QUALITY ASSURANCE PROJECT PLAN

Phosphorus, Sediment, and Bacteria TMDLs

Milwaukee Harbor Estuary, Wisconsin

EPA Grant 00E00592-0

Prepared For:

Milwaukee Metropolitan Sewerage District

February 3, 2012 Revision

CDM Smith

Section A – Project Management

A1. Approval Sheet

EPA Grant 00E00592-0

Dan Bounds, CDM Smith Inc.
Consultant Team Project Manager

2/3/2012
Date

Steve Heinz, Milwaukee Metropolitan Sewerage District (MMSD)
Project Manager

2/7/12
Date

Donalea Dinsmore, Wisconsin Department of Natural Resources (WDNR)
Quality Assurance Reviewer

2/9/12
Date

Kevin Kirsch, WDNR
Technical Approach Reviewer

2/17/12
Date

David Werbach, U.S. EPA Region 5
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2/22/12
Date

Daniel Samardzich, U.S. EPA Region 5
Project Officer

2/21/12
Date

Approval Sheet, continued
EPA Grant 00E00592-0

Jean Chruscicki

Jean Chruscicki, U.S. EPA Region 5
Quality Assurance Coordinator, Watersheds and Wetlands Branch

2/22/12
Date

for Peter Swenson

Tinka Hyde, U.S. EPA Region 5
Water Division Director

2/22/12
Date

A2. Table of Contents

Appendices

A3. Distribution List

Steve Heinz of the Milwaukee Metropolitan Sewerage District will distribute this Quality Assurance Project Plan (QAPP) to the following entities:

U.S. Environmental Protection Agency, Region 5
Watersheds and Wetlands Branch
77 W. Jackson Boulevard (WW-16J)
Chicago, IL 60604
Attn: Jean Chruscicki

Wisconsin Department of Natural Resources
101 S. Webster Street
P.O. Box 7921
Madison, WI 53707-7921
Attn: Donalea Dinsmore

Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, WI 53187-1607
Attn: Mike Hahn

Southeastern Wisconsin Watersheds Trust
600 E. Greenfield Avenue
Milwaukee, WI 53204-2944
Attn: Jeff Martinka

Baird & Associates
2981 Yarmouth Greenway Drive
Madison, WI 53711
Attn: Mark Riedel

Oneida Total Integrated Enterprises
1033 N. Mayfair Road, Suite 200
Milwaukee, WI 53226
Attn: Mike Hemmingsen

M Squared Engineering, LLC
W62N215 Washington Avenue
Cedarburg, WI 53012
Attn: Minal Hahm

Kapur and Associates, Inc.
7711 North Port Washington Road
Milwaukee, WI 53217
Attn: Dave Misun

Beth Foy and Associates, LLC
N87w15685 Kenwood Boulevard
Menomonee Falls, WI 53051
Attn: Beth Foy

Environmental Consulting
1633 Waldrop Road
Lawrenceville, GA 30043
Attn: Mike McGhee

Great Lakes WATER Institute
University of Wisconsin—Milwaukee
600 E. Greenfield Avenue
Milwaukee, Wisconsin 53204
Attn: Sandra McLellan

List of Acronyms and Terms

303(d) List	List of impaired waters
2020 FP	2020 Facilities Plan
BMPs	Best Management Practices
CAFO	Concentrated Animal Feeding Operation
Compliance Points	Locations where concentrations will be compared to water quality targets
Cooperating Agency	One of several entities overseeing or participating in the TMDL development; includes USEPA, WDNR, MMSD, SEWRPC, and SWWT
ECOM	Estuarine Coastal and Ocean Model
GLRI	Great Lakes Restoration Initiative
HSPF	Hydrological Simulation Program—Fortran
LSPC	Load Simulation Program in C++
Milwaukee River Basin	The Milwaukee Harbor Estuary and its three tributary watersheds (the Menomonee River, Kinnickinnic River, and Milwaukee River watersheds)
MMSD	Milwaukee Metropolitan Sewerage District
MS4	Municipal Separate Storm Sewer System
PR-50	SEWRPC Planning Report No. 50
QAPP	Quality Assurance Project Plan
RCA	Row-Column AESOP (Advanced Ecological Simulation Program)
RMSE	Root Mean Square Error
RWQMPU	Regional Water Quality Management Plan Update
SEWRPC	Southeastern Wisconsin Regional Planning Commission
SWWT	Southeastern Wisconsin Watersheds Trust
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TR-39	SEWRPC Technical Report No. 39
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
WDNR	Wisconsin Department of Natural Resources
WLA	Wasteload Allocation
WisCALM	Wisconsin Consolidated Assessment and Listing Methodology

WQI	Water Quality Initiative, a combined planning effort between WDNR, MMSD, and SEWRPC to assess water resources within the Greater Milwaukee Watersheds
WWTF	Wastewater Treatment Facility

A4. Project/Task Organization

The Milwaukee Metropolitan Sewerage District (MMSD) received a Great Lakes Restoration Initiative (GLRI) grant for Nearshore Health and Nonpoint Source Pollution to develop third-party bacteria, phosphorus, and sediment total maximum daily loads (TMDLs) for the Milwaukee Harbor estuary in southeastern Wisconsin. Pending approval by the Wisconsin Department of Natural Resources (WDNR), the TMDLs will be submitted to the U.S. Environmental Protection Agency (USEPA) for review and approval.

A4.1 The Milwaukee Metropolitan Sewerage District (MMSD)

The TMDL project will be carried out by MMSD working collaboratively with USEPA, WDNR, the Southeastern Wisconsin Regional Planning Commission (SEWRPC), and the Southeastern Wisconsin Watersheds Trust, Inc (SWWT). MMSD will lead the TMDL development effort in partnership with these "collaborating agencies" and with the assistance of the consultant team. Steve Heinz will be the Project Manager and primary contact for MMSD.

A4.2 U.S. Environmental Protection Agency (USEPA)

USEPA will be responsible for review of project approaches and deliverables to ensure technical quality and to verify that project objectives and contractual obligations are met. Quality assurance reviews will include review of this QAPP and external performance and system audits. David Werbach will be the primary contact for USEPA.

A4.3 Wisconsin Department of Natural Resources (WDNR)

WDNR will hold several roles on the TMDL development team, from both headquarters and regional office perspectives. Staff at WDNR will provide data and technical input, local watershed information, and implementation plan guidance. Staff will ensure that the data provided is being used appropriately and that analysis results are being developed in a manner consistent with current and planned WDNR programs and measures. Staff will also conduct technical review of all project approaches and deliverables. This QAPP and its updates will be reviewed for acceptance by WDNR staff. Jim Fratrick will be the primary contact for WDNR.

A4.4 Southeastern Wisconsin Regional Planning Commission (SEWRPC)

The primary role of SEWRPC will be to provide data, previous study information, and tools developed as part of the MMSD 2020 Facilities Plan and SEWRPC's Regional Water Quality Management Plan Update—the combined effort known as the Water Quality Initiative. TMDL development will rely on and make extensive use of this information, so technical coordination with SEWRPC will be frequent throughout the TMDL and implementation plan development. Mike Hahn will be the primary contact for SEWRPC.

A4.5 The Southeastern Wisconsin Watersheds Trust (SWWT)

The primary role of SWWT will be to provide public outreach, agency coordination, and education to citizens and stakeholders. The SWWT is a relatively new, voluntary, non-taxing partnership of independent units of government, special purpose districts, agencies, businesses, organizations, and members at large who share common goals and are coming together to achieve these goals through

coordinated collaboration and cooperation within the greater Milwaukee watersheds, including the Milwaukee Harbor estuary. Jeff Martinka will be the primary contact for SWWT.

A4.6 Consultant Team

The TMDL development consulting team will be led by CDM Smith, and includes the following team firms in subconsultant roles. CDM Smith is responsible for the overall management of the consulting team and development of the TMDL and implementation plan. CDM Smith's Project Manager and key Task Manager will direct select team members from each firm on each unique task in the project scope. Dan Bounds, Project Manager, and Kim Siemens, Task Manager, will be the primary consulting team contacts.

- Baird will provide hydrodynamic modeling assistance.
- Three other subconsulting firms (Oneida Total Integrated Enterprises [OTIE], M Squared Engineering, and Kapur and Associates) will serve general technical support roles across most tasks throughout TMDL development, with a focus on data management and analysis, database development, and GIS usage.
- The Great Lakes WATER Institute has first-hand knowledge of the various bacterial indicator and pathogen sources throughout the greater Milwaukee watersheds, including extensive work on identifying illicit sanitary sewer connections. The Institute will be consulted throughout the project to make sure that all sources are adequately considered in the TMDL and implementation plan development, including developing a representative "translator" between bacterial indicators for use in the estuary TMDL.
- Environmental Consulting will provide consultation on developing the TMDL in line with the pollutant trading framework being developed in Wisconsin.
- Beth Foy and Associates will serve as the nontechnical translator in developing materials for a public audience for TMDL stakeholder meetings and related stakeholder communication.

Figure 1 shows an organizational chart that provides the structure of the cooperating agencies and consulting team firms working together to develop the TMDL. Representatives from these agencies and firms make up the "TMDL development team," which will provide leadership and work collaboratively on all aspects of developing the TMDL and supporting information. All data use and analysis aspects will be discussed, considered, and/or reviewed by the TMDL development team, with MMSD and WDNR representatives making final determinations when necessary.

Stakeholders to the TMDL development process will include an extensive and diverse set of entities that discharge to the watershed, including NPDES permit holders (POTWs, industrial dischargers, MS4s, and general permit holders), and nonpoint source load contributing entities. As described in more detail later in this QAPP, TMDL stakeholders will have review opportunities at each key step in the TMDL development process, and will be able to provide input at each step. Public informational meetings will also be held to inform the general public throughout the process. These meetings will also provide a forum for additional review and input.

TMDL stakeholders will include, but not be limited to:

- Municipal Representatives
    - MS4s
    - POTWs
    - MMSD Technical Advisory Team

  - League of Wisconsin Municipalities
  - Wisconsin Alliance of Cities
  - Counties
- WisDOT
- Industrial Dischargers
- Rural Nonpoint/Agriculture Representatives
  - County Land Conservation Offices
  - Agricultural Drainage Districts
  - Lake Management Districts
  - Sanitary Districts
  - Dairy Business Association
  - Farm Bureau
- General Permit Holders
  - Construction sites
  - Scrap Recyclers
  - Non-metallic mines
- Cooling Water Dischargers
- Professional Organizations
  - Central States Water Environment Association Committees
  - Nutrient Management Consultants
- Non-Governmental Organizations
  - Milwaukee Riverkeeper
  - Sixteenth Street Community Health Center
  - Midwest Environmental Advocates
  - Clean Wisconsin
  - Local Watershed Groups
  - UW Extension
  - UW-Milwaukee
  - Groundwork Milwaukee

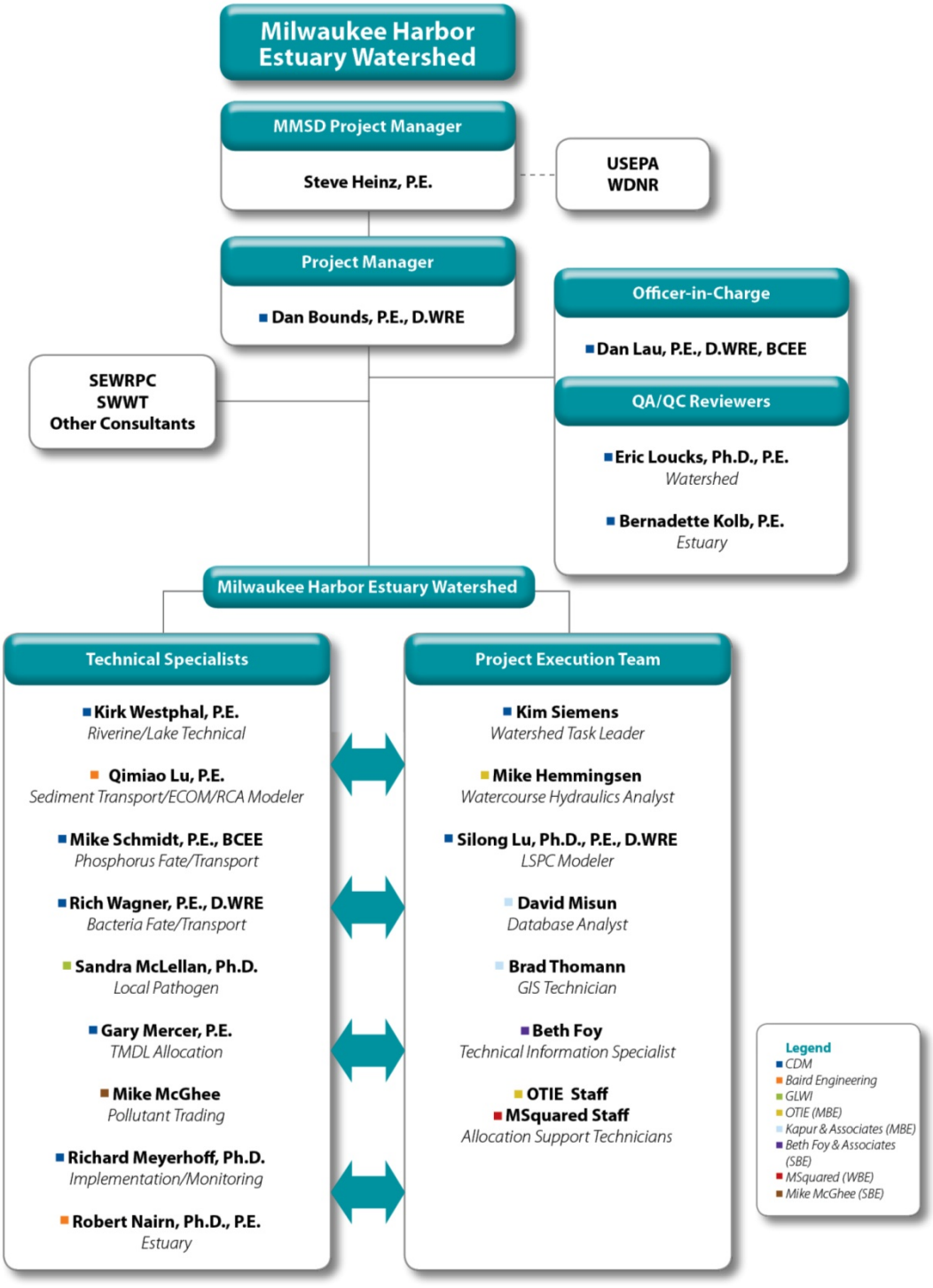


Figure 1. Organizational Chart for the Milwaukee Harbor Estuary TMDL Development Team

A5. Problem Definition/Background

A5.1 Introduction

USEPA regulations and the Clean Water Act require states to identify water bodies that do not meet established water quality criteria and to develop TMDLs for those impaired waters. A TMDL is the maximum amount (expressed in load per day) of a pollutant a water body can receive from both point and nonpoint sources and still meet water quality standards for that particular pollutant.

Elevated phosphorus, sediment, and bacteria levels in the Milwaukee River Basin[1] have led to low dissolved oxygen concentrations, degraded habitat, excessive algal growth and turbidity, and beach closures. As a result, impairments to beneficial uses such as preservation and enhancement of fish and other aquatic life, and recreational use, have occurred.

Under Great Lakes Restoration Initiative funding, Milwaukee Metropolitan Sewerage District has contracted with CDM Smith to develop TMDLs for phosphorus, sediment (as measured by total suspended solids, or TSS), and fecal coliform bacteria in the Menomonee River, Kinnickinnic River, and Milwaukee River watersheds, and the Milwaukee Harbor estuary. Figure 2 presents the TMDL study area. This QAPP focuses on the data and procedures that will be used for the Milwaukee Harbor estuary.

The purpose of this QAPP is to describe the quality assurance activities that must take place to ensure that the results of the project will meet project specifications. The technical approach outlined in this document is based on a number of assumptions and will evolve as the project progresses. Refinements to the technical approach will be documented in a series of technical memoranda that will be attached to this QAPP.

A5.2 Background

In the last decade, 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). The RWQMPU is documented in SEWRPC Planning Report No. 50 (PR-50), entitled *An Update to the Regional Water Quality Management Plan for the Greater Milwaukee Watersheds* (SEWRPC, 2007b). The "Greater Milwaukee watersheds" is an area that includes the watersheds for which TMDLs will be 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, 2007a), 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.

[1] For the purposes of the TMDLs, the term "Milwaukee River Basin" is defined as the Milwaukee Harbor Estuary and its three tributary watersheds: the Menomonee River, Kinnickinnic River, and Milwaukee River watersheds.

The SEWRPC work was done in parallel with MMSD's 2020 Facilities Plan (FP), 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 sets a foundation upon which scientifically sound TMDLs can be developed. The studies provide 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 will be used in the TMDL development, as described in Section A5.6. The models have been accepted by WNDR as appropriate for this use with no further calibration necessary. Appendix A presents a memorandum of understanding between MMSD, SEWRPC, and WDNR regarding the WQI. Appendix B includes a letter that documents WDNR acceptance of the 2020 FP.

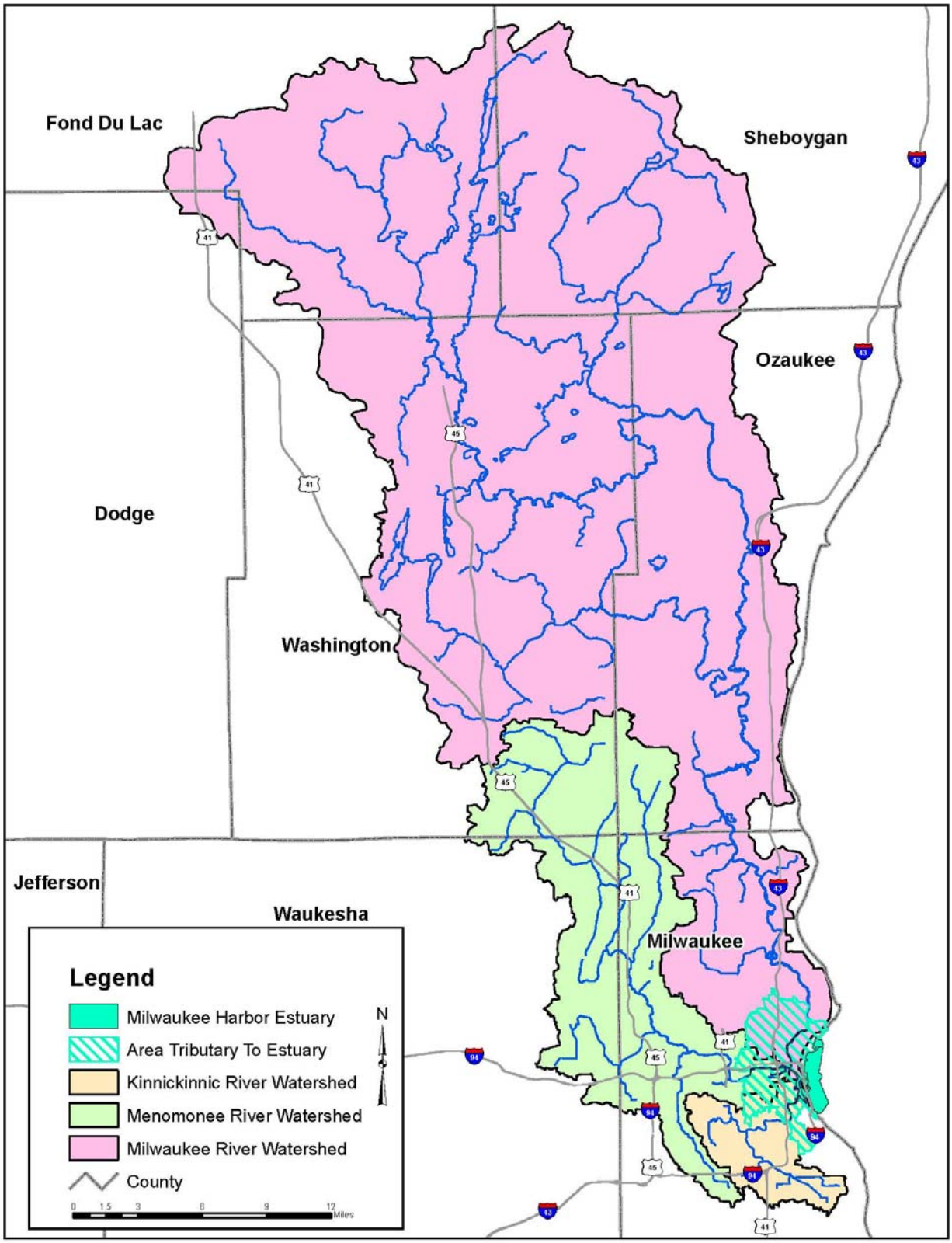


Figure 2. TMDL Study Area

A5.3 Study Area

The Milwaukee Harbor estuary is located in the southeastern portion of the Milwaukee River Basin and is tributary to Lake Michigan (Figure 3). The Milwaukee Harbor estuary includes the outer harbor area—from the breakwater 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 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

The area directly tributary to the Milwaukee Harbor estuary is approximately 16 square miles. Sources of pollution in this tributary area include a wastewater treatment facility (WWTF), industrial discharges, CSOs, and stormwater runoff from urban areas. Pollution also enters the Milwaukee Harbor estuary from the Menomonee, Kinnickinnic, and Milwaukee Rivers. 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 small portion. The area immediately adjacent to the estuary is highly urbanized, but the Menomonee River watershed and, to a greater extent, the Milwaukee River watershed contain rural and agricultural areas.

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. A portion of the Lake Michigan direct drainage area is shown in Figure 3.

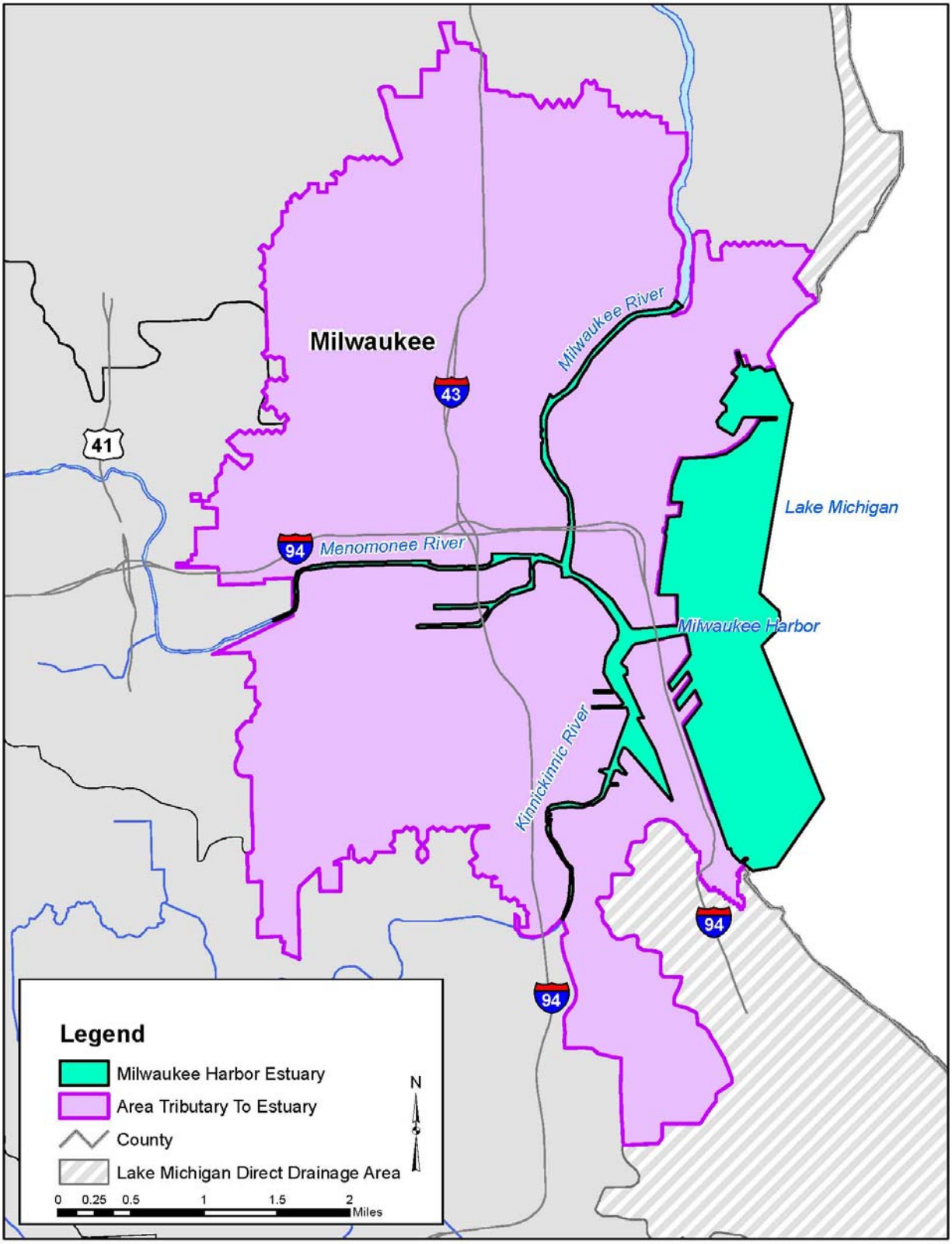


Figure 3. The Milwaukee Harbor Estuary

A5.3.1 Impaired Waters

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." The 2008 303(d) list has been approved by USEPA and the 2010 303(d) list is pending USEPA approval. The Milwaukee Harbor estuary TMDL will be based on WDNR's proposed 2012 303(d) list. Table 1 presents the proposed 2012 303(d) list and Figure 4 presents a map of the segments.

Table 1.Proposed 2012 303(d)-Listed Segments Included in the Milwaukee Harbor Estuary TMDL

Water Body	Description	Counties	Water Body ID Code	Pollutants	Impairments
Kinnickinnic River	Mile 0-2.83	Milwaukee	15100	*E. coli*, Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Low DO
Menomonee River	Mile 0-2.67	Milwaukee	16000	*E. coli*, Fecal Coliform, Total Phosphorus	Recreational Restrictions – Pathogens, Low DO
Milwaukee River	Mile 0-2.9	Milwaukee	15000	*E. coli*, Total Phosphorus	Recreational Restrictions – Pathogens, Low DO
Outer Harbor	Mile 0-0.32	Milwaukee	15010	*E. coli*	Recreational Restrictions - Pathogens

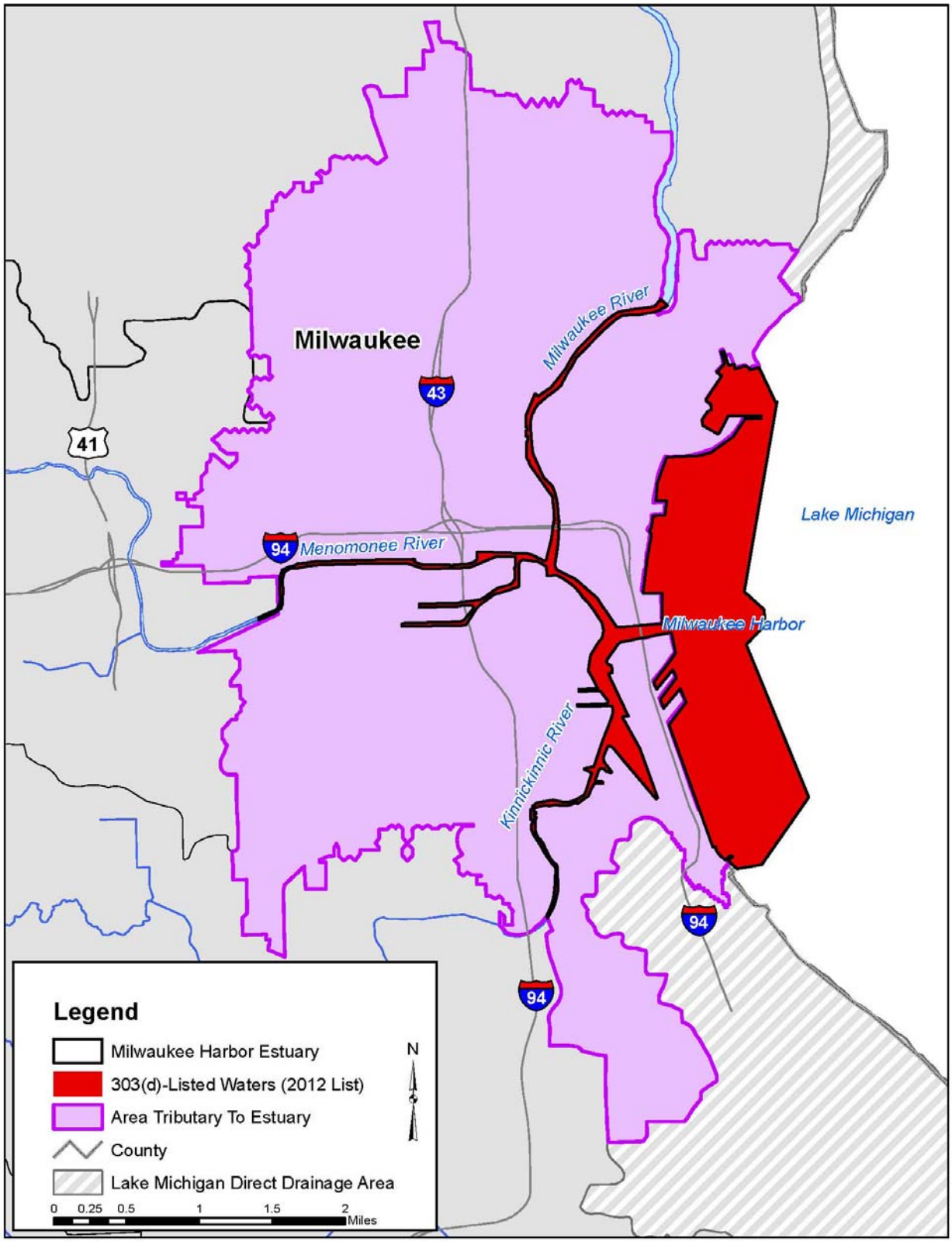


Figure 4. Impaired Waters in the Milwaukee Harbor Estuary

A5.3.2 Designated Uses

While the majority of the waters in the Milwaukee River Basin are designated for "fish and other aquatic life uses" and full recreational uses, the lower reaches of the Menomonee River, Kinnickinnic River, and Milwaukee River and the inner harbor area are subject to variance designations under Chapter 104 of the Wisconsin Administrative Code.

A5.3.3 Water Quality Targets

The target instream concentrations for total phosphorus (TP) are equivalent to the criteria in Wisconsin Administrative Code Chapter NR 102. NR 102.06 sets TP criteria of 0.100 mg/L for rivers or other specified waterbodies and 0.075 mg/L for streams. According to NR 102.06(3)(a), the 0.100 mg/L standard applies to both the inner and outer harbor areas of the Milwaukee Harbor estuary.

There are no existing or proposed statewide numeric standards for sediment concentrations, so TSS TMDLs will be based on relationships between TSS and TP loading. Sediment loads from nonpoint sources are correlated with phosphorus loads, because much of the phosphorus that is delivered to streams is bound to sediment (Robinson et al., 1992). Therefore, the observed relationships between phosphorus and biological characteristics of surface waters are to some extent related to sediment, too. It is reasonable to expect that TMDL implementation actions that reduce TP to acceptable levels will also reduce TSS loads to an extent sufficient to achieve designated fish and other aquatic life uses. The TSS targets for this TMDL are proposed to be calculated for each reach by determining the TSS load that is typically associated with the TP load that meets the phosphorus criteria. These targets will be confirmed in an analysis of the relationship between TSS concentrations/loads and the aquatic life use. This approach is considered to be reasonable and acceptable based on other TMDLs recently completed in Wisconsin.

For the inner harbor area, which has a variance designation under Chapter NR 104, the membrane filter fecal coliform count may not exceed 1,000 colonies per 100 mL as a geometric mean. In addition, the membrane filter fecal coliform count may not exceed 2,000 colonies per 100 mL in more than 10 percent of all samples for the portion of the inner harbor that extends from the Kinnickinnic River.

USEPA has promulgated bacteriological criteria for open water Lake Michigan areas and the outer harbor area of the Milwaukee Harbor estuary. The criteria include an *E. coli* geometric mean standard of 126 cells per 100 mL and single sample maxima of 235 cells per 100 mL. Also, an enterococci geometric mean standard of 33 cells per 100 ml and single sample maxima of 61 cells per 100 ml apply.

A5.4 Goals and Objectives

The purpose of the TMDL is to allocate loads of TP, TSS, and fecal coliform bacteria that will result in attainment of applicable designated uses throughout the Milwaukee Harbor estuary. The allocated loads will be presented in a series of tables attached to a TMDL document that will outline the procedures used to calculate the loads. An additional objective of the project discussed in this QAPP is to develop an implementation plan for the TMDL. Stakeholder input and coordination with cooperating agencies will be sought throughout the project.

A5.5 TMDL Calculations

TP, TSS, and fecal coliform TMDLs will be calculated for each impaired stream reach of the inner harbor and the outer harbor area. The TMDL for a reach is also referred to as the loading capacity of that reach—the maximum amount of a pollutant that a water body can receive and still meet water quality objectives.

Nonpoint source pollution and a water body's assimilative capacity are driven by hydrology. The loading capacity of a reach is calculated by multiplying the target water quality concentration by the streamflow in a reach that represents a specific hydrologic condition. The range of flows represented in the model simulation period will be examined and the hydrologic condition will be set to ensure that the loading capacities are not driven by anomalously high or low flows. Compliance locations within the outer harbor area will be selected with input from the cooperating agencies that will result in achievement of water quality targets. The loading capacity calculations will be done on a monthly basis to account for seasonal variation in flow and the assimilative capacity of the water body.

The "allowable" loads will then be allocated to the various pollutant sources in the area draining to the reach. Multiple allocation methods may be considered for the Milwaukee Area TMDLs. An initial proposed method is to divide the loading capacity between sources according to each source's relative contribution to the baseline, or current, load in each reach. This method assigns responsibility for attaining water quality targets in proportion to each source's current contribution to the excess load. Attainment of water quality targets will be dependent upon whether necessary loading reductions are achieved for each source. Required by the Clean Water Act, reasonable assurances provide a level of confidence that the allocations in TMDLs will be achieved. Wisconsin regulations establish management strategies for both point and nonpoint sources of pollution providing reasonable assurance. As described in Section A6.7, an implementation plan will lay out actions aimed at achieving the loading allocations identified during TMDL development.

A5.6 Selected Modeling Tools

As part of the WQI, mathematical simulation models were developed to conduct analysis of hydrology, hydraulics, and water quality under existing and alternative future conditions. These models will be used in tandem with customized database tools for the TMDL calculations.

Water quality within the Milwaukee Harbor estuary is strongly influenced by turbulent mixing caused by wind, river flow, and large-scale dynamics in Lake Michigan. To account for these mechanisms, the Milwaukee Harbor estuary model was constructed using the ECOM/RCA model. The Estuarine Coastal and Ocean Model (ECOM) model 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 nearshore area between Fox Point to the north and Wind Point to the south.

Boundary conditions at the upstream boundaries of the estuary model are input from Hydrological Simulation Program—Fortran (HSPF) and Load Simulation Program in C++ (LSPC) models of the Menomonee River, Kinnickinnic River, and Milwaukee River watersheds. 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 HSPF/LSPC models are input directly to the ECOM/RCA model. Meteorological data and point source data are also included as inputs to the model. Combined and separate sewer overflows are simulated in a separate MMSD conveyance model built in MOUSE software and input to the ECOM/RCA model.

A custom Microsoft Access database will be designed to store and analyze hydrodynamic and pollutant load data from the ECOM/RCA model, as shown in Figure 5. The database will be used for two main calculations: 1) calculation of the loading capacities for each reach and pollutant, and 2) allocation of the allowable loads to the various sources that contribute load to each reach.

Between the two sets of calculations, initial allowable loads will be input into the RCA model and run with results from the hydrodynamic simulation to calculate the concentrations that would result from implementation of the TMDL within a simulated hydrologic period. The movement of water and pollutants through the model will be verified and the concentrations will be compared to the water quality targets. The model or allowable loads will be adjusted until the TMDL objectives are met. Because the estuary model includes boundary conditions from the HSPF/LSPC watershed models, iterative adjustment to the allowable loads from the Menomonee River, Kinnickinnic River, and Milwaukee River watersheds may be required.

The database will also perform subsequent calculations on the allocated loads for presentation in the TMDL report. The municipal separate storm sewer system (MS4), industrial point source, and WWTF loads will be divided among individual permitted dischargers according to their relative contributions to the baseline load. Monthly allocated loads will be converted to daily loads to meet USEPA requirements for TMDLs. Daily loads for WWTFs will be calculated according to USEPA guidance (USEPA, 2007). The database will also be used to calculate the percent load reductions to meet the TMDL.

The WQI models were calibrated by comparing observed data and simulated values and adjusting the input parameters of the model as necessary. Model validation was done to test the calibrated model using input from a different time period with no further adjustment of input parameters. There will be no need for additional calibration or validation of the models for use in the TMDLs. Further description of model calibration is included in Section B7.

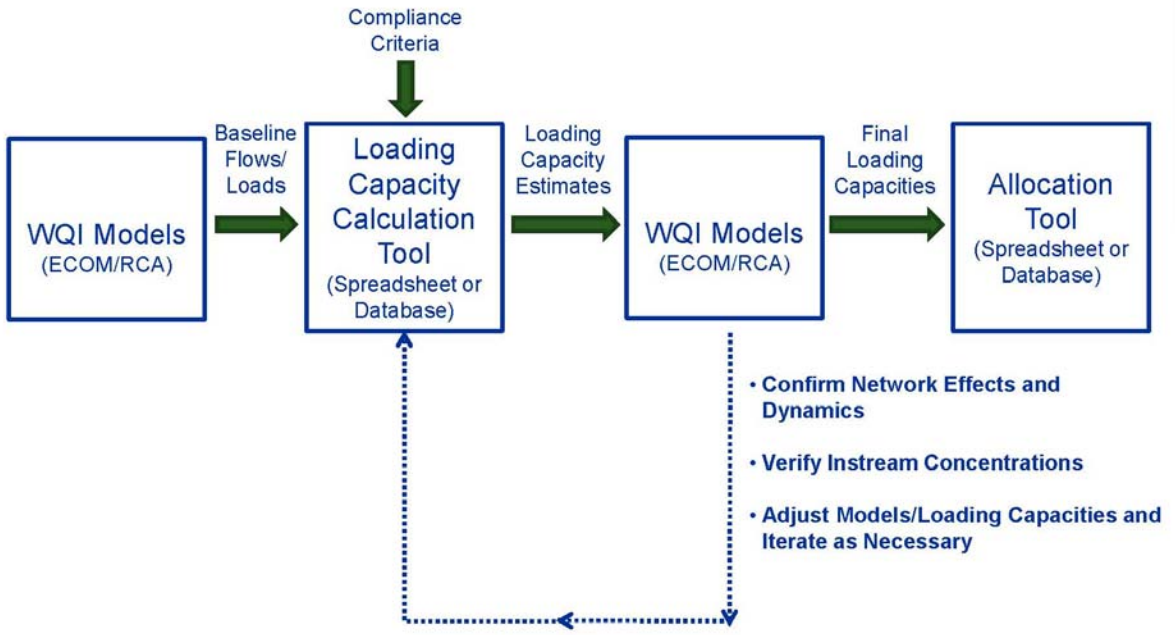


Figure 5. Proposed Use of WQI Models and Custom Tools for the Milwaukee Harbor Estuary TMDL

A5.6.1 Fecal Coliform to *E. coli* Translation

As discussed above, the water quality standard for bacteriological organisms in the rivers and inner harbor is based on fecal coliform concentrations. As such, much of the historical bacteriological data is for fecal coliform and the upstream watershed models have been calibrated for this organism. However,

the water quality standard for the outer harbor and nearshore area of Lake Michigan is based on *E. coli* concentrations. Therefore, a "translator" will need to be developed based on existing data to convert the fecal coliform loadings to *E. coli* loadings for use in evaluating impacts to the outer harbor area. All of the calculations performed by the tools shown in Figure 5 will be done in terms of fecal coliform. The conversion to *E. coli* will occur as a side calculation after the loading capacities for the study area are calculated to confirm that resulting *E. coli* concentrations would meet the water quality standards for the outer harbor. Allocated loads will be reported in terms of fecal coliform in the TMDL report.

The translator will be developed based on concurrent fecal coliform and *E. coli* samples that were collected and analyzed by the McLellan lab at the Great Lakes WATER Institute. Watershed-specific fecal coliform to *E. coli* relationships will be developed from this data so that calculated fecal coliform loading capacities and resulting instream concentrations can be translated to *E. coli* for the outer harbor area.

Details of the translator development will be incorporated into an appendix to this QAPP that will be reviewed by the development team and quality assurance reviewers.

A5.6.2 SUSTAIN

MMSD has completed a modeling analysis of green infrastructure using the USEPA System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) model. The analysis was done to determine the most cost-effective set of green infrastructure practices for runoff volume reduction. Investigated practices included rain gardens, local and regional bioretention, bio-swales, rain barrels, green roofs, porous pavement, and green alleys. The results of the analysis will be used to inform the selection of practices that will be recommended in the TMDL implementation plan. See Appendix C for Section 3.5 of the analysis report, which describes the SUSTAIN model set up.

A6. Project/Task Description and Schedule

The main TMDL development tasks will include:

- Task 0) Prepare Quality Assurance Project Plan (which this document intends to satisfy)
- Task 1) Identify Waterbody, Pollutants of Concern, Pollutant Sources, and Priority Ranking
- Task 2) Describe the Applicable Water Quality Standards and Numeric Water Quality Targets
- Task 3) Determine Load Capacity and Link Water Quality and Pollutant Sources
- Task 4) Calculate TMDLs and Allocate Loads to Sources
- Task 5) Allocate to Promote Watershed-Based Permitting and Trading and Prepare Reports
- Task 6) Recommendations Regarding Follow-up Monitoring/Effectiveness Monitoring
- Task 7) Prepare Implementation Plan

As part of the process of performing these tasks, several technical approach decisions will be made after data / model review and coordination with the cooperating agencies and TMDL stakeholders. These decision points are identified in the following tasks where stakeholder input is described. The process of making these decisions will be as follows:

1. The consultant team will review data and model information and develop options and recommendations for consideration.
2. The cooperating agencies will review, decide and approve a decision and direction for moving on to the next step or task.
3. Stakeholders will review decisions made by the cooperating agencies and will be able to provide comments and suggestions for cooperating agency consideration.

Each technical approach decision made will be documented as part of the TMDL development record and kept within the files maintained by the consulting team and cooperating agencies. The decisions will also be contained in TMDL development documentation made available to stakeholders.

Details on each task are provided below. Some preliminary work on these tasks—particularly with regard to background data gathering and approach development—has been performed and is discussed throughout this QAPP.

A6.1 Task 1 – Identify Water Body, Pollutants of Concern, Pollutant Sources, and Priority Ranking

Task 1 is to identify the impaired water bodies (Table 1), the pollutants of concern, the pollutant sources, and each water body's priority ranking. Priority ranking is a requirement of the 303(d) list and is determined by WDNR to account for the severity of the pollution and the designated use of the water body. The priority ranking has been set to 'high' for all of the waterbodies under consideration in the TMDL and the water bodies will have equal priority in developing the TMDL calculations. The consultant team will review available information to better understand the impairments, the causes of impairment, and review and consider any new data that have been collected since the listings were made. A summary of the information that was used by WDNR to make the draft 2010 303(d) impairment decisions will be provided as well as a summary of any new data that may have been collected after the assessment was completed. Summary plots and graphs of the flow, fecal coliform bacteria, phosphorus, sediment, and other relevant data to help identify the problem areas, assess trends, compare data to water quality standards, and assist in the source assessment process will be provided.

Available data will be used to characterize the estuary so that TMDLs can be put into context with estuary characteristics. The background section of the TMDL report will contain a summary of the following characteristics: soils, land use, geology, elevation, climate, and cultural characteristics. All of this information is already available from extensive previous work in the estuary, and the TMDL report will summarize the key points and include references to other documents. At the conclusion of this task, WDNR and USEPA will be consulted.

A6.2 Task 2 – Describe the Applicable Water Quality Standards and Numeric Water Quality Targets

This task is to develop numeric water quality targets for the impaired or threatened streams in the Milwaukee Harbor estuary. For fecal coliform, the Wisconsin numeric water quality standards for full recreational use, including variance standards that apply, will apply. A sensitivity analysis of the requirements to achieve full use where variances apply will be performed. The TMDL will assume other potential bacterial indicators will be impacted similarly to fecal coliform, and using work that has been performed in the region, very basic calculations will be applied to estimate their impacts. The Consultant team will comment on the relationship between fecal coliform and other pathogen parameters.

Work will be performed closely with WDNR during development of the TMDL to ensure the TMDL target is consistent with the new State numeric criteria for total phosphorus. The Consultant team will also work closely with WDNR to determine how sediment TMDLs will be calculated as there is no sediment standard. The team will define the details of how model output will be compared to the standards (e.g., how to convert hourly output to daily maximums and monthly geometric means). Consideration will also be given to the locations used to assess compliance with the standards, as this may eventually be important for determining reasonable load reductions and promoting flexible implementation activities, such as watershed-based permitting.

The Consultant team will also consider other parameters that can contribute to the nonsupport of designated aquatic life uses but for which TMDLs are traditionally not developed (e.g., biological and habitat indicators and flow alterations). The intention is to complement the traditional fecal coliform bacteria, phosphorus, and sediment TMDLs with more innovative targets that are based, for example, on imperviousness or flashiness flow indices. Specific recommendations for habitat improvements will also be included. The Consultant team will work with WDNR and USEPA to clearly identify how the TMDL will address the listed impairments, as well as how any additional recommendations also address designated uses.

A6.3 Task 3 – Determine Load Capacity and Link Water Quality and Pollutant Sources

This task is to identify and quantify fecal coliform bacteria, total phosphorus, and sediment loads from all of the potentially significant point and nonpoint sources within the Milwaukee Harbor estuary, specifically targeting the draft 303(d) listed streams. Information already exists on these topics from historic and recently completed studies of the estuary, including the detailed estuary modeling that has been calibrated, validated, and peer-reviewed by both USEPA and WDNR.

A6.3.1 Source Identification and Documentation

The team will identify and map all potentially significant sources at the scale of the entire Milwaukee Harbor estuary and at a sub-watershed scale. The Consultant will also coordinate with WDNR staff

(TMDL, permitting, etc.) and other state/local agencies to characterize the sources and provide a summary of each source in the TMDL document (e.g., location, type, history, water quality data, etc). Locations of the pollutant sources within the Milwaukee Harbor estuary will be documented in a technical memorandum. The technical memorandum will contain available metadata to identify the source of the location information, reporting conventions, and the geographic projection and datum used.

A6.3.2 Source Load Quantification

A detailed estuary model will be used that was set up and calibrated/validated for the Milwaukee Harbor estuary as part of the WQI. There is no need for additional calibration/validation of the model; however, the model may be revised to account for potential reductions in phosphorus loads associated with the strict limitations on phosphorus in non-agricultural fertilizer that took effect in 2010. For the TMDL analysis, the model will be executed for the same 1988 through 1997 period of record (under year 2020 land use and population conditions) as was simulated under the WQI. The model has been used by planners to evaluate the potential water quality benefits of a range of implementation measures, including facility improvements and urban, suburban, and rural stormwater best management practices (BMPs), and has also helped to determine that unknown sources, such as illicit discharges, are a very important source of bacteria within the estuary. The model has a very high degree of acceptance by local stakeholders and can therefore be used during TMDL development to quantify existing sources as well as the water quality benefits that will result from addressing them.

A6.3.3 Linkage Between Sources and Water Quality Targets

The linkage will be identified between sources and water quality targets. In addition to the modeling output, a weight of evidence approach will be used to assess the degree to which known sources are likely or unlikely to be contributing to the impairment. This weight of evidence analysis will be conducted and documented it in a "linkage analysis" section of the TMDL report.

A6.4 Task 4 – Calculate TMDLs and Allocate Loads to Sources

This task is to calculate the loading capacities (TMDLs) and to allocate the allowable loads to sources. Once the daily loading capacity of each water body is defined, it must be allocated to the appropriate sources. The "proportionality" approach will be considered and used based on year 2020 modeled pollutant loads from the various sources to derive load allocations. This method has been applied by WDNR for the Rock River TMDL and the preference is to be consistent across the State.

The bacteria TMDLs will be developed in terms of fecal coliform bacteria. *E. coli* is considered to be a better indicator of harmful pathogens whose presence would limit recreational uses in a waterbody and USEPA is recommending that states change their water quality standards to be in terms of *E. coli*. However, fecal coliform is the current regulatory indicator and a large amount of fecal coliform data has been collected throughout the TMDL study area. In addition, the RCA model has been calibrated for fecal coliform. The USEPA Region 5 staff has indicated that a TMDL for the inner harbor of the estuary must be developed for fecal coliform bacteria since it is the regulatory indicator, but that a more-limited analysis than full-scale modeling, such as the load duration approach, would be acceptable since the implementation plan can focus on control measures that are targeted toward pathogens. The load duration approach may be used to develop fecal coliform bacteria TMDLs and also to assist in developing load allocations for each of the pollutants to be considered. The Consultant team will evaluate the effort involved in applying the load duration curve approach to develop fecal coliform bacteria TMDLs versus

application of the RCA model and will consult collectively with MMSD, WDNR, USEPA, and SEWRPC before making a decision on the approach.

The water quality standard for bacteria in the outer harbor of the estuary is based on *E. coli* concentrations. To evaluate the concentrations resulting from the TMDL in the outer harbor, fecal coliform concentrations will be converted to *E. coli* concentrations using the translator to be developed by the Great Lakes WATER Institute.

The most significant fecal coliform bacteria, phosphorus, and sediment sources have largely already been estimated and summarized through the efforts of the WQI. The potential benefits of a wide array of point and nonpoint source controls also have been assessed. Task 4 will focus on extracting information from previously derived alternatives and performing analysis to assess the reductions needed to meet water quality standards. As has been done for the WQI, the results will be summarized in a variety of ways to provide information on how water quality standards are met, significance of sources, etc. to allow for stakeholder understanding and input. Consistent with USEPA requirements, seasonal variations in fecal coliform bacteria levels must be considered.

When determining allowable loads, the TMDL will consider an iterative approach that will take into account all available data from the WQI. Allowable loads will be calculated for the tributary rivers first and then input as boundary conditions in the estuary model to evaluate impacts. Adjustments to the allowable river loads may be necessary to equitably distribute required loading reductions. A series of TMDL compliance points, based on the "assessment point" locations used for the WQI, will be identified to evaluate allowable loads that result in the achievement of water quality standards. Many of the WQI assessment points correspond with the location of MMSD water quality sampling sites, but they do not necessarily correspond to those used through the Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) for listing and delisting use impairments. Preference will be given to compliance points that are located near the downstream end of each subwatershed to facilitate watershed-based permitting, water quality trading, etc. The most downstream compliance point in the TMDL study area will be at the breakwall opening between the outer harbor and Lake Michigan.

The Consultant team will repeat the model runs representing final load and wasteload allocations to evaluate possible climate change effects by applying downscaled precipitation and air temperature time series developed by the University of Wisconsin—Madison Center for Climate Research and provided by SEWRPC. Two scenarios, representing the best and worst cases, will be simulated. The results will be summarized in the same manner as the original model runs. These results will be evaluated in the context of the TMDLs derived from the non-climate change model. The intent of this analysis is only to evaluate the impact of climate change on meeting water quality standards with the final load and wasteload allocations determined previously. Allocations will not be adjusted in response to climate change.

The determination of a technically-sound and equitable TMDL allocation strategy may potentially require the consideration of numerous management practices, both individually and in combination. For each pollutant source, the Consultant will provide a summary of practices that are appropriate for the pollutants under consideration. The practices will be prioritized and organized according to subwatershed. Prioritization will be based on a cost/benefit approach where costs reflect capital and operational expenditures and benefits reflect the expected reductions in pollutant loadings. The June 2007 MMSD 2020 Facilities Plan State of the Art Report will be consulted in assessing pollutant removal efficiencies and costs of nonpoint source BMPs and point source controls. The District intends to use USEPA's recently released SUSTAIN model within the Milwaukee Harbor estuary (as part of a separate

effort from the TMDL) and the results from that analysis will be factored into the TMDL allocations and implementation recommendations.

Once the loading capacity of each water body is determined, allocation of that loading capacity to the various sources will be performed. Several possible allocation scenarios that result in meeting water quality standards may be identified. Therefore, prior to establishing a final allocation, a set of feasible scenarios will be developed, taking into account the level of control for each source or source category necessary to achieve water quality targets. The allocation analysis may be performed by following these tasks:

A6.4.1 Application of the Model to the 2020 TMDL Baseline with Point Sources at Permit Concentration Limits

The WQI models are representative of year 2020 population and land use conditions and include the effect of full implementation of Wisconsin Administrative Code Chapter NR 151 urban stormwater controls, and a level of implementation of NR 151 agricultural controls that would be expected based on current levels of cost-share funding for such measures. The models will be adjusted to reflect potential phosphorous reductions due to the 2010 state law.

Concentrations and effluent flow rates for permitted point sources will be set equal to permit limits, with concentration capped at 1 mg/L per NR 217. Observed flow and effluent concentration can be used for point sources that do not have specified permit limits for a given pollutant. This use of observed versus permitted data will be evaluated to verify that there are no unintended consequences when loads are allocated or in the future when a permit is issued for that pollutant. Observed flow and concentrations for these discharges will be compiled from Discharge Monitoring Reports or other available information. Baseline flow and concentration assumptions will be developed with WDNR based on this data. Monthly flow and concentration data is preferred, but all available data from the last five years in WDNR databases will be considered. If data is not available for a given discharger, values will be determined through discussions with WDNR and based on limits for similar facilities. A lack of TP data is unlikely given that WDNR has had all known dischargers conduct monitoring for TP.

A6.4.2 Develop and Test Allocation Scenarios

Once the model has been updated to account for permitted point source loads and phosphorous adjustments, the Consultant team will develop and apply sample allocation scenarios by taking into account the most significant sources under year 2020 conditions and utilizing the “proportionality” approach. If an alternative approach is preferred, justification will be provided and WDNR approval obtained. The results of each scenario will be compared with the applicable water quality standard at a set of pre-identified compliance locations. The scenarios will be adjusted until water quality standards are met and the resulting loading capacity will be used to establish allocations. The significant information available on the associated costs for point and nonpoint source controls to evaluate the various loading scenarios based on cost and efficiency will be utilized. In some cases, there may be cost thresholds that define significant increases in management costs to reach various load reduction scenarios and those thresholds will be considered in the load allocation scenarios.

Ultimately, attainment of water quality targets will be dependent upon whether the required reductions are achieved to meet the allocations for each source. Required by the Clean Water Act, reasonable assurances provide a level of confidence that the allocations in TMDLs can be achieved. Wisconsin regulations establish management strategies for both point and nonpoint sources of pollution. As

described in Section A6.7, an implementation plan will lay out the steps necessary to achieve the loading reductions determined during TMDL development.

A6.4.3 Select Final TMDL Scenario

The stakeholders will participate in selecting the final TMDL scenario, which will then be used to prepare the TMDL report. WDNR and MMSD will make the final determination as to the selected TMDL scenario. The Consultant team will derive the necessary TMDL components (e.g., load allocations for nonpoint sources, wasteload allocations (WLAs) for point sources, and margin of safety) in accordance with current USEPA approval requirements and the final scenario model input and output files will be saved for the administrative record.

Some elements unique to TMDL development on the Milwaukee harbor estuary include:

- Interaction with Upstream Watersheds – loads and flows from upstream watersheds will influence the loading capacities of the reaches that make up the Milwaukee Harbor estuary. Iteration of the loading capacity calculations between the watersheds and the estuary may be necessary.
- Characterization of Lacustrine Environment – the outer harbor area of the estuary acts more like a lake than a riverine environment with turbulent mixing and dispersion in the lateral, longitudinal, and vertical directions. Compliance points will be selected to define where modeled concentrations will be assessed. In addition, the complex movement of water and pollutants in the outer harbor cannot be simply represented with a completely mixed reach where the loading capacity is defined by a single streamflow. Instead, simulated hydrodynamic data within the outer harbor area will be coupled with compliance targets to define the loading capacity calculations.
- High Percentage of Pollutant Load From Point Sources – WWTF and industrial discharges, CSOs/SSOs, and other point sources account for high percentages of the pollutant loads. These more urban characteristics will be used to determine the TMDL allocations unique to the estuary and drive implementation plan recommendations.

A6.5 Task 5 – Allocate to Promote Watershed-Based Permitting and Trading and Prepare Reports

The consultant team will submit an outline of the TMDL report for review and comment by WDNR and USEPA at an early stage. This will allow for more efficient report review and approval later. The consultant team will identify WLAs for facilities with individual WPDES permits as well as for MS4s in aggregate that are regulated under Phase II of USEPA's stormwater program. WLAs will also be identified for industrial stormwater permittees. Various options are available for grouping the stormwater loads under the WLA system and will be considered, consistent with recent USEPA guidance published in the draft TMDLs to Stormwater Permits Handbook.

The consultant team will evaluate the potential for implementing the TMDL through a water quality trading program taking into account USEPA regulatory developments, such as the "Water Quality Trading Toolkit for Permit Writers."

The consultant team will work with the appropriate stakeholders to include a margin of safety, either implicitly or explicitly, which accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body.

The final TMDL scenario and allocations will include full implementation of the MMSD's 2020 Facilities Plan and the Combined Sewer Overflow Long Term Control Plan. The impacts resulting from possible revisions to NR 151 Runoff Management will be considered and recommendations made for the needed reductions in TSS discharges in the estuary based upon the modeling analysis. Cost effectiveness of various actions and technologies will be considered as this effort is undertaken. A "knee of the curve" approach can be taken that identifies where significant increases in the cost of controls do not result in similar increases in water quality improvement. This may help in determining not only where and how controls should be implemented but also whether water quality standards can be reasonably achieved given water quality conditions in the estuary.

At the completion of this task, all of the previous analyses will be summarized and documented in a draft TMDL report to be submitted to WDNR and USEPA. The report will include appropriate background information (including descriptions of the TMDL targets selection, source identification and characterization, technical analysis of source loadings and water quality response, all legally required elements of a TMDL) and administrative records to facilitate USEPA review and approval as well as achieve public understanding.

After receipt of comments, the Consultant team will revise the report to address those comments and submit a final report.

A6.6 Task 6 – Recommendations Regarding Follow-up Monitoring/Effectiveness Monitoring

The consultant team will identify any data gaps in the Milwaukee Harbor estuary TMDL process and provide recommendations for filling those gaps during implementation. This step will build on the results from Task 2, and will provide a rationale for all data gaps and follow up monitoring, including the data's purpose, expectations for use, and timeframes.

The TMDL will also include recommendations that it be evaluated five years after its completion. At that time, a formal review will use available water quality and habitat data for each pollutant (and/or the measures that best represent interpretations of the water quality and habitat conditions existing at that time) to assess overall progress toward meeting water quality restoration goals. This effort will develop recommendations that may include a combination of water quality and biological monitoring and habitat assessment aimed at determining the effectiveness of restoration activities. Recommended data trends to be tracked (at a minimum) may include the following:

- Fecal coliform and other bacteria water quality data
- Fish and aquatic life conditions
- Phosphorus water quality data
- Sediment data

A6.7 Task 7 – Prepare Implementation Plan

An implementation plan will be developed to meet the load reductions specified in the TMDL. The implementation plan will lay out the steps necessary to implement the controls identified during TMDL development. Because stormwater runoff is episodic, and making assignment of specific effluent limits is impractical, the implementation plan will specify sets of stormwater BMPs, which may vary according to pollutant load source that could be applied to meet the TMDL load allocation for each nonpoint source. Those BMPs should recognize, and build from, the set of pollution controls recommended under the 2007

SEWRPC regional water quality management plan for the greater Milwaukee watersheds, the 2007 MMSD 2020 facilities plan, and the 2010 Menomonee and Kinnickinnic River watershed restoration plans.

A6.8 Schedule

Figure 6 presents a project schedule.

Task	Month																											
	2011						2012												2013									
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0. Prepare Quality Assurance Project Plan (QAPP)			◇																									
1. Identify Waterbody, Pollutants of Concern, Pollutant Sources, and Priority Ranking				◇																								
2. Describe the Applicable Water Quality Standards and Numeric Water Quality Targets						◇																						
3. Link Water Quality and Pollutant Sources								◇																				
4. Calculate Loading Capacities (TMDLs)											◇																	
5. Allocate to Promote Watershed-Based Permitting and Trading and Prepare Final TMDL Report																												
Draft Report to WDNR															◇													
Final Report to WDNR																		◇										
6. Make Recommendations Regarding Follow-up Monitoring/Effectiveness Monitoring																		◇										
7. Prepare Implementation Plan																												◇

◇ Deliverable/Schedule Check Point

Figure 6. Project Schedule

A7. Quality Objectives and Criteria for Model Inputs/ Outputs

A7.1 Database Inputs

All input data will either be provided by one of the cooperating agencies or developed through discussions with the TMDL development team. As such, the input data to the models inherently meets the quality objectives for use in the TMDL as it must be acceptable to the cooperating agencies. In addition, input data will be presented and discussed at stakeholder workshops and the data will be adjusted if necessary.

As discussed previously, a database will be constructed to calculate loading capacities for each reach and allocate the allowable loads to the various sources in the area tributary to the estuary. The database queries will account for the interconnected network of reaches for which TMDLs will be defined. These reaches will align with the extents of the 303(d)-listed segments. In addition, the queries will be driven by a set of compliance criteria that will be driven by the water quality standards. These compliance criteria will be determined through discussions with the cooperating agencies and stakeholders. The main data inputs to the database will be hydrodynamic simulation data for the period of 1988 through 1997, and baseline loads.

A7.1.1 Hydrodynamic Simulation Data

Hydrodynamic simulation data from ECOM will be used in defining the allowable loads of the Milwaukee Harbor estuary. The complex movement of water and pollutants cannot be simply represented with a completely mixed reach where the loading capacity is defined by a single streamflow. Instead, simulated hydrodynamic data within the outer harbor area will be coupled with compliance targets to define the loading capacity calculations. The performance of the ECOM model was assessed during model calibration and validation. For both calibration and validation, model results were compared to measured data using both graphical and statistical means. The hydrodynamic model was found to reasonably reproduce overall water circulation and mixing characteristics.

A7.1.2 Baseline Loads

Baseline loads will also be input to the database for use in allocating the allowable loads to sources. The loading data will be derived from the WQI models, permit information, and per-acre loading rates applied to MS4 and non-permitted urban areas. The representation of baseline conditions will be discussed with the cooperating agencies and the resulting baseline loads will be reviewed with the stakeholders to check for completeness. A completeness objective of greater than 90 percent of the sources in the watershed will be used for the baseline loads. A reserve capacity, which would account for unknown sources, may be included as part of the TMDL.

Potential baseline loads include the following:

- Agricultural and natural ("background") areas: Loads by sub-basin from WQI simulations
- Non-permitted urban areas: Per-acre loading rates from WQI simulations
- General permits: Portion of the urban loads in the sub-basin
- MS4s: Per-acre loading rates from WQI simulations, adjusted to represent compliance with the TSS reduction target in NR 216
- Wastewater treatment facilities: Concentrations and effluent volumes set equal to permit limits, with concentration capped at 1 mg/L per NR 217; average measured values used for industrial dischargers with no specified permit limits

- Concentrated Animal Feeding Operation (CAFO) discharges: Set as zero to represent compliance with permit requirements
- CAFO land spreading operations: Accounted for in agricultural/natural area WQI model loads

A7.2 Database Outputs

Outputs from the database will include loading capacities for each reach and allocated loads for each source category.

A7.2.1 Loading Capacities

The loading capacity of each reach for each pollutant will be calculated on a monthly basis to account for seasonal variation in flow and the assimilative capacity of the water body. Because weather has a random characteristic, streamflows do not follow a smooth typical pattern. To cancel out some of the statistical "noise" in the data, the loading capacity for each reach will be calculated as a three-month moving average of a set of initial calculated loading capacities. For example, the June loading capacity will be the average of the initial May, June, and July loading capacities. This proposed approach is consistent with the approach used for other TMDLs in Wisconsin. The approach for calculating the loading capacity of the outer harbor area will be determined based on hydrodynamic data from ECOM.

A7.2.2 Allocated Loads

The allowable loads for each reach will be divided up into allocations for MS4s, other point sources, and nonpoint sources. Before allocating loads to these "controllable" sources, a natural "background" load (if quantifiable) will be subtracted from the total allowable load. The background load will likely be derived from the WQI model output.

The fraction of the allowable load that is allocated to each source will be equal to its average fraction of the baseline load. These fractions will be smoothed using the method described above. This method assigns responsibility for attaining water quality targets in proportion to each source's current contribution to the excess load.

The nonpoint source allocation will be split between background, non-permitted urban, and agricultural loads. The wasteload allocation to sources covered by general permits will be set as the baseline load from these sources. The remaining wasteload allocation will then be divided among individually permitted sources according to their proportional contribution to the baseline load. CAFOs will be assigned a wasteload allocation of zero to represent permit compliance.

A7.3 Resulting Instream Concentrations

The ECOM/RCA model will also be used to calculate instream concentrations to validate that the allowable loads meet the selected compliance criteria. Areas that do not appear to react to the decreased loads as expected will be evaluated further if necessary. Fecal coliform concentrations in the outer harbor will be converted to *E. coli* concentrations using the translator developed by the Great Lakes WATER Institute so that they can be evaluated with respect to the applicable water quality standard. The translator will only be used if its error is less than the difference between the fecal coliform and *E. coli* water quality standards.

A7.4 Implementation Plan

After TMDL development is complete, the development team will produce a TMDL Implementation Plan based upon the results of TMDL development, stakeholder input and review, and other available information sources. It will include and be guided by the data objectives set for TMDL development. The implementation plan will include a list of potential BMPs and other techniques that may be used to achieve the loading allocations. The TMDL results will also guide where implementation measures should be focused and the extent or magnitude of implementation measures needed. A recent analysis of green infrastructure that MMSD conducted using SUSTAIN modeling will provide BMP performance data. Other performance data sources identified as acceptable by the development team will also be used. The performance and implementation information from the SUSTAIN analysis, other acceptable sources, and stakeholder knowledge of the feasibility of various measures will be used to develop the implementation plan. The plan will receive at least two reviews by stakeholder workshop participants for data and information acceptance.

A8. Special Training Requirements/Certification

No special training or certifications will be required for this project.

A9. Documentation and Records

All documentation, including the QAPP, meeting notes, technical memoranda, and reports will be prepared by CDM Smith and kept electronically on CDM Smith servers that are backed up daily. Paper files will be housed in CDM Smith's Milwaukee office and kept in accordance with CDM Smith's internal Quality Management System. CDM Smith will be responsible for document distribution to the cooperating agencies.

The following documents are anticipated to be produced during the project:

- Project kickoff meeting notes
- QAPP
- Progress meeting notes
- Stakeholder workshop notes
- Public informational meeting notes
- GIS mapping and databases
- Calculation spreadsheets and databases
- Model input/output files
- Technical memoranda for each task described in Section A6
- Draft TMDL document
- Public hearing notes
- Response to stakeholder comments on draft TMDL document
- Final TMDL document
- Draft Implementation Plan
- Response to stakeholder comments on draft Implementation Plan
- Final Implementation Plan

At the completion of the project, digital media (CDs, DVDs, and/or external hard drives) containing the final project files will be delivered with the final TMDL report to USEPA, WDNR, and MMSD. The final project files will be kept at the USEPA Region 5 office for a period of 10 years.

Section B – Measurement and Data Acquisition

B7. Calibration

The Milwaukee Harbor estuary ECOM/RCA model was calibrated and validated as part of the WQI. The hydrodynamic portions of the model were calibrated first since the simulation of pollutant transport mechanisms is based on accurate simulation of hydrodynamic processes.

The calibration period of the hydrodynamic model 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. The model validation period was 1999 through 2002. For both calibration and validation, model results were compared to measured data using both graphical and statistical means. Graphical 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 (RMSE) 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 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. A “weight of evidence approach” was used where no one absolute criterion was used to determine model acceptance or rejection.

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 system.

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

B9. Non-Direct Measurements (Data Acquisition Requirements)

All data will be housed at the CDM Smith office. Electronic files will be stored on a server and backed up daily.

The vast majority of the data will be provided by the cooperating agencies. As such, it is assumed that the data has been reviewed by the agency and complies with the agency's standard operating procedures and quality assurance protocols. Technical memoranda will be prepared at the conclusion of each major task that will include a summary of collected data. These technical memoranda will be reviewed by the cooperating agencies to ensure that the data is being used in the TMDL development as intended. Table 2 summarizes the types of data collected, data sources, and intended uses in the TMDL development.

Table 2. Data To Be Used in TMDL Development

Description	Type	Source	General Use
Watershed Boundaries	GIS	SEWRPC	Background Information and Mapping
WQI Model Files and Documentation	Input/Output Files Documents	SEWRPC	Allowable Load Calculations and Verification
WQI Model Subbasins	GIS	SEWRPC	Model Reach Delineation and Mapping
Year 2020 Land Use Data	GIS	SEWRPC	Background Information and Mapping
Hydrography	GIS	WDNR	Background Information and Mapping
Municipal Civil Divisions (through 2011)	GIS	WDNR	Background Information and Mapping
Draft 2012 303(d) List	Spreadsheet/GIS	WDNR	Establishing TMDL Reaches and Mapping
List of Permitted MS4 Areas (through 2011)	Spreadsheet/GIS	WDNR	Establishing Baseline Loads for MS4s and Mapping
List of Permitted Point Source Dischargers (through 2011)	Spreadsheet/GIS	WDNR	Point Source Identification and Mapping
List of General Permit Holders (through 2011)	Spreadsheet	WDNR	Point Source Identification
Municipal WWTP Permits (through 2011)	Documents	WDNR	Establishing Baseline Loads for WWTPs
Discharge Monitoring Reports (2006 – 2011)	Documents	WDNR	Establishing Baseline Loads for Dischargers with No Specified Permit Limits
Combined Sewer Area Extents	GIS	MMSD	Background Information and Mapping
CSO/SSO Locations (through 2011)	GIS	MMSD	Point Source Identification and Mapping
Precipitation and Air Temperature Timeseries	Input Files	SEWRPC	Evaluation of Climate Change Effects on Post-TMDL Water Quality
Green Infrastructure Analysis (SUSTAIN Modeling) Documentation	Document	MMSD	Implementation Plan Development

Data that will not come from a cooperating agency includes bacteria data collected and analyzed by the McLellan Laboratory at the Great Lakes WATER Institute for use in developing the fecal coliform to *E. coli* translator discussed in Section A5.6.1. The scientists at the McLellan Laboratory are recognized by the

cooperating agencies as experts on pathogens in the environment and have documented procedures for data collection and processing.

B10. Data Management and Hardware/Software Configuration

As discussed in Section A5.6, a Microsoft Access (Version 2007) database will be designed to store and analyze data for two main calculations: 1) calculation of the loading capacities for each reach and pollutant, and 2) allocation of the allowable loads to the various sources that contribute load to each reach. One database will be developed to perform calculations for the three river watersheds and the estuary to ensure consistency and so that connections between the river reaches and the estuary are maintained.

Input data will be maintained in tables within the database and queries will be coded to perform the calculations on the data. Outputs from the calculations will also be stored in tables within the database and can be exported to Microsoft Excel for input into TMDL document tables. Input data will include, at a minimum:

- Reach information:
    - Water body name and extents
    - Associated water quality targets
    - Tributary MS4 areas
    - Tributary non-permitted urban areas
- Reach connectivity
- MS4 areas by municipality
- MS4 and non-permitted urban loading rates per month
- Baseline WWTP flows and loads by discharger
- Baseline nonpoint source loads and flows per month by reach
- Natural background loads per month by reach
- General permit loads per month by reach

After the database is developed, input data attributes and the relationships between database tables will be documented in an appendix to this QAPP.

Section C – Assessments and Oversight

C1. Assessment and Response Actions

As existing models will be used for this TMDL development, the primary hardware / software tools that will be used by the consulting team will be Microsoft Access database and Excel spreadsheet tools, and GIS tools. Assessment and oversight of the work performed using the existing models and developed tools will be performed by independent reviewers identified in QAQC roles in the project organization chart. These reviewers will perform independent calculation checks and database pathway checks to ensure the calculations and results generated from using the tools have been performed correctly. Calculations and analysis performed by the consulting team subconsultants will be checked by the prime consultant (CDM Smith) using the same identified QAQC reviewers and CDM Smith task leaders.

The scope of work for the TMDL development includes schedule check-in points after every major task. While bi-weekly technical approach conference calls will be held throughout the TMDL development, review at these check-in milestones will consist of an overall review of the entire task. In particular, the coordinating agencies will review technical memoranda that are prepared by the consultant team to verify the direction of the TMDL development before moving on to the next task. The technical memoranda will be attached as amendments to this QAPP. Task milestone and review points include:

- Task 0) Prepare Quality Assurance Project Plan (QAPP)
- Task 1) Identify Waterbody, Pollutants of Concern, Pollutant Sources, and Priority Ranking
- Task 2) Describe the Applicable Water Quality Standards and Numeric Water Quality Targets
- Task 3) Determine Load Capacity and Link Water Quality and Pollutant Sources
- Task 4) Calculate TMDLs and Allocate Loads to Sources
- Task 5) Allocate to Promote Watershed-Based Permitting and Trading and Prepare Reports
- Task 6) Recommendations Regarding Follow-up Monitoring/Effectiveness Monitoring
- Task 7) Prepare Implementation Plan

In addition, stakeholder workshops will be held at various milestones throughout the project. At these workshops, stakeholders will be asked to review and comment on waterbody information, input data, and assumptions used in the TMDL calculations. This feedback will be used to check assumptions and identify errors.

C2. Reports to Management

Project status reports will be sent from the consultant team to MMSD approximately monthly. Status reports will include a summary of completed and planned activities, schedule/budget concerns and proposed corrective actions, cash flow information, and a list of completed deliverables.

Issues identified by TMDL development team members or other stakeholder input requiring corrective action will be presented to the TMDL development team for discussion and resolution within the TMDL development process. Corrective actions will be implemented within the process and results will be documented in technical memoranda and/or the draft TMDL development report as appropriate.

As part of GLRI grant reporting requirements, MMSD will submit various reports to USEPA throughout the TMDL development process, as outlined in Table 3.

Table 3.MMSD Reporting Requirements to USEPA

Report	Sent To	Responsible MMSD Staff	Due Date
Interim Annual Federal Financial Report (SF-425)	Las Vegas Finance Center	Robert Schermeister Auditing & Loan Administrator	90 Days After End of 3rd Quarter
Single Audit Annual Report and Copy of the SF-SAC	Federal Audit Clearinghouse	Robert Schermeister Auditing & Loan Administrator	9 Months After End of a Fiscal Year
Form 5700-52A "MBE/WBE Utilization under Federal Grants, Cooperative Agreements and Interagency Agreements"	Adrianne M. Callahan Region 5 MBE/WBE Coordinator	José Galvan S/W/MBE Coordinator	By April 30 and October 30
Great Lakes Accountability System (GLAS) Report	Daniel Samardzich EPA Project Officer	Steve Heinz Senior Project Manager	15 Days After End of a Quarter
Semi-Annual Project Report	Daniel Samardzich EPA Project Officer	Steve Heinz Senior Project Manager	By April 30 and October 30

Section D – Data Validation and Usability

D1. Departures from Validation Criteria

See Section D2 below.

D2. Validation Methods

All input data will either be provided by one of the cooperating agencies or developed through discussions with the TMDL development team. As such, the input data to the models inherently meets the quality objectives for use in the TMDL as it must be acceptable to the cooperating agencies.

As discussed in Sections A7 and B7, the validity of the ECOM/RCA model is assessed by comparing model predictions to observed data through graphical and statistical methods. The results of calibration and validation indicated acceptable agreement with observed data, and estimated loads. While some validation of model results will be necessary, these performance measures generally indicate that the model is adequate for use in modeling hydrodynamic processes to estimate loading capacities.

The database that will be created to calculate the loading capacities and allocate the allowable loads to sources will be independently reviewed by an experienced technical specialist. The specialist will go through each database query and reproduce calculations outside of the database to verify the results. The database structure has multiple benefits: 1) the raw input data is not modified and can be easily checked, and 2) the database queries serve as a comprehensive, permanent record of the calculations performed in the analysis.

Finally, the allowable loads will be input into the ECOM/RCA model and the model will be run for the period of 1988 through 1997 to calculate the resulting instream concentrations. These concentrations will be used to verify that the target concentrations are in fact met. Fecal coliform concentrations in the outer harbor will be converted to *E. coli* concentrations using the translator to be developed by the Great Lakes WATER Institute so that they can be evaluated with respect to the applicable water quality standard.

D3. Reconciliation With User Requirements

The resulting load and wasteload allocations will be presented in a TMDL document. The document will be composed of text sections describing the TMDL development approach and results, with a series of tables tailored to provide the numerical results for stakeholder review and WDNR use in permit development. To meet USEPA requirements, all allocations will be presented on a daily basis for each reach and each pollutant. In addition, baseline loads will be presented. Wasteload allocations for WWTPs and MS4s will be presented on both a daily and monthly basis by individual discharger.

References

Robinson, J. S., A. N. Sharpley, and S. J. Smith. 1992. Estimating bioavailable phosphorus loss in agricultural runoff: Method development and application. In Proceedings of the Water Environment Federation 65th Annual Conference and Exposition, September 20-24, 1992. New Orleans, LA, pp. 375-385.

Southeastern Wisconsin Regional Planning Commission. 2007. Technical Report No. 39, Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds. November 2007.

Southeastern Wisconsin Regional Planning Commission. 2007. Planning Report No. 50, A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds. December 2007.

HydroQual. 2007. Estuary Model Hydrodynamic Calibration/Validation, MMSD 2020 Facility Planning Project Memorandum from A. Thuman and H. Li to R. Printz, M. Hahn, and W. Krill. September 25, 2007.

HydroQual. 2007. Estuary Model Water Quality Calibration/Validation, MMSD 2020 Facility Planning Project Memorandum from A. Thuman and C. Mancilla to R. Printz, M. Hahn, and W. Krill. December 3, 2007.

United States Environmental Protection Agency, Office of Wetlands, Oceans & Watersheds. 2007. Options for Expressing Daily Loads in TMDLs (Draft). June 22, 2007.

APPENDIX A

Memorandum of Understanding Between the Milwaukee Metropolitan Sewerage District (District), the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and the Wisconsin Department of Natural Resources (DNR) for cooperation in the watershed approach to water quality and facilities planning.

Whereas, the Wisconsin Department of Natural Resources (DNR), the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and the Milwaukee Metropolitan Sewerage District (DISTRICT) share related organizational missions to cost-effectively protect public health and the environment, prevent pollution and enhance the quality of the area's waterways; and

Whereas the DNR, SEWRPC and the DISTRICT currently face water resource and environmental challenges of sewage overflows, flooding, polluted runoff and documented risk of waterborne disease,

Now, therefore, the DNR, SEWRPC and the DISTRICT agree to cooperatively evaluate the causes and magnitude of the water resources challenges and to evaluate alternatives directed toward identification of the most cost effective means of achieving water quality standards and criteria as well as other goals for the water resources, all within the context of comprehensive watershed planning. In this context, cost refers to the total cost including short term and long term monetary, social and environmental cost factors and effectiveness refers to measures of water resource objective achievement as well as to achievement of refined regulatory requirements.

The DNR, SEWRPC, and the DISTRICT further agree to use an inclusive, open and science based approach to evaluate the cost effectiveness and feasibility of the alternatives distinct from the responsibility for their implementation in order to identify the alternative that offers the greatest improvement in the water resource at the least total cost to society.

The DNR, SEWRPC and the DISTRICT further agree that the implementation responsibility for new policies, operational improvements, facilities and programs identified during the collaborative planning process will be assigned only after the cost effective alternative is defined.

The DNR, SEWRPC, and the DISTRICT, further agree to respect each other's traditional roles and authorities with respect to the overall water resource planning. The DNR has the primary responsibility for setting water quality standards and criteria, as well as the regulatory authority for implementing the Clean Water Act within the State of Wisconsin. The SEWRPC has the primary responsibility and authority for areawide water quality management planning consistent with areawide land use planning. The DISTRICT has the primary responsibility and authority for research, recommendation, and ultimate funding and implementation of cost effective sewerage and flood management facilities and programs within the DISTRICT planning area.

The DNR, SEWRPC, and the DISTRICT further agree to consider, negotiate, and potentially approve distinct agreements that allocate specific funding or analysis responsibilities for specific tasks necessary for completion of the cooperative planning.

These specific tasks include, but are not limited to, implementation of citizen involvement activities, definition of committed future conditions irrespective of this planning effort, development of water quality evaluation tools, and fiscal support arrangements.

The DNR, SEWRPC, and the DISTRICT further agree to conduct the necessary planning work in two separate, but coordinated and cooperative, planning programs as summarized below. These two planning programs would be coordinated for certain work elements, while certain other work elements may be jointly carried out. The overall concepts of the two parallel planning programs and the agency involvement are generally as follows:

- One planning effort is the preparation of an update to the regional water quality management plan for the watershed areas involved, including the Milwaukee Harbor estuary and the nearshore Lake Michigan area. SEWRPC will be the lead agency in that planning program, to be conducted under the framework of the ongoing cooperative SEWRPC-DNR continuing water quality planning program. The water quality evaluation tools developed will be designed to be used by SEWRPC, the DISTRICT and DNR in the regional water quality management plan updating and in the other related studies. This planning program will develop and evaluate alternative means of achieving water use objectives, including meeting water quality standards and criteria, for the surface waters. It will recommend a control strategy, including levels of control for point, nonpoint and other pollution sources located throughout the watersheds involved. This planning program will be coordinated with the DISTRICT facility planning and DNR work efforts.

- The second planning program will involve facility planning for the Milwaukee Metropolitan Sewerage District sewerage systems, including watercourse floodland management facilities. The DISTRICT will be the lead agency in that facilities planning program. This program will include all analyses and evaluations needed to determine the recommended means of achieving the sewerage related public water resources objectives and consistent with the aforedescribed regional water quality management plan. These objectives are expected to include complying with the Wisconsin Pollutant Discharge Elimination System permit criteria, the Wisconsin Combined Sewer Overflow Policy, and the evolving sanitary sewer overflow policy.

- The DNR will be directly involved in the review and approval of the scope of the final plan for both planning programs. The DNR will also be directly involved in the analytical tools and plan development in a stepwise review function.

- The DNR, SEWRPC and the DISTRICT will jointly develop citizen involvement programs, databases and an analytical base to support completing both planning programs in full compliance with the current permit and court stipulations as well as the emerging U.S. EPA policies regarding watershed approach, Total Maximum Daily Load (TMDL), and use attainability analyses (if required). DNR, SEWRPC and the DISTRICT recognize that the citizen involvement effort required for this joint effort is very extensive.

Recognizing the complexity of the watershed water quality management and facilities planning efforts, the regulatory time restraints and extensive fiscal commitment required, the DNR, SEWRPC and the DISTRICT agree to develop and commit to a schedule that completes the efforts and the plans within the most restrictive time frame applicable. The DISTRICT agrees to negotiate additional interagency agreements as necessary to provide funding for timely and efficient development of the required databases and planning tools.

The DNR, SEWRPC and the District further agree to form an oversight committee charged with implementation of this MOU. The committee will consist of two members of each agency, appointed by that agency. The three agencies agree that a workplan will be established for the implementation of the MOU and submitted to the oversight committee for approval. The workplan shall be reviewed on an annual basis. Disputes regarding the workplan or within technical committees charged with developing work products to implement this MOU, shall be negotiated by the oversight committee

This agreement will be retired after approval of the 2020 Facility Plan for the Milwaukee Metropolitan Sewerage District.

Memorandum of Understanding Between the Milwaukee Metropolitan Sewerage District (District), the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and the Wisconsin Department of Natural Resources (DNR) for cooperation in the watershed approach to water quality and facilities planning.

Kevin L Shafer 2/11/03
Date

Kevin L. Shafer, P.E.
Executive Director
Milwaukee Metropolitan Sewerage District

1/23/03
Date

Thomas H. Buestrin
Commission Chairman
Southeastern Wisconsin Regional Planning Commission

Philip C. Evenson 1/23/03
Date

Philip C. Evenson
Commission Deputy Secretary
Southeastern Wisconsin Regional Planning Commission

Scott Hassett 2/19/03
Date

Scott Hassett
Secretary
Wisconsin Department of Natural Resources

APPENDIX B

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Matthew J. Frank, Secretary

101 S. Webster St.
Box 7921
Madison, Wisconsin 53707-7921
Telephone 608-266-2621
FAX 608-267-3579
TTY Access via relay - 711

December 26, 2007

Project Number: S-2007-0538

Kevin Shafer, Executive Director
Milwaukee Metropolitan Sewerage District
260 West Seeboth Street
Milwaukee, WI 53204 1446

Subject: Approval of Milwaukee Metropolitan Sewerage District
2020 Facilities Plan

Dear Mr. Shafer:

The Department of Natural Resources has completed the review of your 2020 Facilities Plan. We concur with the selected alternative that includes: the addition of 150 million gallons per day of physical-chemical treatment capacity at the South Shore Wastewater Treatment Plant; increased pumping capacity from the Inline Pump Station to the Jones Island Wastewater Treatment Plant; 9 Metropolitan Interceptor Sewer (MIS) projects to improve hydraulic constraints; construction of a new MIS in the Franklin, Muskego, New Berlin area; various other recommendations to improve water quality and operation of the Milwaukee Metropolitan Sewerage District's (MMSD) sewerage facilities.

The facilities plan recommends that MMSD follow an "adaptive implementation schedule" as discussed in Chapter 11 of the facilities plan. Many of the capital improvements identified in the 2020 Facilities Plan are based on population growth assumptions that may not be realized within the planning period. In addition, many of the proposed improvements are interrelated and may need to be amended dependent on the additional on-going or planned analyses. Therefore, the use of an adaptive implementation schedule is appropriate. Condition number 4 below will allow the Department to monitor the progress of the 2020 Facilities Plan implementation and this reporting requirement will be proposed for incorporation into the reissued MMSD WPDES discharge permit. Approval of the 2020 Facilities Plan also constitutes the Department's approval of the MMSD combined sewer overflow Long Term Control Plan.

The 2020 Facilities Plan is hereby approved subject to the following conditions:

1. That approval of the MMSD 2020 Facilities Plan does not authorize the discharge of untreated wastewater from the MMSD sewerage system. As required by your WPDES permit any unscheduled bypass or overflow of wastewater at the treatment works or from the collection system is prohibited.

2. That the Department reserves the right to require additional improvements to further reduce the risk of combined or sanitary sewer overflows based on the actual performance of the MMSD sewerage system, technological advances or changes in state or federal regulations.

3. That by June 30, 2008 MMSD will provide a report to the Department that prioritizes the 9 MIS capacity improvements identified in Table 10-3 item 6 of the 2020 Facilities Plan report based on the risk that hydraulic constraints will cause sanitary sewer overflows. This report will be updated annually as part of the report required by condition number 4 below.

4. That by June 30, 2008, and annually thereafter, MMSD shall submit for approval by the Department a report updating the status of the "adaptive management implementation plan" and providing a schedule for evaluation, design and construction of capital improvements recommended in the 2020 Facilities Plan. This requirement will be proposed as a condition of the reissued MMSD WPDES permit.

5. That MMSD continue its efforts to develop and implement a flow monitoring system plan, a rain gauge system plan, and peak flow performance standards in accordance with the reissued MMSD WPDES permit or a court-approved stipulation in settlement of *State of Wisconsin v. Milwaukee Metropolitan Sewerage District, et al.*, Milwaukee County Circuit Court Case No. 2005-CX-13

6. That approval of this facility plan does not constitute approval of modeling assumptions or water quality goals not promulgated in any Wisconsin State Statute or Wisconsin Administrative Code

7. That MMSD continue its program to reduce runoff in the combined sewer system using the concept of "opportunistic sewer separation."

8. That MMSD submit for approval by the Department a report evaluating the feasibility of an operational strategy to maximize the control of combined sewer overflows at South Shore Park in accordance with the requirements of the MMSD WPDES permit.

9. That in the design of the two major treatment plant capital improvement projects recommended by the 2020 Plan, (a. the additional pumping capacity from the Inline Storage System, and, b. the additional treatment capacity at the South Shore Wastewater Treatment Plant) MMSD maximize the utilization of the overall conveyance, storage and treatment capacity of its sewerage system.

10. That in the design of all interceptor sewer improvements MMSD evaluate alternatives that reduce the risk of sanitary sewer overflows beyond the overall 5-year recurrence design goal.

11. That MMSD continue monitoring flows in the sewerage system serving Whitefish Bay and by September 30, 2012 submit a report to the Department evaluating whether there are hydraulic constraints associated with the MIS during wet weather conditions.

12. That the Department reserves the right to require additional monitoring to evaluate the risk of combined sewer overflows causing or contributing to an exceedance of state or federal water quality standards.

13. That the Department reserves the right to require additional system analyses and improvement should the Department determine that "sensitive areas" as described in the 1994 CSO Control Policy have not been fully evaluated consistent with the policy or if the Department identifies additional potential sensitive areas.

14. That approval of this facility plan does not constitute approval of financial analysis included in the plan or its assumptions and conclusions. The Department reserves the right to require additional financial analysis as necessary to satisfy the intent of the 1994 CSO Control Policy.

If you believe you have a right to challenge this decision made by the Department, you should know that Wisconsin statutes, administrative codes and case law establish time periods and requirements for reviewing Department decisions.

To seek judicial review of the Department's decision, sections 227.52 and 227.53, Stats., establish criteria for filing a petition for judicial review. Such a petition shall be filed with the appropriate circuit court and shall be served on the Department. The petition shall name the Department of Natural Resources as the respondent.

To request a contested case hearing pursuant to section 227.42, Stats., and ch. NR 2, Wis. Adm. Code, you have 30 days after the decision is mailed, or otherwise served by the Department, to serve a petition for hearing on the Secretary of the Department of Natural Resources. The filing of a request for a contested case hearing is not a prerequisite for judicial review.

This notice is provided pursuant to section 227.48(2), Stats.

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES
For the Secretary

Gerald Novotny

Gerald Novotny, P.E.
Wastewater Engineer

Duane H. Schuettpelz, P.E.
Chief, Wastewater Section
Bureau of Watershed Management

cc: William Krill - HNTB Corporation - Milwaukee
Jim Fratrick - SER Milwaukee
Michael Hahn - SEWRPC
Dan Olson - CF/8
Peter Swenson – US EPA, Region 5

APPENDIX C

Table 3-6. Maximum Extent of Green Infrastructure Practices by Sewershed Based on Opportunity Assessment

Green Infrastructure Practice		CS5134#2	CS5134#1-W	CS5135A3	CS5134#1-E
Porous pavement (acre)		1.7	3.3	3.3	26.9
Green alley (acre)		3.2	6.6	2.6	0.0
Block bioretention (acre)		2.2	5.8	8.9	5.2
Rain gardens (unit)		250	400	200	0
Regional bioretention (acre)		0.0	8.0	0.0	10.2
Rain barrel (unit)		500	800	400	0
Green roof (acre)		2.2	3.9	2.9	42.1
Road side porous pavement (acre)		3.4	5.9	3.1	3.7
Green street	Road side porous pavement (acre)	1.6	2.6	2.0	1.3
	Rain garden (acre)	0.7	1.3	0.6	0.7

3.5 SUSTAIN Model Setup

This section provides a description of how the SUSTAIN model was set up to simulate green infrastructure in the pilot area.

3.5.1 Model Input

The data collection process for a SUSTAIN application is similar to that of other modeling projects and involves a thorough compilation and review of information available for the study area. The more site-specific and detailed the available data, the better the model representation. The application development process includes gathering GIS data layers, including conveyance system networks, land use data, critical source information, and monitoring data for calibration and validation.

3.5.1.1 GIS Data Layers

The following GIS layers were collected and used for setting up SUSTAIN:

- Sewershed boundary clipped from the MMSD sewershed layer.
- Pipelines and manhole data layers.
- Land use raster with 1 foot cell size. The raster was generated using SEWRPC land use data, based on circa 2000 imagery.
- Land use lookup table providing the link between land use raster ID and land use name and description.
- Potential green infrastructure practice footprint shape file through review of aerial photography (see previous section).

3.5.1.2 Watershed Representation – Land Use Time Series

In 2009, MMSD developed a set of watershed, sewer, and lake models that were used to develop management plans for the year 2020. This suite of models spanned a 900 mi^2 drainage area, and integrated CSO and SSO model outflows within the larger stream network. The watershed models used in support of the 2020 Facilities Plan were the HSPF model and the Loading Simulation Program in C++ (LSPC) model[1]. Following setup, these models were extensively calibrated and validated and then used to simulate a variety of pollutants such as sediment, nitrogen, and phosphorus, among others.

[1] LSPC is a version of the HSPF model that has been ported to the C++ programming language to improve efficiency and flexibility. LSPC's algorithms are identical to a subset of those in the HSPF model. It is currently maintained by the EPA Office of Research and Development in Athens, Georgia.

For consistency with model hydrology representation in the combined sewer area, parameters for pervious and impervious land hydrology used for the MACRO model were directly mapped to LSPC pervious and impervious land uses to be used by SUSTAIN. Water quality parameters from the MMSD LSPC watershed models were also mapped as shown in Table 3-7 so that water quality benefits could be evaluated in SUSTAIN (water quality within the CSSA is not modeled by MACRO).

Table 3-7. HSPF, LSPC, and SUSTAIN Model Parameter Mapping by Land Use.

LSPC/SUSTAIN Land Use File	HSPF Parameter Mapping Used As Input to MACRO	LSPC Parameter Mapping (by Land Use) Used in SUSTAIN
1.out	PERLND	GRASS_B
11.out	PERLND	WETLAND
13.out	IMPLND	RESIDENTIAL
14.out	IMPLND	COMMERCIAL
15.out	IMPLND	INDUSTRIAL
16.out	IMPLND	GOVT_INSTIT
17.out	IMPLND	TRANS_FREE

When linking to an existing watershed model, SUSTAIN associates land use time series to land use polygons in the GIS coverage. Because the GIS coverage does not differentiate pervious and impervious polygons, percent impervious assumptions from SEWRPC were used.

Table 3-8 shows the SEWRPC percent impervious assumptions by land use. Impervious area was assigned to the corresponding impervious land use boundary condition shown in Table 3-7. The most prevalent soil type within this study area was categorized as hydrologic soil group B; therefore, pervious areas from all urban land use categories were assigned the “Grass_B” land use time series. There was no forest or agricultural land uses (cropland or pasture) within the modeled drainage area.

Table 3-8. SEWRPC Percent Impervious Assumptions by Urban Land Use Category.

Land Use Group	Land Use Category	Percent Connected (DCIA)	Percent Supplemental	Percent Total Impervious
Residential	Estate	8	0	8
	Suburban	10	0	10
	Low	10	5	15
	Medium	15	8	23
	High	20	15	35
Commercial	All	60	0	60
Industrial	All	60	0	60
Transportation	Freeway	60	0	60
	Streets	50	0	50
	Parking	100	0	100
Government /institutional	All	25	0	25
Cemeteries	All	4	0	4
Recreational	All	4	0	4

DCIA = directly connected impervious area

3.5.2 Simulation Time Period

The optimization component of SUSTAIN requires numerous iterations of model simulation, making it impractical to use the model for the 64.5 year simulation period used by MACRO in Section 2. Instead, measured precipitation data at the General Mitchell International Airport (GMIA) were analyzed to identify a time period

that reflects a range of weather variation that occurs in the watershed. Figure 3-12 is a graph of average annual precipitation volume for 1950 through 2009, with the first, middle, and last 10 years highlighted.

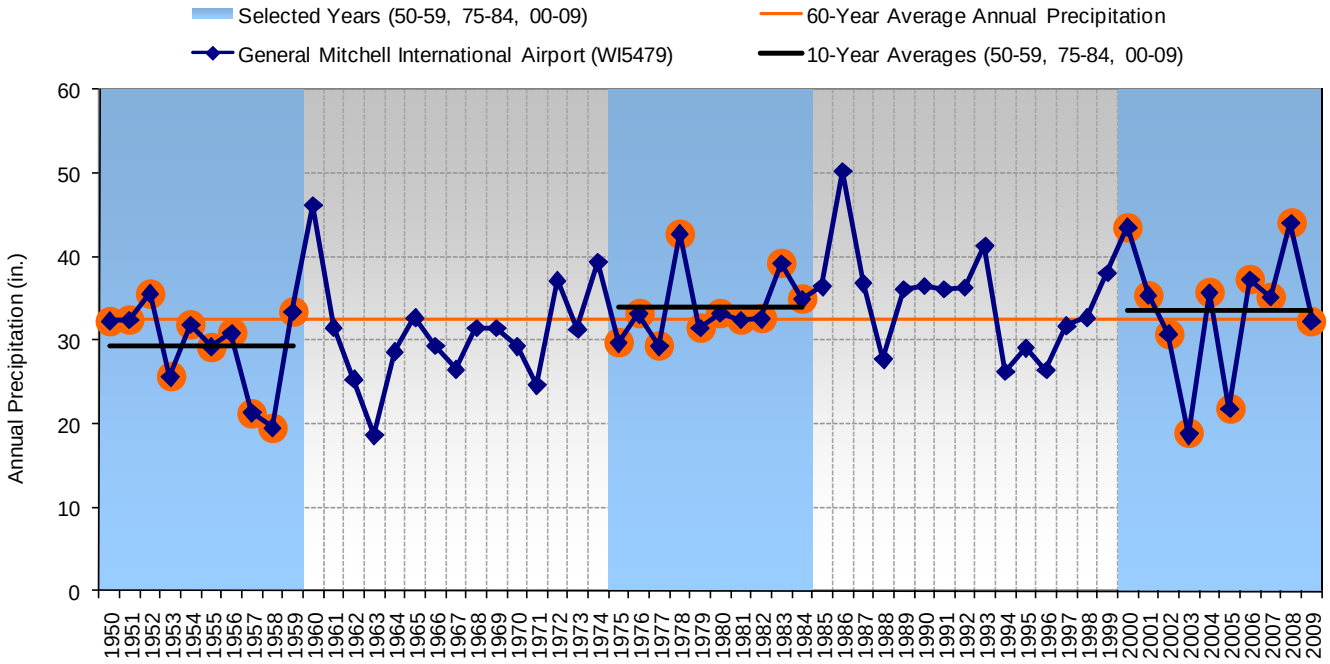
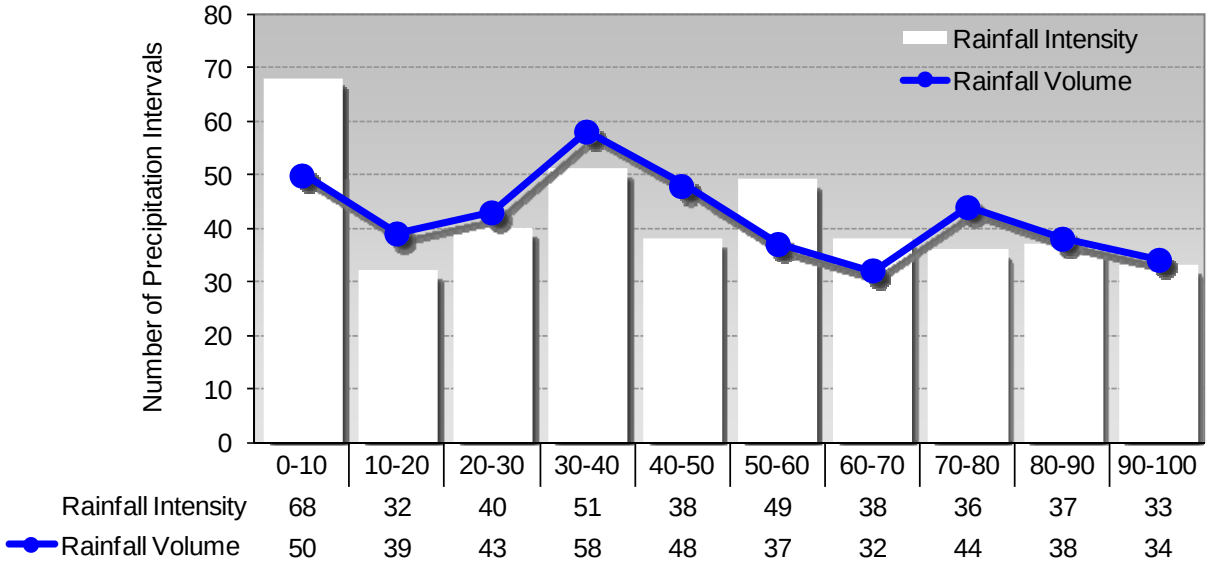


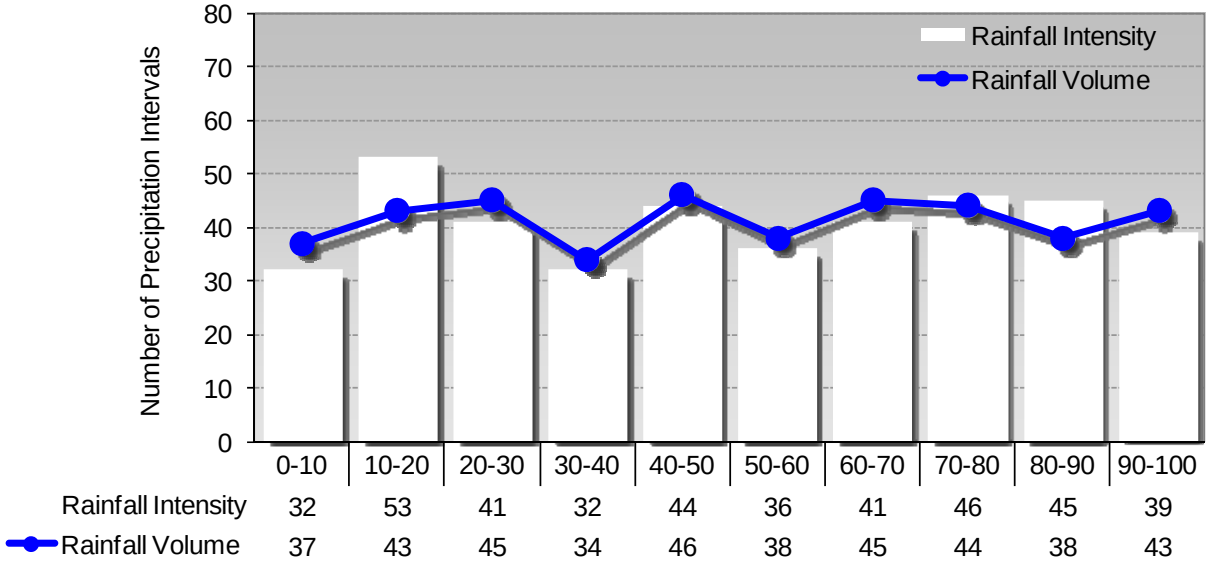
Figure 3-12. Annual Precipitation at General Mitchell International Airport for Years 1950–2009.

A simple linear trend line suggests a gradual increase in precipitation of approximately 0.1 inch per year over the 60 years. However, the average precipitation for the three selected (evenly spaced) 10-year periods varies around the linear trend line. The three 10-year periods were also evaluated for precipitation volume and intensity variation relative to the 60-year volume and intensity distribution. This first involved separating the observed hourly precipitation records into discrete storm intervals. Storm intervals were defined as continuous stretches of precipitation separated by at least 72 continuously dry hours. The storm interval classification averaged about 40 storm intervals per year. Figure 3-13, Figure 3-14, and Figure 3-15 show rainfall volume and intensity distributions for the three 10-year intervals 1950-1959, 1975-1984, and 2000-2009, respectively. In the figures, the volume and intensity percentile ranges are based on the entire record of storms occurring over the entire 60-year period.



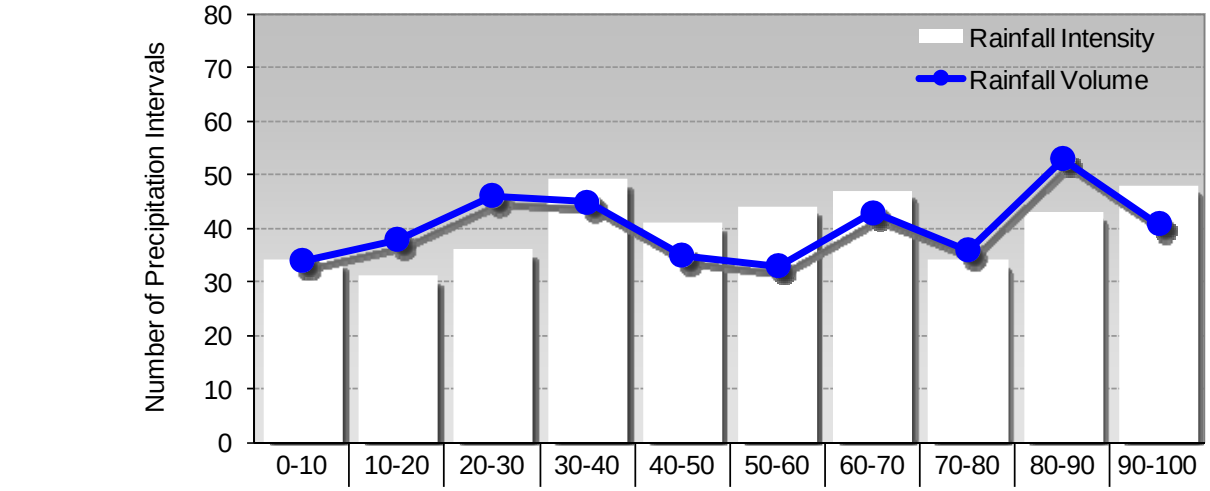
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Rainfall Intensity	68	32	40	51	38	49	38	36	37	33
Rainfall Volume	50	39	43	58	48	37	32	44	38	34

Figure 3-13. Rainfall Volume and Intensity Wet-interval Distribution for Years 1950–1959.



	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Rainfall Intensity	32	53	41	32	44	36	41	46	45	39
Rainfall Volume	37	43	45	34	46	38	45	44	38	43

Figure 3-14. Rainfall Volume and Intensity Wet-interval Distribution for Years 1975–1984.



	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Rainfall Intensity	34	31	36	49	41	44	47	34	43	48
Rainfall Volume	34	38	46	45	35	33	43	36	53	41

Figure 3-15. Rainfall Volume and Intensity Wet-interval Distribution for Years 2000–2009.

The chronological progression of these figures suggests that over the 60-year period, storms in the last decade evaluated (Figure 3-15) show a volume and intensity increase relative to the first decade (Figure 3-13). In fact, the first decade showed the strongest skew toward lower intensity and volume storm intervals. The middle decade (Figure 3-14), showed a relatively even volume and intensity distribution that was consistent with the 60-year volume and intensity distribution. Because storm volume and intensity are primary drivers for sizing green infrastructure practices, the decade with the most notable shift toward higher volume and intensity was selected to be the representative period for modeling. The 2000-2009 decade also represents the most recent recorded precipitation time period available at the time of this study.

3.5.3 Representation of Green Infrastructure Practices

Green infrastructure practices are simulated within SUSTAIN according to specific design specifications, with the performance modeled using a unit-process parameter-based approach. This contrasts with and has many advantages over most other modeling tools which simply assign a single percent effectiveness value to each type of practice.

The practices were simulated in aggregate, recognizing the scale and model resolution of the original watershed models. The aggregate approach is a computationally efficient and analytically robust way of evaluating relative practice selection and performance at a small subwatershed scale. An aggregate green infrastructure practice consists of a series of process-based optional components, including on-site interception, on-site treatment, routing attenuation, and regional storage/treatment. The aggregate component evaluates storage and infiltration characteristics from multiple practices simultaneously without explicit recognition of their spatial distribution and routing characteristics within the selected watershed. For this application, the aggregate practice included seven component practices—rain barrels, rain gardens, block bioretention, green alley, porous pavement, green roof, and regional bioretention. Figure 3-16 is a schematic diagram of aggregate components, drainage areas, and practice-to-practice routing networks.

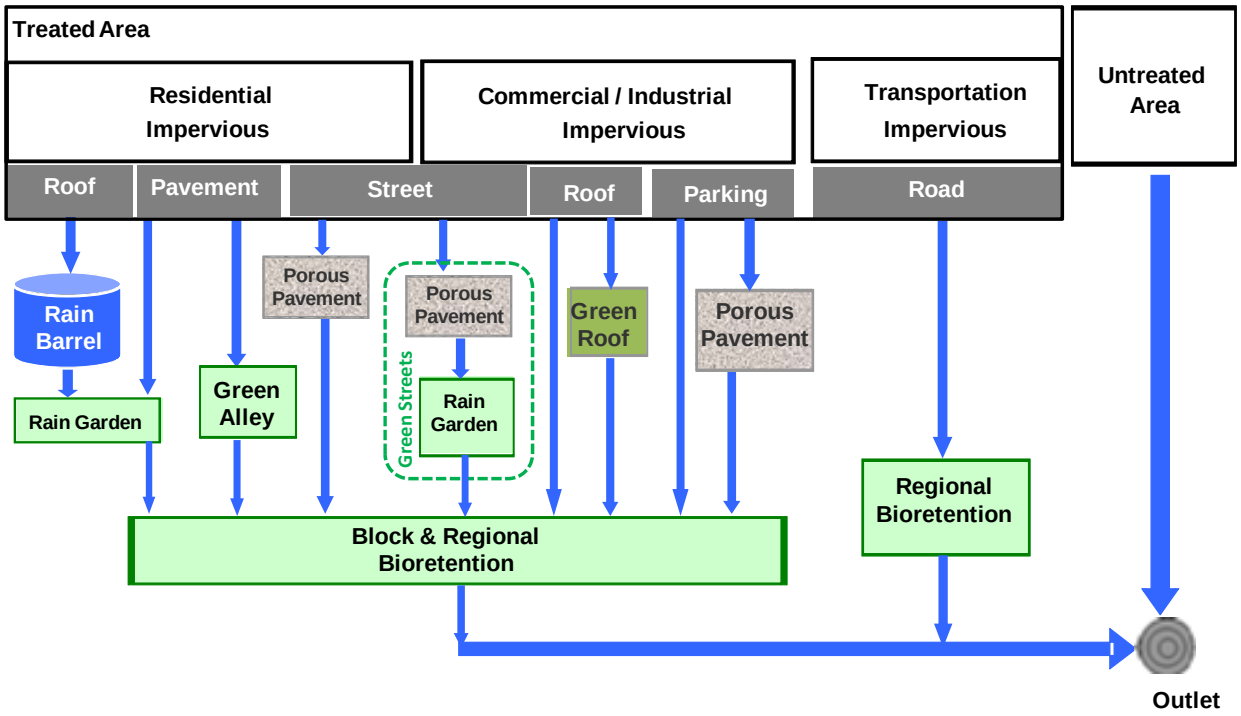


Figure 3-16. Aggregate Green Infrastructure Practice Schematic.

As shown in Figure 3-16, the rain barrel component collects runoff from rooftops (as part of the impervious surfaces) in residential areas. Outflow and bypass from the rain barrel is assumed to flow directly to residential rain gardens. Other residential impervious pavement areas can be treated by block bioretention or treated by a green alley first, and outflow from green alleys is routed to block bioretention. Highway runoff is assumed to flow to a regional bioretention site. Selected rooftops and pavement in commercial and industrial areas are available for conversion into green roofs and porous pavement sites, respectively. These two types of practices can treat up to the entire drainage area to which they are assigned. The neighborhood streets can be treated by road-side porous pavement, and larger connector streets can be treated by road-side porous pavement in series with rain gardens to make green streets. Outflow and bypass from these facilities are assumed to be captured by downstream block or regional bioretention sites. Some commercial and industrial areas that are not subject to green roof or porous pavement may also flow into block or regional bioretention facilities. Any other runoff from any type of land use that is not subject to treatment by any aggregate practice components is routed directly to the subbasin outlet.

To run the optimization analysis, the user must define decision variables that are used to explore the various possible practice configurations. The range and types of decision variables define the optimization search space. For this analysis, the decision variables include:

- Number of fixed-size rain barrel and rain garden units,
- Surface area of block and regional bioretention area,
- Surface area of porous pavement, green alleys, green roofs, road side porous pavement, and green streets.

Because the decision variable values can range anywhere between zero to a maximum number or size, it is possible for one component in the treatment train to never be selected if it is not cost-effective. During an optimization run, if the size value of zero for a practice is selected, that point will act as a transfer node in the network (i.e. inflow = outflow), and the associated cost that is a function of the number of practices or surface area will be set to zero. Table 3-6 previously summarized the maximum extent of each practice in each sewershed, defining the upper boundary of the optimization search space.

The physical configuration data, infiltration parameters, water quality parameters, and unit capital cost assumptions for each green infrastructure component are listed in Table 3-9. The main reference for the capital

cost assumptions was the *Fresh Coast Green Solutions* publication (MMSD 2009) which provided general estimates for the proposed green infrastructure solutions based on past MMSD project experience and cost references including University of New Hampshire (2008), City of Portland (2009), and Federal Highway Administration (2009). Some of the cost estimates were adjusted to more specifically reflect the design assumptions in SUSTAIN. Rain gardens, as assumed in the model, were estimated to cost less than the *Fresh Coast Green Solutions* median estimate, and a similar local project was used as a reference to estimate the capital cost of $6 per square foot. Schueler et al. (2007) was used to estimate the capital cost of $15 per square foot for the remaining bioretention practices whose per unit costs are expected to be higher than rain gardens due to the inclusion of a gravel underdrain and the need for more extensive excavation and structural retrofits. Stormwater trees were also assumed for half of the bioretention cells based on the *Fresh Coast Green Solutions* cost. For porous pavement and green alleys, a $2 per square foot cost was added to the *Fresh Coast Green Solutions* medians to account for the inclusion of underdrains. For the remaining practices, the median of the *Fresh Coast Green Solutions* cost range was assumed without adjustment. Operation and maintenance were not included in these costs in order to be consistent with the *Fresh Coast Green Solutions* document.

Table 3-9. Green Infrastructure Practice Configuration Parameters.

Parameter	Rain Barrel	Bioretention				Porous Pavement	Green Alley	Green Roof
		Rain Garden	Street Rain Garden	Block	Regional			
Physical Configuration								
Unit size	60 gal	50 ft^2	N/A	N/A	N/A	N/A	N/A	N/A
Design drainage area (acre)	0.005	0.02	N/A	N/A	N/A	N/A	N/A	N/A
Substrate depth (ft)	N/A	1	2	2	2	2	2.5	0.3
Underdrain depth (ft)	N/A	N/A	1	1	1	1	1	0.1
Ponding depth (ft)	N/A	0.5	0.5	1.5	2	0.1	0.1	0.1
Infiltration (Source: Prince George's County 2001)								
Substrate layer porosity	N/A	0.45	0.45	0.45	0.45	0.5	0.5	0.5
Substrate layer field capacity	N/A	0.25	0.25	0.25	0.25	0.055	0.055	0.4
Substrate layer wilting point	N/A	0.1	0.1	0.1	0.1	0.05	0.05	0.1
Underdrain gravel layer porosity	N/A	N/A	0.5	0.5	0.5	0.5	0.5	0.5
Vegetative parameter, *A*	N/A	1	1	1	1	1	1	0.6
Background infiltration rate (in./hr), f_c	N/A	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Media final constant infiltration rate (in./hr), f_c	N/A	0.15	0.5	0.5	0.5	0.5	0.5	1
Water Quality (Source: calibrated values using University of Maryland monitoring data, Prince George's County 2003)								
Total suspended solids 1st order decay rate (1/day), *k*	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total suspended solids filtration removal rate, P_{rem} (%)	N/A	85	85	85	85	70	70	70
Total nitrogen 1st order decay rate (1/day), *k*	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total nitrogen filtration removal rate, P_{rem} (%)	n/a	35	35	35	35	20	20	20
Total phosphorus 1st order decay rate (1/day), *k*	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total phosphorus filtration removal rate, P_{rem} (%)	n/a	n/a	65	65	65	50	50	50
Cost Data (Source: MMSD *Fresh Coast Solutions* publication)								
Unit Capital Cost	$118 ea.	$6 / ft^2	$15 / ft^2	$15 / ft^2	$15 / ft^2	$6 / ft^2	$11 / ft^2	$18 / ft^2

3.5.4 Optimization Formulation

The optimization objectives were to maximize annual volume reduction and to minimize implementation cost. As a result, the optimization outcome defines a set of solutions that show the maximum achievable volume reduction at each minimum-cost interval.

3.6 Model Results

Model results are presented below for (1) the cost-effectiveness curve, (2) performance summaries by storm size for selected solutions along the cost effectiveness curve, and (3) performance summaries for two selected storms. This section concludes with a summary of observations from this analysis.

3.6.1 Cost-Effectiveness Curve

Figure 3-17 shows the average annual runoff volume reduction cost-effectiveness curve within the study area, as defined by the aggregate decision variables. In this figure, the small points represent all solutions that were evaluated during optimization, while the larger points along the left-and-upper-most perimeter represent the least cost options at each volume reduction interval. The maximum achievable volume control through the use of all potential green infrastructure practices within the study area is around 85 percent; however, there is clearly a point above which the marginal costs of additional controls increases dramatically. To further investigate this, four solutions at different intervals along the curve (the larger, highlighted points on Figure 3-17, and shown in Table 3-10) were selected for detailed performance evaluation.

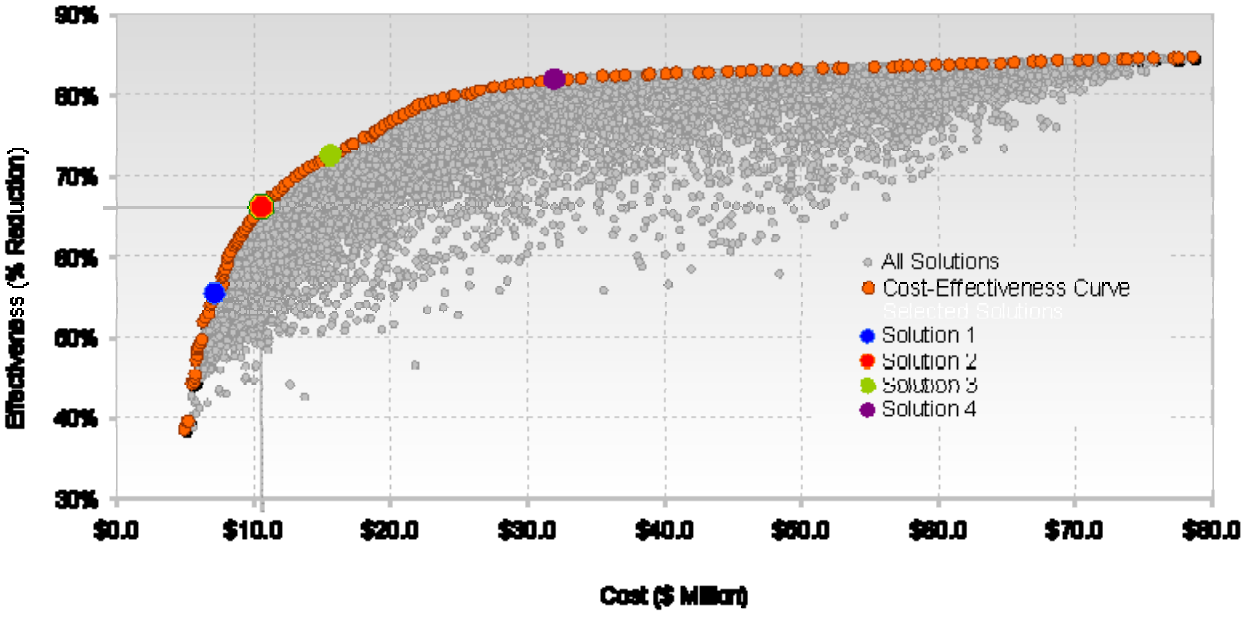


Figure 3-17. Maximum Runoff Volume Control Cost-effectiveness Curve.

Table 3-10. Selected Solutions around the Knee of the Cost-effectiveness Curve.

Selected Solution	Cost ($ Million)	Annual Runoff Volume Reduction (%)
1	7.2	55.4%
2	10.6	66.0%
3	15.7	72.6%
4	32.0	81.9%