program by WDNR, MMSD, and SEWRPC. In 2007 (and an amendment in 2013), an update of the RWQMP was completed to integrate previous regional water quality management efforts completed by SEWRPC and MMSD's 2020 Facilities Plan. The plan update was for the design year 2020 and represented a major amendment to the RWQMP for southeastern Wisconsin.

The goal of the update was to produce a scientifically defensible and implementable plan to improve water quality within the greater Milwaukee watersheds. The RWQMP was developed as a framework for the management of surface water for the greater Milwaukee watersheds that would abate existing water quality issues and allow for flexibility to address future concerns. The success of the RWQMP is dependent on local implementation efforts including, but not limited to: refinement and detailing of sanitary sewer service areas; the development of stormwater management plans and sewerage system facilities plans; and the integration of the plan recommendations into county land and water resource planning as a means for implementing the rural land management recommendations.

The RWQMP includes planning objectives for land use development, water quality management, outdoor recreation and open space preservation, water control facility development, plan structure and monitoring, educational and informational programming, and objectives for water use classifications and standards. Screening alternatives were developed to address upgrades to the MMSD sewerage system, and BMP implementation for nonpoint source pollution reduction. The recommended plan was comprised of elements to address plans for the following:

- Land Use – recommendations under the land use plan element of the RWQMP include the preservation of environmentally significant lands to maintain an integrated system of open space lands throughout the study area and the preservation of the area's most productive farmland.
- Surface Water – elements of this plan include point and nonpoint source pollution reductions. Recommendations include, but are not limited to, upgrades to sanitary sewer services throughout the study area, maintenance of adequate sewage collection system capacity, and a wet weather control plan for CSOs and SSOs. Nonpoint source control recommendations include, but are not limited to, reduction of soil erosion from cropland, manure and nutrient management, and the installation of riparian buffers.

7.2.2 Watershed Restoration Plans for the Menomonee and Kinnickinnic River Watersheds

The Southeastern Wisconsin Watershed Trust (SWWT or Sweet Water) developed Watershed Restoration Plans (WRPs) for the Kinnickinnic River and Menomonee River watersheds. The WRPs build on the SEWRPC RWQMP and MMSD's 2020 Facilities Plan. The WRPs incorporate input from SWWT and its associated Kinnickinnic and Menomonee River Watershed Action Teams (WATs) and Science Committees. The WRPs were developed to identify specific water quality improvement actions to implement between 2010 and 2015 and to present general recommendations for implementation activities beyond 2015. Actions were identified with consideration of results, regulations, stakeholder goals, and cost-effectiveness. The WRPs established the baseline (year 2000) and year 2020 characteristics of water quality and the watersheds, and identified the most significant sources of pollution. Water quality goals presented in the WRPs were selected by SWWT and load reductions to meet those goals were calculated based on year 2020 predictions.

The implementation strategy for the WRPs includes a phased approach coupled with adaptive management that monitors progress and adjusts actions as necessary. The phases of implementation under the WRPs are: Completed and Committed Actions/Projects (actions completed prior to 2008 or slated to be completed by 2010); Implement Identified Foundation Actions and Other Identified High Priority Actions (progress between 2010 and 2015); Full Implementation of the RWQMPU; Enhanced Level of Controls (improvements beyond the goals of the RWQMPU); and Fully Meet Water Quality Standards (after 2020).

Three major focus areas were identified for both the Menomonee River and the Kinnickinnic River WRPs: Bacteria/Public Health; Habitat/Aesthetics; and Nutrients/Phosphorus. Planning considerations for the Kinnickinnic watershed include the urban nature of the watershed, the unknown nonpoint sources of bacteria, the nonpoint source contributions to nutrient loads, and the variable habitat conditions throughout the watershed. Planning considerations for the Menomonee watershed include the diverse land uses present in the watershed (ranging from rural land uses to highly developed urban areas), the unknown nonpoint sources of bacteria, the nonpoint source and non-contact cooling water contributions to nutrient loads, and the variable habitat. The WRPs use a "bottom-up" approach to identify cost-effective actions that would improve water quality while working across political and jurisdictional lines.

Both WRPs identify priority actions and implementation strategies for the three focus areas. Implementation actions are provided in detailed tables categorized by the phased approach described above (refer to Section 8 of each WRP for complete lists of implementation actions). Examples of completed actions in the watersheds include bank stabilization along the Menomonee River, sediment removal to remove contaminants and improve habitat in the Kinnickinnic River, the development of outreach and communication strategies, and the implementation of projects to comply with nonagricultural ch. NR 151, Wis. Adm. Code, requirements to reduce TSS and potentially reduce bacteria and nutrients. Future actions recommended in the WRPs include the development of a Riparian Corridor Management Guide, development of focused programs to assess the impacts of older septic systems on water quality, and restoration of the Wilson Park Lagoon in the Kinnickinnic River watershed.

7.2.3 Management Strategies for Point Sources

WDNR regulates point sources through the WPDES permit program. Individual permits are issued to municipal and industrial wastewater discharges. General permits are issued to classes of industries or activities that are similar in nature, such as non-contact cooling water and certain stormwater discharges. Construction site runoff and runoff from certain industrial activities are issued coverage under WPDES general permits pursuant to ch. NR 216, Wis. Adm. Code. WPDES general permits and individual permits are issued to certain MS4s. Of the 43 permitted MS4s in the Basin, 12 are covered under a general permit, 7 are covered under an individual permit, and the remaining 24 are covered under a group individual or watershed-based permit. Standard requirements for all permitted MS4s are discussed further below. WPDES permits issued to municipal and industrial wastewater discharges will include discharge limits consistent with the approved wasteload allocations. Once the TMDL WLAs have been state and federally approved, reissued WPDES permits must contain limits consistent with the WLA.

For phosphorus, the mass allocation contained in the TMDL will be expressed as a mass limit. In many cases, discharges will also receive a concentration limit for P, based on the TBEL requirements in ch. NR 217, Wis. Adm. Code.

For solids, the mass allocation contained in the TMDL will be expressed as a mass limit for TSS, unless the equivalent concentration is $\leq$ 12 mg/L. In those cases, the limit will be expressed as a monthly average concentration of 12 mg/L TSS. See Section 3.2.2 for more information.

For bacteria, no reductions will be required for municipal wastewater dischargers that already employ disinfection. Limits for fecal coliform will continue to be expressed as 400 cfu/100 mL from May through September, in order to provide protection from human health impacts during the recreation season.

Dischargers with general WPDES permits will be evaluated to determine if additional requirements are necessary to ensure that discharges are consistent with TMDL goals. This could include issuing individual WPDES permits.

7.2.3.1 Statewide Non-Agricultural Performance Standards for Construction Sites

Chapter NR 151, Wisconsin Administrative Code, establishes runoff management performance standards and prohibitions for agricultural and non-agricultural facilities and practices. These standards are intended to be the minimum standards of performance necessary to achieve water quality standards. In addition to standards for sediment and erosion control during construction, implementation and enforcement of the performance standards, listed below, for post-construction storm water runoff from redevelopment, new-development and transportation facilities is necessary to reduce sediment loading (and associated phosphorus) to meet overall TMDL reductions in permitted and non-permitted urban areas:

- **Construction Site Allowable Soil Loss:** No more than 5 tons/acre/year of soil may be eroded and discharged from a construction site from the time of initial grading to final stabilization. This rule replaced the former 80% annual average reduction standard, and is demonstrated through using the USLE spreadsheet tool to inform BMP selection and project schedule (maximum bare soil exposure time).

- **Total Suspended Solids:** An average annual reduction in total suspended solids from development is required as presented in the table below.

TSS Reduction Standards	
Development Type	TSS Reduction
New Development	80 percent
Re-Development	40 percent
In-fill development	80 percent

- **Peak Discharge:** Maintain or reduce post-development peak discharge rates for the 1 year, 24-hour and 2-year, 24-hour design storm events to pre-development conditions. The purpose of the peak discharge control requirement is to minimize streambank and shoreline erosion under bank-full conditions.

- **Infiltration:** The pre-development infiltration volume under an average annual rainfall year must be quantified, and the site storm water management design must include practices to infiltrate runoff according to the development's level of connected imperviousness as follows:

Infiltration Volume Standards			
Level of Imperviousness	Percentage of Pre-Development Volume to Infiltrate		Percentage of Development Dedicated to Infiltration
Low (up to 40%)	80 percent		1 percent
Medium (40% < 80%)	40 percent	OR	2 percent
High (> 80%)	80 percent		2 percent

- **Protective Areas:** Minimize imperviousness within setbacks from waterways and wetlands as determined by the susceptibility of the receiving resource. Runoff generated from impervious areas within protective areas must be treated prior to discharge to the maximum extent practicable. Protective areas range from 10 feet to 75 feet depending on the adjacent resource.

In addition to the above-mentioned performance standards, the current construction site storm water runoff general permit includes permit language requiring that the designed stormwater management

CDM Smith

plan identify best management practices that will address discharges of pollutants that may contribute to an impairment of a waterway from the development, which may include construction and post-construction best management practices and approaches that go beyond the minimum performance standards and prohibitions identified in NR 151.

7.2.3.2 Statewide Non-Agricultural Performance Standards for Municipal Separate Storm Sewer Systems

Chapter NR 151, Wisconsin Administrative Code, establishes a developed urban area performance standard for permitted municipalities requiring 1) a public information and education program for beneficial reuse of leaves and grass clippings, proper use of garden fertilizers and pesticides, pet waste management, and prevention of illicit dumping into storm sewers; 2) A municipal leaf and grass clipping management program; 3) Turf nutrient management planning for municipal properties 5 acres and larger; and 4) a calculation of the percent reduction of total suspended solids discharged from the MS4 on average per year and an implementation plan to minimally achieve a 20% reduction in TSS.

Other minimum control measures are required through Chapter NR 216, Wisconsin Administrative Code, and include programs such as pollution prevention planning and construction site inspection and enforcement. In particular, continued implementation of dry-weather outfall screening and illicit discharge detection and elimination (IDDE) is required in all MS4 permits. The IDDE program will be a critical element in reducing bacteria loads entering the MS4 system through illicit connections and inflow and infiltration from leaky private laterals and aging sanitary sewer infrastructure. Furthermore, the risk of pathogen contamination is greater with human sources making prioritization and expansion of the IDDE program integral to TMDL implementation.

WDNR will incorporate permit conditions into MS4 permits that are consistent with the TMDL WLAs. The existing MS4 general permits include TMDL implementation language requiring the permitted MS4 to update storm sewer mapping and complete a pollutant loading analysis to either demonstrate compliance or to develop alternatives and a schedule for achieving the percent reduction targets identified in the TMDL. WDNR has developed program guidance to assist permitted MS4s with this effort, and can be found on WDNR's website at: http://dnr.wi.gov/topic/stormwater/standards/ms4_modeling.html. This guidance document also suggests demonstrating continual progress through benchmark setting every permit term. Benchmarks represent a progress increment – a level of pollutant reduction or an application of a pollutant reduction measure, which is part of a larger TMDL implementation plan designed to bring the overall MS4 discharge of pollutants of concern down to a level which is comparable to the MS4's TMDL WLA.

7.2.3.3 Combined Sewer Overflows

MMSD will continue to implement the Long-Term Control Plan (LTCP) to eliminate combined sewer overflows in the region. Existing structural controls for CSOs will be operated and maintained, and the first phase of planning for non-structural runoff volume controls, a regional green infrastructure plan, has been completed.

7.2.3.4 Sanitary Sewer Overflows

Existing municipal programs that prevent SSOs will continue. Municipalities will operate and maintain their systems as required by WPDES permit, and WDNR will monitor and enforce permit requirements.

7.2.3.5 Concentrated Animal Feeding Operations

CAFOs will be operated and maintained to prevent discharges as required by WPDES permit. WDNR will monitor and enforce permit requirements.

7.2.4 Management Strategies for Nonpoint Sources

To ensure the reduction goals of this TMDL are attained, management measures must be implemented and maintained to control phosphorus, sediment, and bacteria loadings from nonpoint sources of pollution. Wisconsin's Nonpoint Source Pollution Abatement Program (NPS Program), described in the state's Nonpoint Source Program Management Plan, outlines a variety of financial, technical, and educational programs, which support implementation of management measures to address nonpoint source pollution. WDNR and the Department of Agriculture, Trade, and Consumer Protection (DATCP) coordinate statewide implementation of the NPS Program. The NPS Program includes core activities and programs, which are a high priority and the focus of WDNR and DATCP's efforts to address NPS pollution; these programs include the following:

7.2.4.1 Statewide Agricultural Performance Standards & Manure Management Prohibitions

WDNR is a leader in the development of regulatory authority to prevent and control nonpoint source pollution. Chapter NR 151, Wis. Adm. Code, establishes runoff management performance standards and prohibitions for agricultural and non-agricultural facilities and practices. These standards are intended to be the minimum standards of performance necessary to achieve water quality standards. Implementing the performance standards and prohibitions on a statewide basis is a high priority for the NPS Program. In particular, the implementation and enforcement of agricultural performance standards and manure management prohibitions, listed below, will be critical to achieving the necessary nonpoint source load reductions throughout the TMDL area.

- **Tillage setback:** A setback of 5 feet from the top of a channel of a waterbody for the purpose of maintaining stream bank integrity and avoiding soil deposits into state waters. Tillage setbacks greater than 5 feet but no more than 20 feet may be required if necessary to meet the standard. Harvesting of self-sustaining vegetation within the tillage setback is allowed.

- **Phosphorus Index (PI):** A limit on the amount of phosphorus that may run off croplands and pastures as measured by a PI with a maximum of 6, averaged over an eight-year accounting period, and a PI cap of 12 for any individual year.

- **Process wastewater handling:** a prohibition against significant discharge of process wastewater from milk houses, feedlots, and other similar sources.

- **Meeting TMDLs:** A standard that requires crop and livestock producers to reduce discharges if necessary to meet a load allocation specified in an approved TMDL by implementing targeted performance standards specified for the TMDL area using BMPs specified in ch. ATCP 50, Wis. Adm. Code. If a more stringent or additional performance standard is necessary, it must be promulgated by rule before compliance is required.

- **Sheet, rill and wind erosion:** All cropped fields shall meet the tolerable (T) soil erosion rate established for that soil. This provision also applies to pastures.

- **Manure storage facilities:** All new, substantially altered, or abandoned manure storage facilities shall be constructed, maintained or abandoned in accordance with accepted standards, which includes a margin of safety. Failing and leaking existing facilities posing an imminent threat to public health or fish and aquatic life or violate groundwater standards shall be upgraded or replaced.
- **Clean water diversions:** Runoff from agricultural buildings and fields shall be diverted away from contacting feedlots, manure storage areas and barnyards located within water quality management areas (300 feet from a stream or 1,000 feet from a lake or areas susceptible to groundwater contamination).
- **Nutrient management:** Agricultural operations applying nutrients to agricultural fields shall do so according to a nutrient management plan. This standard does not apply to applications of industrial waste, municipal sludge or septage regulated under other WDNR programs provided the material is not commingled with manure prior to application.
- **Manure management prohibitions:**
  - no overflow of manure storage facilities
  - no unconfined manure piles in a water quality management area
  - no direct runoff from feedlots or stored manure into state waters
  - no unlimited livestock access to waters of the state in locations where high concentrations of animals prevent the maintenance of adequate or self-sustaining sod cover

WDNR, DATCP, and the county Land Conservation Departments (LCDs) will work with landowners to implement agricultural and non-agricultural performance standards and manure management prohibitions to address sediment and nutrient loadings in the TMDL area.

Many landowners voluntarily install BMPs to help improve water quality and comply with the performance standards. Cost-sharing funds may be available for many of these BMPs. Wisconsin statutes require that farmers must be offered at least 70% cost-sharing funds for BMP installation before they can be required to comply with the agricultural performance standards and prohibitions. If cost-share money is offered, those in violation of the standards are obligated to comply with the rule. DATCP's Farmland Preservation Program requires that any agricultural land voluntarily enrolled in the program must be in compliance with the performance standards.

7.2.4.2 WDNR Cost-Sharing Grant Programs

The counties and other local units of government in the TMDL area may apply for grants from WDNR to control NPS pollution and meet the TMDL load allocation. The WDNR supports NPS pollution abatement by administering and providing cost-sharing grants to fund BMPs through various grant programs, including, but not limited to:

- The Targeted Runoff Management Grant Program
- The Notice of Discharge Grant Program
- The Urban Nonpoint Source & Storm Water Management Grant Program

- The Lake Planning Grant Program
- The Lake Protection Grant Program
- The River Planning & Protection Grant Program

Many of the counties and municipalities in the TMDL area have a track record of participating in these NPS-related grant programs.

7.2.4.3 Targeted Runoff Management Grant Program

Targeted Runoff Management (TRM) grants are provided by the WDNR to control nonpoint source pollution from both urban and agricultural sites. A combination of state General Purpose Revenue, state Bond Revenue, and federal Section 319 Grant funds is used to support TRM grants. The grants are available to local units of government (typically counties) and targeted at high-priority resource problems. TRM grants can fund the design and construction of agricultural and urban BMPs. Some examples of eligible BMPs include livestock waste management practices, some cropland protection, and streambank protection projects. These and other practices eligible for funding are listed in s. NR 154.04, Wis. Adm. Code.

Revisions to ch. NR 153, Wis. Adm. Code, (http://legis.wisconsin.gov/rsb/code/nr/nr153.pdf) which governs the program, took effect on January 1, 2011, and modified the grant criteria and procedures, increasing the state's ability to support performance standards implementation and TMDL implementation. Since the calendar year 2012 grant cycle, projects may be awarded in four categories:

Small-Scale TMDL	Small-Scale Non-TMDL
▪ Implements a TMDL ▪ Agricultural or urban focus	▪ Implements NR 151 performance standards ▪ Agricultural or urban focus
Large-Scale TMDL	**Large-Scale Non-TMDL**
▪ Implements a TMDL ▪ Agricultural focus only	▪ Implements NR 151 performance standards ▪ Agricultural focus only

Section 281.65(4c), Wis. Stats., defines additional priorities for Targeted Runoff Management Projects as follows:

- TRM projects must be targeted to an area based on any of the following:
  - Need for compliance with established performance standards.
  - Existence of impaired waters.
  - Existence of outstanding or exceptional resource waters.
  - Existence of threats to public health.
  - Existence of an animal feeding operation receiving a Notice of Discharge.

  - Other water quality concerns of national or statewide importance.

- Projects are consistent with priorities identified by WDNR on a watershed or other geographic basis.

- Projects are consistent with approved county land and water resource management plans.

The maximum cost-share rate available to TRM grant recipients is up to 70 percent of eligible costs (maximum of 90% in cases of economic hardship), with the total of state funding not to exceed established grant caps. TRM grants may not be used to fund projects to control pollution regulated under Wisconsin law as a point source.

Grant application materials are available on the WDNR web site at: http://dnr.wi.gov/aid/targetedrunoff.html.

7.2.4.4 Notice of Discharge Grant Program

Notice of Discharge (NOD) Project Grants, also governed by ch. NR 153, Adm. Code, are provided by WDNR and WDATCP to local units of government (typically counties). A combination of state General Purpose Revenue, state Bond Revenue, and federal Section 319 Grant funds are used to support NOD grants. The purpose of these grants is to provide cost sharing to farmers who are required to install agricultural best management practices to comply with Notice of Discharge requirements. Notices of Discharge are issued by the WDNR under ch. NR 243 Wis. Adm. Code (Animal Feeding Operations - http://legis.wisconsin.gov/rsb/code/nr/nr243.pdf), to small and medium animal feeding operations that pose environmental threats to state water resources. The project funds can be used to address an outstanding NOD or an NOD developed concurrently with the grant award.

Both state agencies work cooperatively to administer funds set aside to make NOD grant awards. Although the criteria for using agency funds vary between the two agencies, WDNR and DATCP have jointly developed a single grant application that can be used to apply for funding from either agency. The two agencies jointly review the project applications and coordinate funding to assure the most cost-effective use of the available state funds. Funding decisions must take into account the different statutory and other administrative requirements each agency operates under.

Grant application materials are available on the WDNR web site at: http://dnr.wi.gov/Aid/NOD.html

7.2.4.5 Lake Planning Grant Program

The WDNR provides grants to eligible parties to collect and analyze information needed to protect and restore lakes and their watersheds and develop lake management plans. Section 281.68, Wis. Stats., and ch. NR 190, Wis. Adm. Code, provide the framework and guidance for WDNR's Lake Management Planning Grant Program. Grant awards may fund up to 66% of the cost of a lake planning project. Grant awards cannot exceed $25,000 per grant for large-scale projects.

Eligible planning projects include:

- Gathering and analysis of physical, chemical, and biological information on lakes.

- Describing present and potential land uses within lake watersheds and on shorelines.

- Reviewing jurisdictional boundaries and evaluating ordinances that relate to zoning, sanitation, or pollution control or surface use.

- Assessments of fish, aquatic life, wildlife, and their habitats. Gathering and analyzing information from lake property owners, community residents, and lake users.
- Developing, evaluating, publishing, and distributing alternative courses of action and recommendations in a lake management plan.

Grants can also be used to investigate pollution sources, including nonpoint sources, followed by incorporation into the lake management plan of strategies to address those sources. Investigation can involve many types of assessment, including determining whether or not the water quality of the lake is impaired. A plan approved by WDNR for a lake impaired by NPS pollution should incorporate the USEPA's "Nine Key Elements" for watershed-based plans.

Grant application materials are available on the WDNR web site at: http://dnr.wi.gov/Aid/SurfaceWater.html.

7.2.4.6 River Planning & Protection Grant Program

The WDNR provides grants to eligible parties for river protection grants. Chapter NR 195, Wis. Adm. Code, provides the framework and guidance for the River Protection Grant Program. This program provides assistance for planning and management to local organizations that are interested in helping to manage and protect rivers, particularly where resources and organizational capabilities may be limited.

River Planning Grants up to $10,000 are available for:

- Developing the capacity of river management organizations,
- Collecting information on riverine ecosystems,
- River system assessment and planning,
- Increasing local understanding of the causes of river problems

River Management Grants up to $50,000 are available for:

- Land/easement acquisition,
- Development of local regulations or ordinances that will protect or improve the water quality of a river or its natural ecosystem,
- Installation of practices to control nonpoint sources of pollution,
- River restoration projects including dam removal, restoration of instream or shoreland habitat,
- An activity that is approved by the WDNR and that is needed to implement a recommendation made as a result of a river plan to protect or improve the water quality of a river or its natural ecosystem,
- Education, planning and design activities necessary for the implementation of a management project.

The state share of both grants is 75% of the total project costs, not to exceed the maximum grant amount.

Grant application materials are available on the WDNR web site at:
http://dnr.wi.gov/Aid/SurfaceWater.html.

7.2.4.7 DATCP Soil & Water Resource Management Program

DATCP oversees and supports county conservation programs that implement the state performance standards and prohibitions and conservation practices. DATCP's Soil and Water Resource Management (SWRM) Program requires counties to develop Land and Water Resource Management (LWRM) Plans to identify conservation needs. Each county Land and Water Conservation Department in the TMDL area developed an approved plan for addressing soil and water conservation concerns in its respective county.

County LWRM plans advance land and water conservation and prevent NPS pollution by:

- Inventorying water quality and soil erosion conditions in the county.
- Identifying relevant state and local regulations, and any inconsistencies between them.
- Setting water quality goals in consultation with the WDNR.
- Identifying key water quality and soil erosion problems, and practices to address those problems.
- Identifying priority farm areas using a range of criteria (e.g., impaired waters, manure management, high nutrient applications).
- Identifying strategies to promote voluntary compliance with statewide performance standards and prohibitions, including information, cost-sharing, and technical assistance.
- Identifying enforcement procedures, including notice and appeal procedures.
- Including a multi-year work plan to achieve soil and water conservation objectives.

Counties must receive DATCP's approval of their plans to receive state cost-sharing grants for BMP installation. DATCP is also responsible for providing local assistance grant funding for county conservation staff implementing NPS control programs included in the LWRM plans. This includes local staff support for DATCP and WDNR programs. In CY 2016 alone, DATCP awarded $1,118,912 in grants to counties in the TMDL area for local assistance and BMP implementation.

The Milwaukee River TMDL provides County Land and Water Conservation Departments with the data necessary to more effectively identify and target pollutant sources so that strategies can be developed and applied to reduce pollutant loads in TMDL waters.

7.2.4.8 Federal Programs

Numerous federal programs are also being implemented in the TMDL area and are expected to be an important source of funds for future projects designed to control phosphorus, sediment, and bacteria loadings in the Milwaukee River Basin. A few of the federal programs include:

- **Environmental Quality Incentive Program (EQIP).** EQIP is a federal cost-share program administered by the Natural Resources Conservation Service (NRCS) that provides farmers with technical and financial assistance. Farmers receive flat rate payments for installing and implementing runoff management practices. Projects include terraces, waterways, diversions, and contour strips to manage agricultural waste, promote stream buffers, and control erosion on agricultural lands.

- **Conservation Reserve Program (CRP).** CRP is a voluntary program available to agricultural producers to help them safeguard environmentally sensitive land. Producers enrolled in CRP plant long-term, resource conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, the Farm Service Agency (FSA) provides participants with rental payments and cost-share assistance.

- **Conservation Reserve Enhancement Program (CREP).** CREP, a joint state/federal partnership, provides annual rental payments up to 15 years for taking cropland adjacent to surface water and sinkholes out of production. A strip of land adjacent to the stream must be planted and maintained in vegetative cover consisting of certain mixtures of tree, shrub, forbs, and/or grass species. Cost-sharing incentives and technical assistance are provided for planting and maintenance of the vegetative strips. Landowners also receive an upfront, lump sum payment for enrolling in the program, with the amount of payment dependent on whether they enroll in the program for 15 years or permanently.

7.2.4.9 Water Quality Trading & Adaptive Management

Water Quality Trading (WQT) and Adaptive Management (AM) may be used by eligible municipal and industrial WPDES permit holders to demonstrate compliance with TMDL WLAs. Both of these compliance options provide a unique watershed-based opportunity to reduce pollutant loading to streams, rivers, and lakes through point and nonpoint source collaboration. AM and WQT may also provide a new source of funding for local assistance and implementation of management measures to address nonpoint source pollution and improve water quality. The WDNR web site provides more details about water quality trading at: http://dnr.wi.gov/topic/SurfaceWater/WaterQualityTrading.html and adaptive management at: http://dnr.wi.gov/topic/SurfaceWater/AdaptiveManagement.html.

7.2.5 Post-Implementation Monitoring

A post-implementation monitoring effort will determine the effectiveness of the implementation activities associated with the TMDL. WDNR will monitor the tributaries of the Milwaukee River Basin based on the rate of management practices installed through the implementation of the TMDL, including sites where WDNR, DATCP, and NRCS grants are aimed at mitigating phosphorus, sediment, and bacteria loading. Monitoring will occur as staff and fiscal resources allow until it is deemed that stream quality has responded to the point where it is meeting its codified designated uses and applicable water quality standards.

In addition, the streams of the TMDL area may be monitored on a 5-year rotational basis as part of WDNR's statewide water quality monitoring strategy to assess current conditions and trends in overall stream quality. That monitoring consists of collecting data to support a myriad of metrics contained in WDNR's baseline protocol for wadeable streams, such as the IBI, the HBI, a habitat assessment tool, and several water quality parameters determined on a site by site basis.

WDNR will work in partnership with local citizen monitoring groups to support monitoring efforts which often provide a wealth of data to supplement WDNR data. All other quality-assured available data in the Basin will be considered when looking at the effectiveness of the implementation activities associated with the TMDL.

Pre- and post-BMP monitoring of urban runoff from permitted MS4s may be incorporated into the MS4 permit to supplement modeled performance.

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Section 8

Public Participation

MMSD established a process and forum for public participation and stakeholder involvement for development of the TMDLs in the Milwaukee River Basin. The process consisted of direction and input from the TMDL Development Team, input and participation from TMDL stakeholders, and participation from the interested general public.

The TMDL Development Team was comprised of representatives from MMSD, Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff, and Southeastern Wisconsin Watershed Trust (Sweet Water). The Wisconsin Department of Natural Resources (WDNR) and U.S. Environmental Protection Agency (USEPA) Region 5 staff also provided support to the Development Team. The team met frequently throughout the TMDL development process to provide direction on each stage of development. SEWRPC, WDNR, and USEPA staff provided primarily technical and procedural direction, while Sweet Water representatives provided direction on stakeholder and public input processes.

TMDL stakeholders were provided opportunities to ask questions and provide input via a series of half-day stakeholder workshops held at the Wauwatosa, WI Public Library. A kickoff workshop was held on November 14, 2011, with additional meetings/workshops held on March 5, 2012, July 31, 2012, and October 30, 2012. A stakeholder meeting was also held on Feb 27, 2012 to focus on MS4 specific elements of the TMDLs. Municipality representatives provided input on setting baseline load conditions for MS4s, as well as input on presenting figures in a manner most useful for permit holders. The stakeholder workshops were well attended, with sometimes more than 100 people in attendance. Each workshop provided an update on TMDL development progress and time for questions, input, and discussion.

A bacteria TMDL focus group meeting was held on July 25, 2012 to discuss available data and the approaches used specific to developing the bacteria TMDLs. Representatives from WDNR, Sweet Water, Great Lakes Water Institute, Clean Wisconsin, Milwaukee Riverkeeper, SEWRPC, and MMSD were in attendance.

The general public was informed of TMDL development progress at a public information meeting on March 13, 2012. The draft TMDL report and draft allocations were released to the public on July 20, 2016 after review by WDNR staff. Informational meetings were held with permitted MS4s on July 21, 2016 and with permitted wastewater facilities on July 25 and August 4, 2016. The TMDL report was posted on the WDNR website followed by an informal comment period. Clarifications were made to the TMDL report based on stakeholder feedback and comments.

A formal public informational hearing was conducted on November 15, 2016 followed by a 30-day comment period. Details pertaining to the public hearing and submission of comments are available on the WDNR website: http://dnr.wi.gov/topic/tmdls/ under the public notice tab. In addition, notifications were sent out using govdelivery: https://public.govdelivery.com/accounts/WIDNR/subscriber/new. A summary of all comments and responses was prepared and is included in Appendix G. Revisions to the TMDL in response to public comments were made as determined appropriate.

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Section 9

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Appendix A
Allocation Tables per Watershed

CDM Smith

Appendix B

Large Format Maps

CDM Smith

Appendix C

TMDL Development Team Decision Memorandum

Appendix D

Fecal Coliform Load Duration Curves per TMDL Reach

Appendix E

Translator Development for Bacterial Indicator TMDLs

CDM Smith

Appendix F

Example Allocation Calculation

Appendix G

WDNR Response to Official Comments Received

CDM Smith