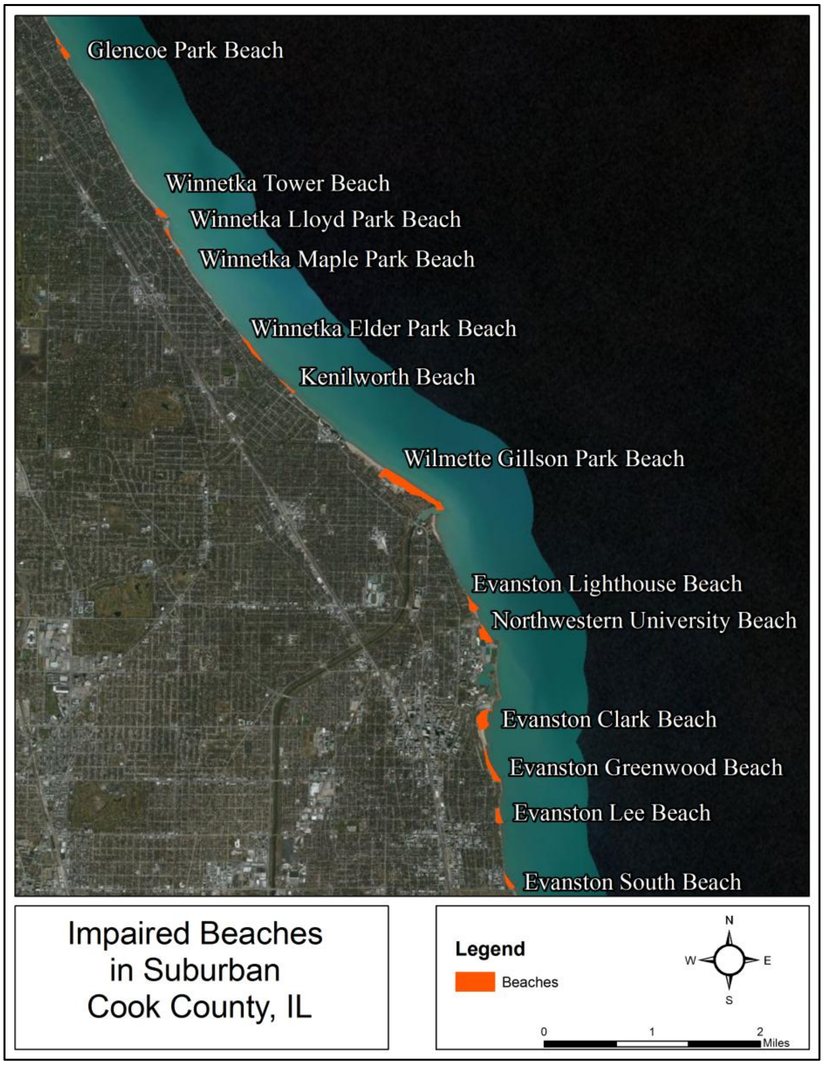
Total Maximum Daily Load

Shoreline Segments in Suburban Cook County, Illinois

13 Segments from Glencoe Park Beach to Evanston South Beach

Pathogen Indicators (*Escherichia coli*)



Illinois Environmental Protection Agency

May 15, 2013

May 2013

RTI Project Number 0211475.031

Lake Michigan Beaches Bacteria TMDL and Implementation Plan. Phase II

Submitted to:

U.S. Environmental Protection Agency
Region 5
Marcy Kamerath
Chicago, IL

Submitted by:

RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709-2194

With Support from:

Environmental Consulting & Technology, Inc
Clinton Township, MI

Table of Contents

1. Introduction 1
1.1 Priority Ranking 1
1.2 Framework for Illinois Shoreline Segments TMDL Development 2
2. Overview of Impaired Segments 5
2.1 Watershed Characterization 8
2.1.1 Glencoe Park Beach 8
2.1.2 Winnetka Beaches 11
2.1.3 Kenilworth Beach 15
2.1.4 Wilmette Gillson Park Beach 17
2.1.5 Evanston Beaches 20
2.2 Current *E. coli* Conditions 25
3. Problem Statement 29
3.1 WQS and TMDL Targets 31
3.2 Linkage Analysis 33
3.2.1 The Great Lakes Coastal Forecasting System 36
3.2.2 Precipitation 37
3.2.3 Land Use/Cover 38
3.2.4 Substrate 39
3.2.5 Shoreline Physical Characteristics 40
3.2.6 Ravines 41
3.2.7 Chicago Area Waterway System (CAWS) 43
3.3 Loading Capacity and Existing Load 43
4. Total Maximum Daily Loads Development 43
4.1 Pollutant Source Assessment 44
4.1.1 Sewage Treatment Plants 44
4.1.2 Stormwater 45
4.1.3 CAWS reversals 46
4.1.4 Other Sources 47
4.2 Pollutant Allocations 47
4.2.1 Wasteload Allocations 48
4.2.2 Load Allocations 48
4.3 Margin of Safety 49
4.4 Seasonal Variation 49
4.5 Critical Conditions 50
4.6 Reserve Capacity 50
4.7 Total Maximum Daily Loads 50
4.8 Load Reduction Calculation Methods 51
4.8.1 Step 1: Data Collection and Initial Analysis 51
4.8.2 Step 2: Initial Model Fitting 51
4.8.3 Step 3: Simulation 52
4.9 Final Reductions 54
4.9.1 Distributional Groups 55
4.9.2 Analysis 59
5. Implementation and Monitoring Recommendations 62
5.1 Implementation Plan 62
5.1.1 Description of BMPs 63
5.1.2 Management Strategy 69

5.1.3 Implementation 73
5.1.4 Funding Opportunities 74
5.2 Reasonable Assurance 75
5.3 Monitoring Recommendations to Track TMDL Effectiveness 80

6. Public Participation 80

References 81

Appendix I: Load Reduction Calculation Methods 86
A.1 Step 1: Exploratory Data Analysis – Response Variable 86
A.2 Step 2: Exploratory Data Analysis – Predictor Variables 87
A.3 Step 3: Initial Model Fitting 87
A.4 Step 4: Simulation for load reduction 89

References 90

Appendix II: Supplemental Model Parameter Information 91

Appendix III: Response to Public Comments 96
References 104

List of Figures

2-1. Impaired Segments (Beaches) within Suburban Cook County, Illinois 7
2-2. Glencoe Park Beach and Drainage Catchment within Illinois 9
2-3. Winnetka Beaches and Drainage Catchments 11
2-4. Kenilworth Beach and Drainage Catchment 15
2-5. Wilmette Gillson Park Beach and Drainage Catchment 17
2-6. Evanston Beaches and Drainage Catchments 20
2-7. Monitored *E. coli* Levels in Suburban Cook County as Compared to the SSM WQS (red line) for May 2007–August 2011 28
3-1. *E. coli* Concentrations by Wave Condition 37
3-2. Influence of 48-hour Precipitation on Water Quality (2007–2011) 38
3-3. Land Use along the Shoreline in Suburban Cook County 39
3-4. Substrate along the Shoreline 40
3-5. Example of Physical Structures at Shoreline Segments 41
3-6. Ravines along the Shoreline in Lake County 42
4-1. Predicted Distributions of *E. coli* at Cook County Group 1 Beaches (top panel) Versus Monitored Distributions at Individual Segments for 2007–2011 Dataset (lower panels) 56
4-2. Predicted Distributions of *E. coli* at Cook County Group 2 Beaches (top panel) Versus Monitored Distributions at Individual Segments for 2007–2011 Dataset (lower panels) 57
4-3. Predicted Distributions of *E. coli* at Cook County Group 3 Beaches (top panel) Versus Monitored Distributions at Individual Segments for 2007–2011 Dataset (lower panels) 58
4-4. Predicted Distributions of *E. coli* at All BSS Segments (top panel) Versus Monitored Distributions at Individual Segments for 2009–2011 (lower panels) 59

List of Tables

1-1. Impaired Lake Michigan Segments from the Illinois 303(d) List 2
2-1. Monitoring and Single Sample Maximum WQS Exceedances for Glencoe Park Beach in the Past 5 Years 10

2-2. Monitoring and Single Sample Maximum WQS Exceedances for Winnetka Beaches in the Past 5 Years ... 13
2-3. Monitoring and Single Sample Maximum WQS Exceedances for Kenilworth Beach in the Past 5 Years ... 16
2-4. Monitoring and Single Sample Maximum WQS Exceedances for Wilmette Gillson Beach in the Past 5 Years ... 19
2-5. Monitoring and Single Sample Maximum WQS Exceedances for Evanston Beaches in the Past 5 Years ... 23
2-6. 5-year Monitored Exceedances of the WQS ... 26
3-1. Guidelines for Identifying Potential Causes of Impairment of Primary Contact (Swimming) Use in Lake Michigan Beaches and Open Waters[1] ... 29
3-2. Swim Ban Statistics for Impaired Segments Based on Reporting to the U.S. EPA's PRAWN System ... 30
3-3. Applicable Water Quality Standards for Bacteria at Lake Michigan Beaches in Illinois ... 31
3-4. Source Parameters as Used in the Multi-Level Modeling for TMDL Development and Potential Management Methods ... 35
3-5. Fields in GLCFS Data ... 36
3-6. Major Land Use and Land Cover Classifications in the 2006 NLCD ... 38
4-1. MS4 Permitted Discharges within Impaired Suburban Cook County Beachsheds/BPAs ... 45
4-2. Permitted Industrial Stormwater Discharges near Suburban Cook County Impaired Segments ... 45
4-3. Applicable Construction Stormwater Permits in Cook County from 2007 to 2011 ... 46
4-4. CAWS Reversal Volume Summary ... 46
4-5. CAWS Reversal Data for Study Period ... 47
4-6. WLAs for Suburban Cook County ... 48
4-7. May–September Cook County Precipitation, Average of Four Stations ... 49
4-8. Examples of Critical Conditions in Cook County 2009–2011 BSS Dataset ... 50
4-9. Summary of Allocations by Category ... 51
4-10. Suburban Cook County Beaches with Similar Distributions of *E. coli*, by Model ... 52
4-11. Cook County BSS Predictor Variables ... 53
4-12. Cook County Group 1 Predictor Variables ... 53
4-13. Cook County Group 2 Predictor Variables ... 54
4-14. Cook County Group 3 Predictor Variables ... 54
4-15. Manageable Variable Thresholds Required to Meet the Load Allocation for the 2009–2011 Cook County BSS Dataset Model ... 60
4-16. Manageable Variable Thresholds Required to Meet the Load Allocation for the 2007–2011 Cook County Group 1 Model ... 60
4-17. Manageable Variable Thresholds Required to Meet the Load Allocation for the 2007–2011 Cook County Groups 2 and 3 Models ... 60
4-18. Observed Bird and 48-hour Rainfall Data Summaries, Suburban Cook County BSS Dataset ... 61
4-19. Observed 48-hour Rainfall Data and Impervious Area Summaries, 2007–2011 Dataset, Suburban Cook County Impaired Segments ... 61
4-20. Relative Occurrence of Rainfall Events Reaching Proposed Reduction Thresholds[1] ... 61
5-1. Best Management Practices to Address *E. coli* Impairments ... 63
5-2. Bacteria Reduction from Stormwater BMPs ... 66
5-3. Funding Opportunities for Implementing Selected Options to Achieve the TMDLs ... 74
5-4. Existing Activities within the Lake Michigan Shoreline Watershed that Support Attainment of the WQS ... 77
6-1. Participating Members of the TAC ... 80

List of Acronyms

BAV	Beach Action Value
BEACH Act	Beaches Environmental Assessment and Coastal Health Act
BIC	Bayesian Information Criteria
BMP	Best Management Practice
BPA	Beach Protection Area
BSS	Beach Sanitary Survey
CART	Classification and Regression Tree
CAWS	Chicago Area Waterway System
cfu	colony forming unit
CPD	Chicago Park District
CSO	combined sewer overflow
CWA	Clean Water Act
E. coli	Escherichia coli
EAOC	Extended Area of Concern
FIB	fecal indicator bacteria
GI	Green infrastructure
GIS	Geographic Information System
GLCFS	Great Lakes Coastal Forecasting System
GLOS	Great Lakes Observation System
GLRI	Great Lakes Restoration Initiative
GM	geometric mean
GPD	Glencoe Park District
IDNR	Illinois Department of Natural Resources
IDPH	Illinois Department of Public Health
IEPA	Illinois Environmental Protection Agency
km	kilometer
K-S test	Kolmogorov–Smirnov test
LA	load allocation
LC	loading capacity
LCHD	Lake County Health Department
LIDAR	Light Detection And Ranging
m	meter
m/s	meters per second

MG	million gallons
mL	Milliliters
MLR	multiple linear regression
MOS	margin of safety
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer System
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OLS	ordinary least squares
PRAWN	U.S. EPA's PRogram tracking, beach Advisories, Water quality standards, and Nutrients
RC	reserve capacity
REML	Restricted Maximum Likelihood Estimator Deviance
RWQC	Recreational Water Quality Criteria
SSM	single sample maximum
SSO	sanitary sewer overflow
STORET	U.S. EPA's STOrage and RETrieval system
STV	Statistical Threshold Value
TAC	Technical Advisory Committee
TARP	Tunnel and Reservoir Plan
TMDL	Total Maximum Daily Load
Tukey's HSD	Tukey's Honestly Significant Difference
U.S. EPA	U.S. Environmental Protection Agency
UIC	University of Illinois at Chicago
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agricultural
USGS	U.S. Geological Survey
WLA	wasteload allocation
WQS	water quality standard
WRP	water reclamation plant

1. Introduction

Lake Michigan beaches and their coastal waters are a highly valued societal and ecological resource. These beaches are widely popular, highly used, and frequently monitored by stakeholders and local government to ensure that water quality conditions support safe and healthy recreation. This Total Maximum Daily Load (TMDL) document addresses 13 of the 51 Lake Michigan shoreline segments (10-digit HUC 0404000205) that are located in suburban Cook County, IL, and were identified by the Illinois Environmental Protection Agency (IEPA) to be in nonattainment of their designated use, primary contact recreation. The remaining 38 segments will be addressed in two companion TMDL documents addressing the Lake Michigan shoreline segments that are in Lake County, IL, and the Chicago Metropolitan Area.

From May through September, the various municipalities, through their beach management units, sample Lake Michigan beaches 5 to 7 days a week for bacteria. The Illinois Department of Public Health (IDPH) and the beach management authorities use these monitoring data to establish the day-to-day operational status of Lake Michigan beaches for swimming. In suburban Cook County, swim bans occur when Escherichia coli (*E. coli*) bacteria exceed the water quality standard (WQS) of 235 colony-forming units (cfu) per 100 milliliters (mL).

The IEPA uses the number and duration of beach closures (i.e., swim bans) to assess whether or not the beaches are supporting use designations for primary contact recreation. Within Illinois, Lake Michigan Beaches are found to be “not supporting” of primary contact use when, on average, over a 3-year period, (1) there is one bathing area closure (i.e., swim advisory where no swimming is advised or swim ban) per year of less than 1 week’s duration or (2) there is one bathing area closure per year of greater than 1 week’s duration or more than one bathing area closure per year. Based on IEPA’s methodology, these 13 segments in suburban Cook County, IL, were not supporting primary contact use and were first included on Illinois’ Section 303(d) list in 2006.

The Clean Water Act (CWA) and U.S. Environmental Protection Agency (U.S. EPA) regulations require that states develop TMDLs for all waters on the Section 303(d) lists. A TMDL is the sum of the allowable amount of a pollutant that a water body can receive from contributing point and nonpoint sources and still meet WQSs. These 13 shoreline segments on Illinois’ 303(d) list span a range of conditions, from suburban beaches with large drainage areas due to shoreline ravines in the north to hydrologically isolated beaches in the south.

In this study, “shoreline segment” is used in place of “beach” because not all 51 segments are considered beaches as defined by the local management agencies. Beach managers monitor licensed beaches for public health concerns, yet some of the segments included in these TMDL documents do not have swimming access and, therefore, are not monitored for swim advisory decisions by beach managers. However, all Lake Michigan nearshore waters have a designated use for primary contact recreation (77 Ill. Adm. Code 820.400); therefore, IEPA assesses any shoreline segment with available monitoring data at the time of the assessment to determine if they are supporting its designated use. For the segments without swimming access, although they are not currently monitored regularly, there were historical data available that indicated a segment was not supporting the designated use.

1.1 Priority Ranking

In accordance with the U.S. EPA regulations, states develop a priority ranking to help prioritize waters for TMDL completion. The prioritization of Illinois’ Section 303(d) List is done on a watershed basis instead of on individual water body segments. IEPA watershed boundaries are based on U.S. Geological Survey (USGS) 10-digit hydrologic units (HUC10).

In 2008 and 2010, prioritization was accomplished through the following steps:

- **Step 1.** The first step in the prioritization process is based on use designations, establishing a High, Medium and Low Priority for specific uses.
  - High Priority – watersheds containing one or more waters that are Not Supporting public and food processing water supply use.
  - Medium Priority – watersheds containing one or more waters that are Not Supporting aquatic life use, fish consumption use, or primary contact (swimming) use.
  - Low Priority – watersheds containing waters that are Not Supporting aesthetic quality use only.
- **Step 2.** The second step in the prioritization process is based on the overall severity of pollution.

The 51 Lake Michigan shoreline segments were grouped under a single entry for Lake Michigan (HUC 0404000205) and were assigned a lower priority relative to the remaining waters on the 303(d) list. States are not required to complete TMDLs in priority order, and where other factors, such as funding availability or existing complementary work, exist in a watershed with impairments, it may result in developing TMDLs other than those with highest priority.

1.2 Framework for Illinois Shoreline Segments TMDL Development

The 51 shoreline segments are addressed in three separate TMDL documents; one for Lake County, one for suburban Cook County, and one for Chicago. Each document contains descriptions for each beach, statistical models of *E. coli* concentrations, a table providing TMDLs for the addressed segments, and corresponding Implementation Plans by segment. Given the large geographical area to cover in the TMDL study and the varying amount of information available for the 51 different segments, a methodology was proposed where beaches could be grouped and analyzed together when they showed similar water quality conditions in response to factors that affect bacteria in beach waters (e.g., physical characteristics, potential sources). The segments in a group are examined in the same statistical analysis to leverage information between the segments. The methods used for this analysis were designed to consider multiple segments in one consistent format, while still ultimately providing individual TMDLs and implementation options.

This document provides the background information, calculation methods, and TMDLs for the 13 segments within suburban Cook County. These segments are highlighted within **Table 1-1** out of all 51 listed segments. Since beaches can be known by various names, this document will attempt to use the IDPH name (i.e., the name used by local beach managers) as much as possible to avoid confusion. This table acts as a cross-reference from IDPH to Assessment and Local names.

Table 1-1. Impaired Lake Michigan Segments from the Illinois 303(d) List

The segments were first listed in 2006 and also appear on subsequent 303(d) lists

Assess-ment Unit ID	Beach ID	IDPH Name	Assessment Beach Name	Name Note[1]	Length (meters)[2]	Monitoring County/ Organization
IL_QH-01	IL913512	North Point Marina Beach	North Point Beach		317	Lake/ LCHD
IL_QH-03	IL677426	Illinois Beach State Park North Beach	IL Beach State Park North		977	Lake/ LCHD
IL_QH-04	IL087773	Waukegan Beach (North segment)	Waukegan North Beach	LCHD considers the Waukegan Beaches to be a single beach	2219	Lake/ LCHD

(continued)

Table 1-1. Impaired Lake Michigan Segments from the Illinois 303(d) List (continued)

Assess-ment Unit ID	Beach ID	IDPH Name	Assessment Beach Name	Name Note[1]	Length (meters)[2]	Monitoring County/ Organization
IL_QH-05	IL234945	Waukegan Beach (South segment)	Waukegan South Beach	LCHD considers the Waukegan Beaches to be a single beach	339	Lake/ LCHD
IL_QH-09	IL215601	Illinois Beach State Park South Beach	IL Beach State Park South		5648	Lake/ LCHD
IL_QI-06	IL195441	Lake Bluff Sunrise Beach	Lake Bluff Beach (Sunrise)		406	Lake/ LCHD
IL_QI-10	IL634222	Lake Forest Forest Park Beach	Lake Forest Beach (Forest Park)		809	Lake/ LCHD
IL_QJ	IL730475	Highland Park Rosewood Beach	Rosewood Beach		292	Lake/ LCHD
IL_QJ-05	IL782704	Highland Park Avenue Boating Beach	Park Avenue Beach		204	Lake/ LCHD
IL_QK-04	IL942128	Glencoe Park Beach	Glencoe Beach (Glencoe Park Beach)		172	Cook/ Glencoe Park District
IL_QK-06	IL108354	Winnetka Tower Beach	Tower Beach (Winnetka Tower Beach)		167	Cook/ Winnetka Park District
IL_QK-07	IL595016	Winnetka Lloyd Park Beach	Lloyd Beach (Winnetka Lloyd Park Beach)		172	Cook/ Winnetka Park District
IL_QK-08	IL750698	Winnetka Maple Park Beach	Maple Beach (Winnetka Maple Park Beach)		76	Cook/ Winnetka Park District
IL_QK-09	IL928218	Winnetka Elder Park Beach	Elder Beach (Winnetka Elder Park Beach)		121	Cook/ Winnetka Park District
IL_QL-03	IL984895	Kenilworth Beach	Kenilworth Beach		122	Cook/ Kenilworth Water & Light Dept.
IL_QL-06	IL637664	Wilmette Gillson Park Beach	Gillson Beach (Wilmette Gillson Park Beach)		445	Cook/ Wilmette Park District
IL_QM-03	IL505764	Evanston Greenwood Beach	Greenwood Beach (Evanston Greenwood Beach)		372	Cook/ Evanston Health Dept.
IL_QM-04	IL327651	Evanston Lee Beach	Lee Beach (Evanston Lee Beach)		222	Cook/ Evanston Health Dept.
IL_QM-05	IL291926	Evanston Lighthouse Beach	Lighthouse Beach (Evanston Lighthouse Beach)		253	Cook/ Evanston Health Dept.
IL_QM-06	IL287401	Northwestern University Beach	Northwestern University Beach		272	Cook/ Evanston Health Dept.

(continued)

Table 1-1. Impaired Lake Michigan Segments from the Illinois 303(d) List (continued)

Assess-ment Unit ID	Beach ID	IDPH Name	Assessment Beach Name	Name Note[1]	Length (meters)[2]	Monitoring County/ Organization
IL_QM-07	IL601796	Evanston Clark Beach	Clark Beach (Evanston Clark Beach)		213	Cook/ Evanston Health Dept.
IL_QM-08	IL636205	Evanston South Beach	South Boulevard Beach (Evanston South Beach)		245	Cook/ Evanston Health Dept.
IL_QN-01	IL705276	Leone Beach	Touhy (Leone) Beach (Loyola Beach)	Considered part of Leone Beach by CPD	881	Cook/ CPD
IL_QN-02		Loyola Beach	Loyola (Greenleaf) Beach	Considered part of Leone Beach by CPD		Cook/ CPD
IL_QN-03	IL923491	Kathy Osterman Beach	Hollywood/ Osterman Beach (Kathy Osterman Beach)		525	Cook/ CPD
IL_QN-04	IL228136	Foster Avenue Beach	Foster Beach		297	Cook/ CPD
IL_QN-05	IL132842	Montrose Beach	Montrose Beach		837	Cook/ CPD
IL_QN-06	IL748682	Juneway Terrace Beach	Juneway Terrace (Juneway Terrace Park Beach)		57	Cook/ CPD
IL_QN-07	IL621748	Rogers Beach	Rogers Beach (Rogers Avenue Park Beach)		53	Cook/ CPD
IL_QN-08	IL120964	Howard Beach	Howard Beach (Howard Street Park Beach)		80	Cook/ CPD
IL_QN-09	IL603994	Jarvis and Fargo Beaches	Jarvis Beach (Jarvis Avenue Park Beach)	Considered 2 separate beaches, but sampled together by CPD	217	Cook/ CPD
IL_QN-10	IL259912	Hartigan North Beach	Pratt Beach (Pratt Blvd and Park Beach)	Considered Hartigan Beach by CPD	193	Cook/ CPD
IL_QN-11	IL274491	Hartigan North Beach	North Shore/ Columbia (North Shore Avenue Beach)	Considered Hartigan Beach by CPD	235	Cook/ CPD
IL_QN-12	IL798802	Hartigan South Beach	Albion Beach	Considered Hartigan Beach by CPD	61	Cook/ CPD
IL_QN-13	IL586992	Thorndale or George Lane Beach	Thorndale Beach	Considered part of Kathy Osterman Beach by CPD	58	Cook/ CPD

(continued)

Table 1-1. Impaired Lake Michigan Segments from the Illinois 303(d) List (continued)

Assess-ment Unit ID	Beach ID	IDPH Name	Assessment Beach Name	Name Note[1]	Length (meters)[2]	Monitoring County/ Organization
IL_QO-01	IL666876	North Avenue Beach	North Ave. Beach		1691	Cook/ CPD
IL_QO-02	IL103378	Fullerton Shoreline	Fullerton Beach (Fullerton [Theater on the Lake])	Fullerton St. Shoreline (No swimming access)[3]	208	Cook/ CPD
IL_QO-03		North Avenue Beach	Webster Beach	Considered North Avenue Beach by CPD		
IL_QO-04		North Avenue Beach	Armitage Beach	Considered North Avenue Beach by CPD		
IL_QO-05	N/A	Schiller Avenue Shoreline	Schiller Beach	Schiller Ave. Shoreline (No swimming access)[3]	N/A	No Data Available
IL_QP-02	IL296528	Oak Street Beach	Oak St. Beach		338	Cook/ CPD
IL_QP-03	IL926480	Ohio Street Beach	Ohio St. Beach		171	Cook/ CPD
IL_QQ-01	IL820929	12th Street	12th St. Beach		325	Cook/ CPD
IL_QQ-02	IL461767	31st Street Beach	31st St. Beach		275	Cook/ CPD
IL_QR-01	IL865711	49th Street Shoreline	49th St. Beach	49th St. Shoreline (No swimming access)[3]	N/A	Cook/ CPD
IL_QS-02	IL118596	63rd Street Beach	Jackson Park/63rd St. Beach		666	Cook/ CPD
IL_QS-03	IL814025	Rainbow Beach	Rainbow		546	Cook/ CPD
IL_QS-04	IL589159	57th Street Beach	57th St. Beach		241	Cook/ CPD
IL_QS-05	IL288152	67th Street Shoreline	67th St. Beach	67th St. Shoreline (No swimming access)[3]	286	Cook/ CPD
IL_QS-06	IL581683	South Shore Beach	South Shore Beach		212	Cook/ CPD
IL_QT-03	IL376700	Calumet South Beach	Calumet Beach (Calumet South Beach)		404	Cook/ CPD

1 This column provides information on how individual segments are related to actual monitored beaches according to Chicago Park District (CPD).

2 "N/A" indicates that the beach is not indexed or monitored by IDPH; blank cells indicate that the beach is part of a larger beach for which a length is provided.

3 Although there is no swimming access at these segments, a TMDL is still required because the entire Lake Michigan shoreline is protected for primary contact recreation by the State of Illinois.

2. Overview of Impaired Segments

Cook County is located northeast Illinois and has Lake Michigan as its eastern border. The eastern portion of the county can be divided into a suburban portion in the north (the focus of this TMDL document) and the City of Chicago in the south (the focus of an accompanying TMDL document). The shoreline of suburban Cook County is divided into the four municipalities of Glencoe, Winnetka, Kenilworth, and Evanston, each of which contains at least one impaired beach. These impaired beaches are, from north to south, Park Beach in Glencoe; Tower, Lloyd Park, Maple Park, and Elder Park Beaches in Winnetka; Kenilworth Beach; Gillson Park Beach in Wilmette; and Lighthouse, Northwestern University, Clark, Greenwood, Lee, and South Beaches in Evanston (**Figure 2-1**). The Ravine/Bluff region stretches from Waukegan Harbor southward to Winnetka, IL, and includes Glencoe Park Beach southward to Evanston Lighthouse Beach. In this area, bluffs run parallel to the shoreline and are cross cut by relatively small, closely grouped ravines hosting intermittent streams that drain into Lake Michigan (IDNR, 2011b). From the Northwestern University Beach southward, the upland slopes gently to the lakeshore, and bluffs are absent. The shoreline in this area is at or near the predevelopment location.

The beaches within suburban Lake County are monitored by several different agencies, including Glencoe Park District, Winnetka Park District, Kenilworth Public Works Department, Wilmette Park District, Evanston Health Department, and IDPH. Each municipality conducts its own monitoring program, while IDPH may conduct additional sampling at any of the listed beaches as well. In recent years, these suburban Cook County beaches are sampled no less than 4 days a week during swimming season, approximately from early/mid-June to Labor Day. In a few cases, monitoring may begin in late May. Beaches are closed when a single sample exceeds 235 cfu/100 mL of *E. coli*.

In 2012, the University of Illinois at Chicago (UIC), in conjunction with IDPH, received funding from the Great Lakes Restoration Initiative to conduct Beach Sanitary Surveys (BSS) for Glencoe Park Beach, Winnetka Elder Beach, Kenilworth Beach, Wilmette Gilson Beach, and Evanston South Beach. Site visits conducted by UIC included limited environmental sampling and physical measurements to provide supplemental information to the daily bacteria monitoring data collected by the local beach monitoring agency. Observations on potential pollution sources were included as part of the BSS.

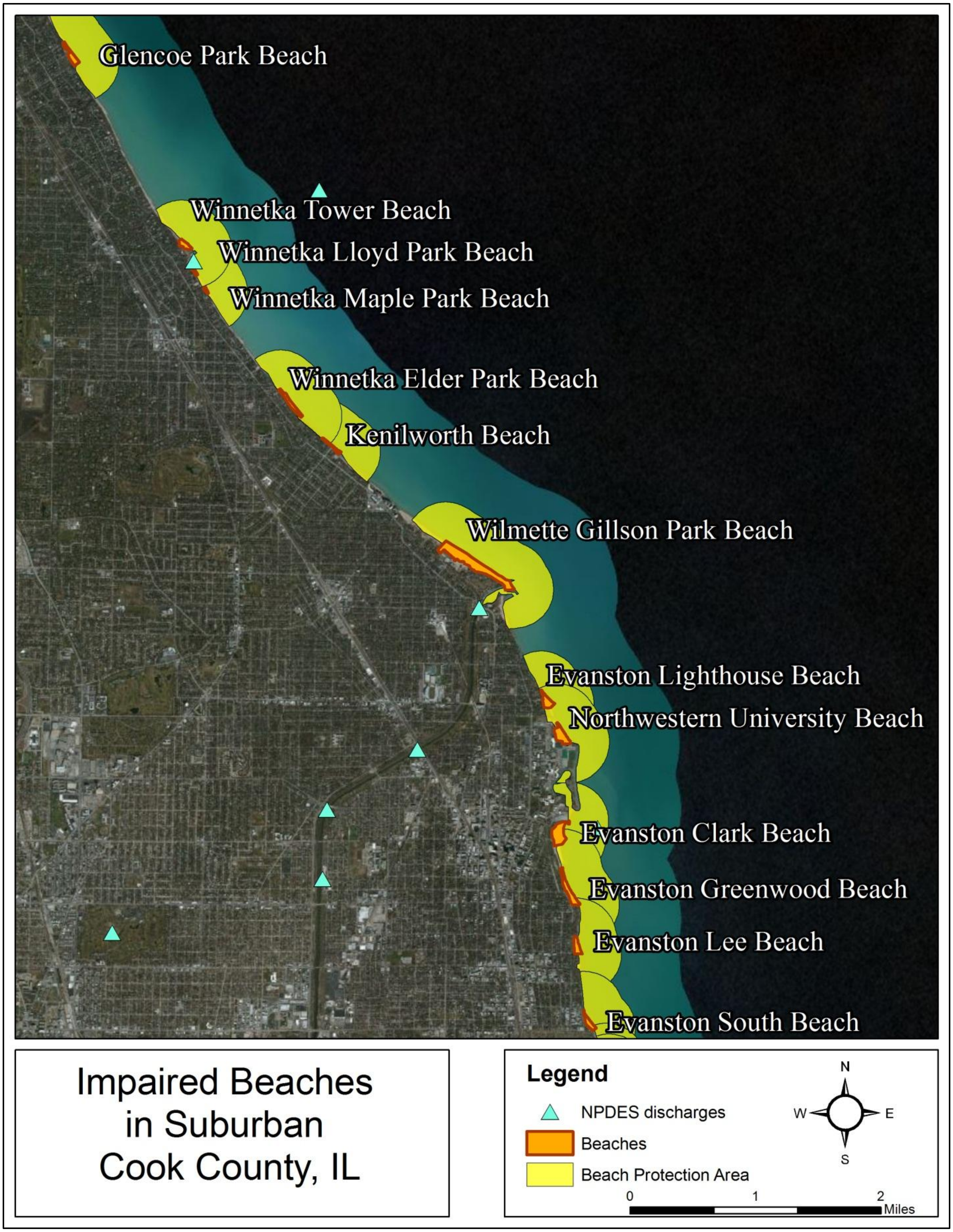


Figure 2-1. Impaired Segments (Beaches) within Suburban Cook County, Illinois

2.1 Watershed Characterization

Along the Illinois shoreline, there are very few stream outlets to Lake Michigan aside from the Chicago River and Calumet River in Cook County. The streams that drain the shoreline to the north are small in scale, ranging up to 10 kilometers (km) in length with a drainage area of up to 14.2 square kilometers (km^2). Ravines exist along the shoreline in the northern areas of the study region (i.e., Glencoe and northern Winnetka) and tend to be the more likely conduits for delivery of point-source loads to the shoreline rather than free-flowing streams (Alliance for the Great Lakes, 2009). The "beachsheds," or watershed areas that contribute surface water flow to the impaired segment area, contain both surface drainage areas based on coastal ravines for the northern two beaches and a direct drainage area where overland runoff drains directly on to the beach. Drainage to the ravines is defined based on both topography and any identified stormwater management systems, which may alter the natural hydrology of the region and transport stormwater runoff through pipes into the ravines and tributaries. The direct drainage area was determined through a Geographic Information System (GIS) analysis using Light Detection And Ranging (LIDAR) remote sensing data. A bare earth elevation grid (i.e., influences of buildings removed) developed from the LIDAR data was used to define the portions of the grid that slope toward the defined beach area. For the majority of the beaches in suburban Cook County, the direct drainage area is limited to a small strip of land along the top of the beach.

Several of the municipalities along the coast have Municipal Separate Storm Sewer Systems (MS4s) and discharge stormwater to Lake Michigan, either through direct runoff or via surface water flow (e.g., discharge to coastal ravines). The ravines in the north may also contain other local stormwater outfalls or intersect aging sanitary sewer infrastructure, potentially introducing contamination to the beach. Industrial and other individual potential point sources of bacteria have been identified and are discussed in the following sections. No concentrated animal feeding operations are located within the suburban Cook County beach drainage areas. An area extending 500 meters (m) along the shore from each end of the beach and 500 m from the beach into the lake is designated the "Beach Protection Area" (BPA) (see **Figure 2-1**). This distance has been identified as an area within which point-source discharges may be influential to the surrounding Lake Michigan shoreline (Scopel et al., 2006). Outside of this region, the lake effects are more likely to attenuate the effects of a point source so that a corresponding change in water quality could not be distinctly detected at a distance 500 m from the discharge. Therefore, the BPA is the focus area for identification of sources of bacteria along the shore and within the lake for each segment. The beachsheds are the focus area for identification of sources of bacteria inland.

2.1.1 Glencoe Park Beach

Glencoe Park Beach is located within the municipality of Glencoe in the Ravine/Bluff region of northern Cook County. The Ravine/Bluff region stretches from Waukegan Harbor southward to Winnetka, IL. In this area, bluffs run parallel to the shoreline and are crosscut by relatively small, closely grouped ravines hosting intermittent streams that drain into Lake Michigan (IDNR, 2011c). The village of Glencoe has an MS4 permit that allows stormwater runoff to drain to Lake Michigan.

Glencoe Beach is a small, rectangular beach about 4.2 acres in size (**Figure 2-2**). Glencoe Beach has a 5-acre direct-drainage area immediately west from the beach and a smaller direct drainage area with a 1-acre ravine to the southeast. There are no stormwater outfalls permitted under the National Pollutant Discharge Elimination System (NPDES) in either of these direct drainage areas, and there are no point sources in the surrounding area.

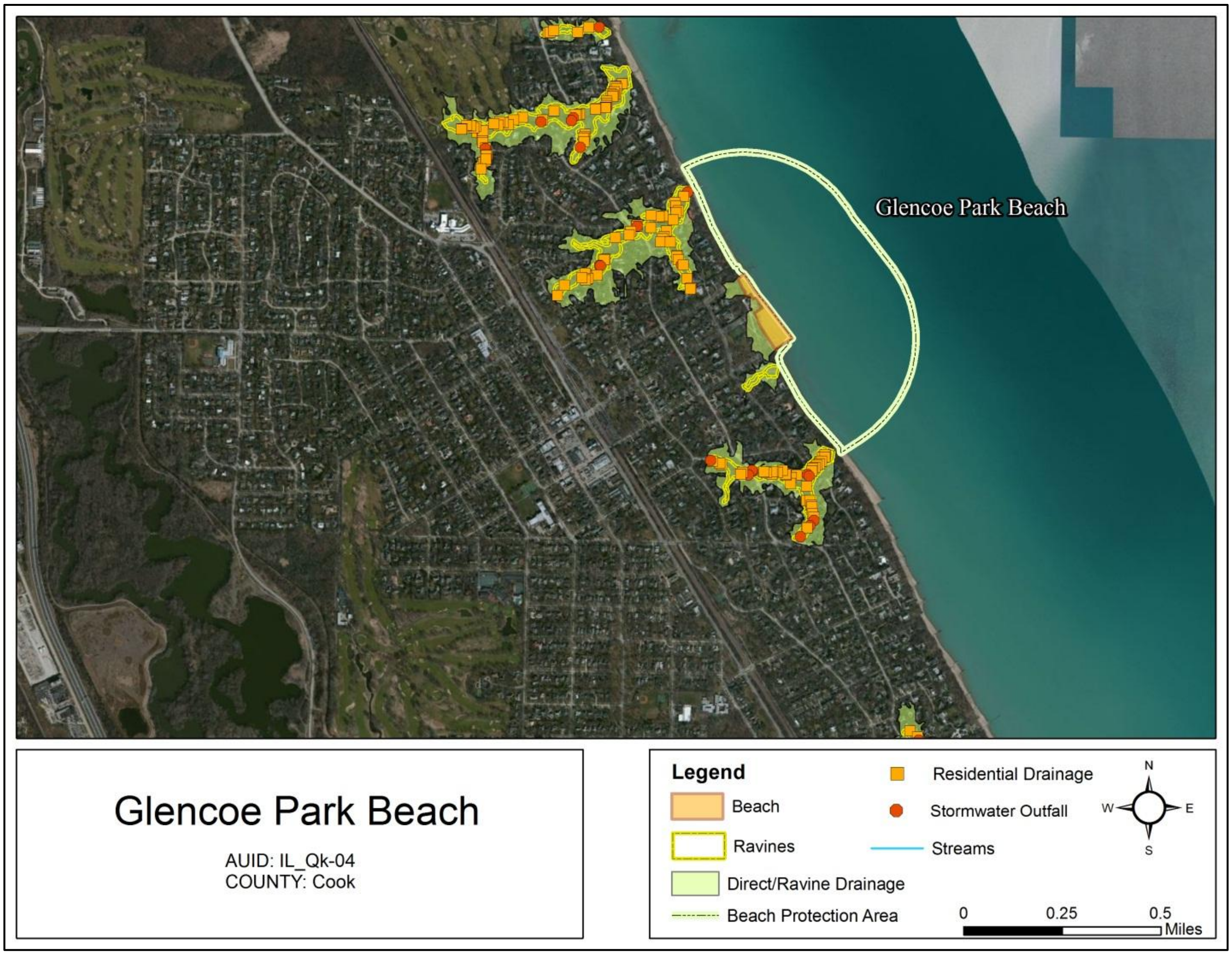


Figure 2-2. Glencoe Park Beach and Drainage Catchment within Illinois

South of Waukegan Harbor, the Zion beach-ridge plain is absent, and beaches are located at the toe of bluffs running along the shoreline. Armoring techniques are commonly employed at beaches in this area to prevent erosion (IDNR, 2011c). Glencoe Park Beach is bounded to the south by a southeast-facing hardened groyne structure.

Table 2-1 shows information about beach monitoring and closures for the past 5 years. Closures in 2011 were attributed to stormwater runoff, sanitary sewer overflows (SSOs), combined sewer overflows (CSOs), and unknown sources (Illinois DPH, 2012).

Glencoe Beach is managed by Glencoe Park District (GPD, 2012). In 2011, sampling was conducted by the Glencoe Park District on a daily basis, with two samples collected on weekends (Lerman, 2012). In 2012, sampling will continue to be conducted daily, with 1 sample per day (Illinois DPH, 2012).

Table 2-1. Monitoring and Single Sample Maximum WQS Exceedances for Glencoe Park Beach in the Past 5 Years

Assessment Units Mapped to Indexed Beaches			Years	BEACH[1] Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						Gull Counts
ID305B Unit ID	STORET[2] Station ID	Impaired Segment Name		Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	
IL_QK-04	GLBEACH	Glencoe Beach	2007	8	2.25	6/29/2007	6/29/2007	1	STORET									
			2008	5	1	6/1/2008	7/29/2008	53	STORET									
			2009	11	1.2	5/24/2009	9/7/2009	87	STORET									
			2010[3]			5/29/2010	9/6/2010	119	STORET									
			2011	18	1.2	5/28/2011	8/3/2011	61	STORET									

[1] BEACH = Beaches Environmental Assessment and Coastal Health
[2] STORET = U.S. EPA's STOrage and RETrieval system
[3] No closures or other actions listed in PRAWN for 2010 at Glencoe Beach.

2.1.2 Winnetka Beaches

The Winnetka Beaches are a series of four beaches (i.e., Tower Beach, Lloyd Park Beach, Maple Park Beach, and Elder Park Beach) located in the municipality of Winnetka in Northern Cook County. Tower Beach is the northernmost of the Winnetka beaches and is located about 1.5 miles south of Glencoe Beach at Tower Road Park. Lloyd Park Beach is located about 200 yards down shore from Tower Beach. The 0.5-acre Maple Park Beach is located just south of Lloyd Park Beach at Maple Street Park. Elder Park Beach is located about a mile south of Maple Park Beach at Elder Lane Park. These beaches are located in the Low Bluffs region, an area that is dominated by shoreline recession (IDNR, 2011a). The village of Winnetka has an MS4 permit for stormwater discharge to Lake Michigan, and 60% of the stormwater is discharged to Lake Michigan through an outfall at the Elder Park Beach pier (Schulte, 2011).

Tower Beach is roughly 3 acres in size, with an additional direct drainage area of about 1.75 acres (**Figure 2-3**). A large pier with a parking lot extends into Lake Michigan at the southern boundary of Tower Beach. Winnetka Water and Electric is located south of Tower Beach.

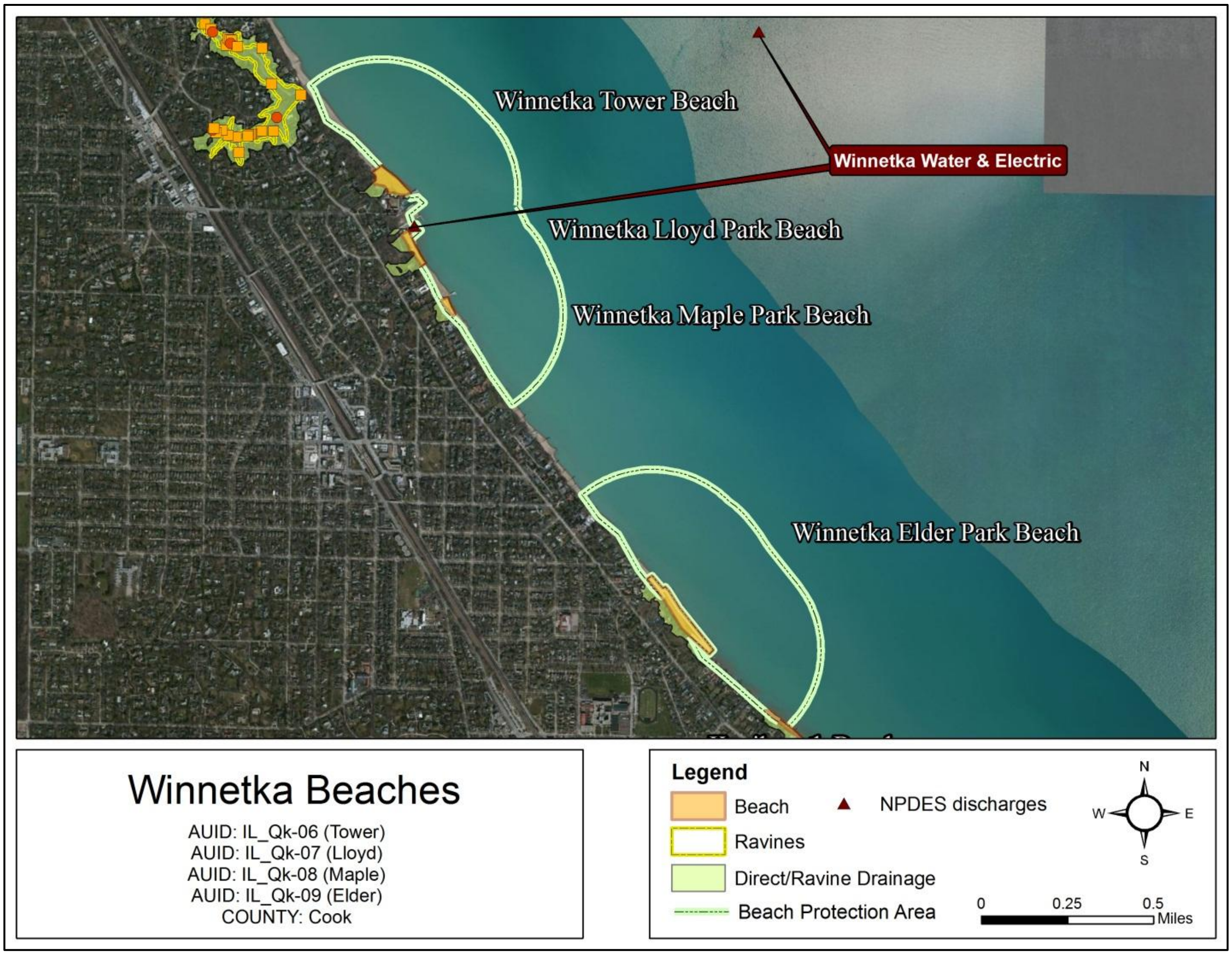


Figure 2-3. Winnetka Beaches and Drainage Catchments

Lloyd Park Beach is roughly 1.25 acres in size, with an additional direct drainage area of about 3 acres (Figure 2-3). This rectangular beach is flanked to the north by a pier/boat launch area. The western boundary of the beach contains parking spaces and a wooden boardwalk, and a large beach house is located in the center of the beach. This site is primarily used as a boat launch and is home to the Winnetka

Yacht Club. Swimming is not permitted. Winnetka Water and Electric is located north of Lloyd Park Beach and has an NPDES permitted discharge for non-contact cooling water at the beach and another point discharge a little over a mile (1.6 km) offshore for non-contact cooling water and stormwater. On average, Winnetka Water and Electric discharges 13.73 million gallons of water to Lake Michigan each day.

Maple Park Beach is a small rectangular beach (Figure 2-3). Its direct drainage area is about 1.5 acres in size and is composed of forested park and residential land. Maple Park Beach is bounded to the north by a pier with parking spaces. There are no point-source discharges in the vicinity.

Elder Park Beach is a thin, northeast-facing beach (Figure 2-3). It is the largest of the Winnetka beaches, with an area of about 4.5 acres with an additional direct drainage area of about 5.5 acres. The surrounding drainage area includes forested park, residential land, paved walkways, and a parking lot.

Shoreline armament to reduce erosion is common along this portion of the Illinois coastline (IDNR, 2011a). Elder Park Beach contains five hardened groyne structures and a concrete pier used primarily for fishing.

Table 2-2 shows information about beach monitoring and closures for the past 5 years. Stormwater is suspected to be a primary source of the contamination, but a 2010 sanitary survey conducted by the Village of Winnetka and the Winnetka Park District to identify sources of the contamination was inconclusive (Huston, 2011; Winnetka PD, 2011). The Village of Winnetka operates separate sanitary and stormwater sewer systems. Stormwater is discharged to waterways, including Lake Michigan. One of these discharges is to Lake Michigan at Elder Lane, near the Elder Park Beach. Sanitary wastewater is pumped to Skokie, IL, for treatment (Winnetka PD, 2011). In 2011 and 2012, the Village of Winnetka conducted a more in-depth examination of the stormwater sewer that discharges at Elder Lane and found several cross connections to and infiltrations from sanitary sewers. *E. coli* concentrations measured in water samples collected from the beach have been consistently low since the repairs were completed (Fornek, 2012). Centennial Dog Beach is located just south of Elder Park Beach. In 2010 and 2011, closures were attributed to agriculture, CSOs, and stormwater at Tower Beach; to agriculture, SSOs, and stormwater at Lloyd Park Beach and Maple Park Beach; and to agriculture, CSOs, stormwater, and other sources at Elder Park Beach (Illinois DPH, 2012).

The beaches are managed and monitored by the Winnetka Park District. The district collects samples daily. Swim bans are issued if a sample exceeds 235 cfu/100 mL (Winnetka PD, 2011).

Table 2-2. Monitoring and Single Sample Maximum WQS Exceedances for Winnetka Beaches in the Past 5 Years

Assessment Units Mapped to Indexed Beaches			Years	BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						Gull Counts
ID305B Unit ID	STORET Station ID	Impaired Segment Name		Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	
IL_QK-06	WNTOWER	Tower Beach	2007	7	1.6	6/14/2007	9/2/2007	70	STORET									
			2008	6	1.2	6/12/2008	8/23/2008	65	STORET									
			2009	1	2	6/12/2009	8/31/2009	79	STORET									
			2010	6	1.3	6/11/2010	8/20/2010	71	STORET									
			2011	4	2	6/11/2011	9/5/2011	80	STORET									
IL_QK-08	WNMAPLE	Maple Beach	2007	8	1.1	6/14/2007	8/13/2007	61	STORET									
			2008	4	1.5	6/12/2008	9/1/2008	73	STORET									
			2009	1	1	6/12/2009	8/30/2009	78	STORET									
			2010	4	1.25	6/11/2010	8/20/2010	72	STORET									
			2011	5	1.2	6/11/2011	9/5/2011	81	STORET									

(continued)

Table 2-2. Monitoring and Single Sample Maximum WQS Exceedances for Winnetka Beaches in the Past 5 Years (continued)

Assessment Units Mapped to Indexed Beaches				BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	STORET Station ID	Impaired Segment Name	Years	Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	Gull Counts
IL_QK-07	WNLLOYD	Lloyd Beach	2007	4	1.5	6/14/2007	8/18/2007	66	STORET									
			2008[1]			6/12/2008	8/23/2008	67	STORET									
			2009	0	N/A	6/12/2009	8/30/2009	78	STORET									
			2010	7	1.1	6/11/2010	8/20/2010	71	STORET									
			2011	0	N/A	6/11/2011	9/5/2011	80	STORET									
IL_QK-09	WNELDER	Elder Beach	2007	17	1.7	6/14/2007	8/18/2007	66	STORET									
			2008	13	1.8	6/12/2008	8/23/2008	67	STORET									
			2009	2	1	6/12/2009	8/30/2009	78	STORET									
			2010	13	3.2	6/11/2010	8/21/2010	72	STORET									
			2011	11	2.9	6/11/2011	9/5/2011	82	STORET									

[1]No closures or other actions listed in PRAWN for 2008 at Lloyd Beach

2.1.3 Kenilworth Beach

Kenilworth Beach is located less than a quarter mile south of Elder Park Beach in the municipality of Kenilworth in the Low Bluff region. The thin, 1.5-acre beach has a direct drainage area of about 6.75 acres (**Figure 2-4**). There are no point-source discharges in the direct drainage or the surrounding area.

Figure 2-4. Kenilworth Beach and Drainage Catchment

Shoreline armament to reduce erosion is common along this portion of the Illinois coastline (IDNR, 2011a). Kenilworth Beach also has two hardened groyne structures, one faces southeast and the other faces northwest.

Table 2-3 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures at Kenilworth Beach were attributed to stormwater and unknown sources (Illinois DPH, 2012). Centennial Dog Beach is located north of Kenilworth Beach in southern Winnetka, IL.

Kenilworth Beach is managed by the Village of Kenilworth Parks Department. Water samples are collected daily.

Table 2-3. Monitoring and Single Sample Maximum WQS Exceedances for Kenilworth Beach in the Past 5 Years

Assessment Units Mapped to Indexed Beaches			Years	BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						Gull Counts
ID305B Unit ID	STORET Station ID	Impaired Segment Name		Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	
IL_QL-03	KENILWORTH	Kenilworth Beach	2007	6	1	6/23/2007	7/29/2007	2	STORET									
			2008	5	1.2	6/6/2008	8/31/200	85	STORET									
			2009	4	1.75	6/5/2009	9/6/2009	93	STORET									
			2010	5	1.4	6/5/2010	9/6/2010	94	STORET									
			2011	4	1	6/10/2011	9/5/2011	88	STORET									

2.1.4 Wilmette Gillson Park Beach

Gillson Park Beach is located about a mile south of Kenilworth Beach in the municipality of Wilmette in the Low Bluffs region of Illinois. Gillson Park Beach is part of 60-acre Gillson Park and is composed of a sailing area, a swimming area, an area where swimming is not allowed, and a fenced-in dog beach (Wilmette PD, 2012). Wilmette Harbor borders Gillson Park Beach to the south and is adjacent to the dog beach area of the Park. The Village of Wilmette has an MS4 permit that allows stormwater discharge to the North Shore Channel, which is separated from Wilmette Harbor and Lake Michigan by a vertical lift gate. The North Shore Channel is part of the Chicago Area Waterway System (CAWS) and was originally built to use Lake Michigan water to flush sanitary wastewater from Chicago and its suburbs away from the lake. In general, the water in the North Shore Channel flows to the south, away from Lake Michigan. The flow within the Wilmette portion of the channel is supplied primarily by CSOs and stormwater overflows with some input from Lake Michigan through the gate. In extreme wet conditions, the flow direction in the North Shore Channel may reverse, carrying stormwater, CSOs, and treated but not sanitized wastewater from the North Side Water Reclamation plant into Lake Michigan. Between 1985 and 2004, 16 reversals occurred (IDNR, 2011b).

The long, 28-acre beach has an additional direct drainage area of about 2 acres (**Figure 2-5**). The North Shore Channel contains several NPDES discharges from CSOs, which periodically cause beach closures (Powers, 2011).

Figure 2-5. Wilmette Gillson Park Beach and Drainage Catchment

Shoreline armament to reduce erosion is common along this portion of the Illinois coastline (IDNR, 2011a). The beach contains a concrete pier and a jetty near its southern end.

Table 2-4 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures at Gillson Park Beach were attributed to agriculture, stormwater, and unknown sources (Illinois DPH, 2012). The dog beach is located at the southern end of Gillson Park Beach. Owners are required to pick up after their pets (Wilmette PD, 2012). North Shore Channel is located adjacent to the southern end of Gillson Park Beach. It accepts stormwater and CSOs from the Village of Wilmette. The harbor is also home to a U.S. Coast Guard Station and has room for approximately 300 vessels. The Wilmette Harbor Association offers pump-out services (Wilmette Harbor Association, 2012). The Village of Wilmette maintains a combined sewer system in the eastern portion of the town. Separate sanitary and stormwater sewers serve the western portion of the village.

Gillson Park Beach is managed by the Wilmette Park District. Water samples are collected at the swimming area daily from Memorial Day through Labor Day by the park district (Illinois DPH, 2012). The park district collects water samples from the dog beach once a week. In 2011, the IDPH also collected water samples from the beach twice a month from May through mid-September (Illinois DPH, 2012).

Table 2-4. Monitoring and Single Sample Maximum WQS Exceedances for Wilmette Gillson Beach in the Past 5 Years

Assessment Units Mapped to Indexed Beaches				BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	STORET Station ID	Impaired Segment Name	Years	Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	Gull Counts
IL_QL-06	WMGILLSON	Gilson Beach	2007	6	1.5	5/25/2007	9/2/2007	131	STORET									
▪ Dog beach adjacent.			2008	5	1.6	5/24/2008	9/1/2008	100	STORET									
			2009	2	1.5	5/23/2009	9/7/2009	227	STORET									
			2010	6	1.1	5/29/2010	9/5/2010	400	STORET	X								
			2011	7	1.7	5/28/2011	9/4/2011	386	STORET	X								

2.1.5 Evanston Beaches

The Evanston Beaches include five public swimming beaches and one private beach located within the municipality of Evanston. Lighthouse Beach is the northernmost beach and is located less than 2 miles south of Gillson Park Beach, Wilmette Harbor, and the North Shore Channel in northern Cook County. Northwestern University Beach is just south from Lighthouse Beach on the campus of Northwestern University. Clark Beach is located just south of the university campus and north of Dog Beach. South of Clark Beach and Dog Beach is Greenwood Beach. Lee Beach is about a quarter mile down shore from Greenwood Beach at Elliot Park, and South Beach is located about a half mile down shore from Lee Beach. Evanston's northernmost beach, Lighthouse Beach, is part of the Low Bluffs region. From the Northwestern University Beach southward, the upland slopes gently to the lakeshore, and bluffs are absent. The shoreline in this area is at or near the predevelopment location. Most of the shoreline has not been filled in; however, Northwestern University expanded their campus by filling in a portion of the shoreline (IDNR, 2011a; Northwestern University, 2012a). The City of Evanston has an MS4 permit that allows stormwater runoff to drain to Lake Michigan.

Lighthouse Beach is roughly 4.25 acres in size, with an additional direct drainage area of about 2.5 acres (**Figure 2-6**). The beach is bordered to the west by Lawson and Northeast parks. The beach is separated from the parks by large boulders designed to provide shoreline protection. Trash is often found in and among the boulders (City of Evanston, 2008). There are no point-source discharges in the immediate area.

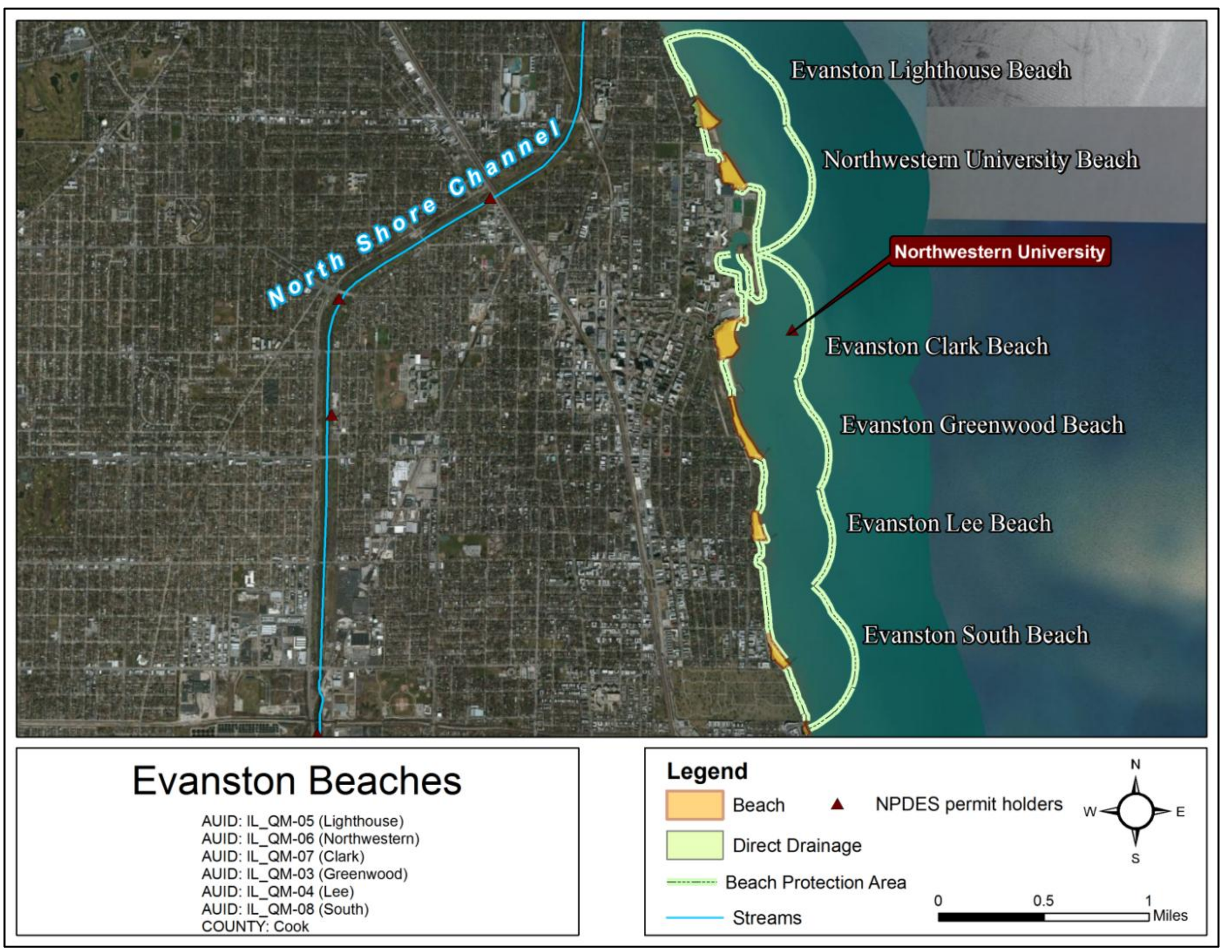


Figure 2-6. Evanston Beaches and Drainage Catchments

Northwestern University Beach (also called North Beach) is roughly 6.75 acres in size, with an additional 0.75 acres of direct drainage. The land surrounding this beach is highly impervious as it contains buildings and parking lots for Northwestern University. The southern end of the beach is flanked by a north-facing breakwater structure. The beach is free for use by University students and faculty; public beachgoers may access the beach for a fee.

Clark Beach is roughly 10 acres in size and drains an additional area of about 2 acres. The beach is the fourth out of the five public swimming beaches in terms of use (City of Evanston, 2008). A large parking lot is located directly north of the beach on the Northwestern University campus. Centennial City Park and Dog Beach border Clark Beach to the west and south, respectively. The rest of the land use in the drainage area is mostly university buildings and residences. Northwestern University has a NPDES discharge about a quarter mile offshore (Figure 2-6). The university is a minor discharger of cooling water to Lake Michigan with an average flow rate of less than 1 million gallons per day and is therefore not expected to be a source of *E. coli* to the nearby beach (i.e., permit limits specify monitoring requirements for chlorine, flow, temperature and pH only).

Greenwood Beach is a long narrow beach that is one of the most heavily used beaches in Evanston (City of Evanston, 2008). The beach is separated from Dog Beach to the north by a hardened boat ramp. The beach is about 7 acres in size and directly drains an area of about 0.5 acres. The landward boundary of the beach is defined by boulders designed for shoreline protection (City of Evanston, 2008). Greenwood Beach is near Dawes Park and is surrounded by mostly residential land. The Dempster St. Boat Launch is located at the south end of the beach.

The 3.5-acre Lee Beach faces east and has an additional drainage area of 0.5 acres. The beach is bordered to the north and west by Elliot City Park and is the most popular beach managed by the City of Evanston (City of Evanston, 2008). The surrounding land use is mostly residential and there are no point-source discharges in the immediate vicinity.

South Beach is the smallest beach in Evanston, with a size of about 3.25 acres and an additional drainage area of 0.5 acres. The beach is bordered by Garden City Park and Sheridan Road. Sand from the beach commonly blows onto the roadway and into the park (City of Evanston, 2008). The surrounding land use in the drainage area is fairly impervious with several high rise buildings and parking lots. There are no point-source discharges at South Beach.

In the Low Bluffs region, shoreline armament to reduce erosion is common (IDNR, 2011a). The southern boundary of Lighthouse Beach is marked by a hardened groyne structure. South of Northwestern University beach, shore-parallel structures are commonly employed for reducing erosion. Rubble-mound revetments are found along most of the Evanston lakeshore parks (IDNR, 2011a). Clark Beach has one east-facing breakwater structure that has created a circular embayment. Greenwood Beach is flanked on either side by two hardened groyne structures (one faces southeast and the other faces northwest). Lee beach contains one northwest-facing groyne at its southern edge. The southern edge of South Beach is bounded by a northwest-facing groyne structure.

Table 2-5 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures were attributed to stormwater and unknown sources at Lighthouse Beach and Lee Beach; agriculture, stormwater, and unknown sources at Northwestern University Beach, Clark Beach, and South Beach; and unknown sources at Greenwood Beach (Illinois DPH, 2012). Dog Park is located between Clark and Greenwood beaches. Owners are required to pick up after their dogs (City of Evanston, 2012). The City of Evanston has a partially separated sewer system.

The Evanston beaches, with the exception of Northwestern University Beach, are managed by City of Evanston Parks, Recreation, and Community Services (City of Evanston, 2012). Northwestern University Beach is owned and managed by Northwestern University (Northwestern University, 2012b). Water samples are collected daily during the beach season (generally Memorial Day weekend through Labor Day) by the Evanston Health Department on all six beaches (City of Evanston, 2012; Illinois DPH, 2012). The beaches are closed when water samples exceed 235 cfu/100 mL, following heavy rainfall, for 24 hours after the locks (gate) separating Wilmette Harbor and the North Shore Channel are opened, or after the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) reports a CSO event (City of Evanston, 2012). In addition, the IDPH collects water samples at Northwestern University Beach twice monthly during the swimming season (Illinois DPH, 2012).

Table 2-5. Monitoring and Single Sample Maximum WQS Exceedances for Evanston Beaches in the Past 5 Years

Assessment Units Mapped to Indexed Beaches				BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	STORET Station ID	Impaired Segment Name	Years	Number of Closures (#)	Average Duration of Closures (days)	Monitoring Start Date	Monitoring End Date	Number of Samples	Source	Replicate Samples	Multiple Samples/ Times per Day	Wind Direction	Wind Speed	Air Temp	Water Temp	Wave Category	Wave Height	Gull Counts
IL_QM-05	EVLIGHT	Lighthouse Beach	2007	10	1.3	6/27/2007	8/24/2007	4	STORET									
			2008	12	1	6/14/2008	8/31/2008	151	STORET									
			2009	7	1.3	6/13/2009	9/4/2009	167	STORET		X	X	X	X		X	X	X
			2010	1	1	6/11/2010	9/5/2010	155	STORET	X	X	X	X	X		X	X	X
			2011	6	1	6/11/2011	9/4/2011	84	STORET	X		X	X	X		X	X	X
IL_QM-06	EVNW	North-western University Beach	2007	7	1.3	6/14/2007	8/18/2007	3										
			2008	13	1.4	6/17/2008	8/31/2008	58	STORET									
			2009	3	2.7	6/17/2009	9/4/2009	38	STORET									
			2010	3	3	6/16/2010	8/31/2010	44	STORET									
			2011	5	1	6/14/2011	9/2/2011	54	STORET			X	X	X		X	X	X
IL_QM-07	EVCLARK	Clark Beach	2007	12	1	6/17/2007	8/9/2007	3	STORET									
			2008	13	1.3	6/14/2008	8/31/2008	152	STORET									
			2009	8	1	6/13/2009	9/4/2009	167	STORET		X	X	X	X		X	X	X
			2010	4	1	6/11/2010	9/5/2010	175	STORET	X	X	X	X	X		X	X	X
			2011	4	1	6/11/2011	9/4/2011	84	STORET			X	X	X		X	X	X

(continued)

Table 2-5. Monitoring and Single Sample Maximum WQS Exceedances for Evanston Beaches in the Past 5 Years (continued)

Assessment Units Mapped to Indexed Beaches				BEACH Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	**STORET Station ID**	**Impaired Segment Name**	**Years**	**Number of Closures (#)**	**Average Duration of Closures (days)**	**Monitoring Start Date**	**Monitoring End Date**	**Number of Samples**	**Source**	**Replicate Samples**	**Multiple Samples/ Times per Day**	**Wind Direction**	**Wind Speed**	**Air Temp**	**Water Temp**	**Wave Category**	**Wave Height**	**Gull Counts**
IL_QM-03	EVGREEN WOOD	Greenwood Beach	2007	10	1.6	7/2/2007	7/5/2007	4	STORET									
▪ Dog beach adjacent.			2008	16	1.4	6/14/2008	8/31/2008	152	STORET									
			2009	5	1	6/13/2009	9/4/2009	167	STORET		X	X	X	X		X	X	X
			2010	3	1	6/11/2010	9/5/2010	157	STORET	X	X	X	X	X		X	X	X
			2011	1	1	6/11/2011	9/4/2011	84	STORET			X	X	X		X	X	X
IL_QM-04	EVLEE	Lee Beach	2007	8	1.1	7/28/2007	8/19/2007	4	STORET									
			2008	13	1.8	6/14/2008	8/31/2008	153	STORET									
			2009	8	1	6/13/2009	9/4/2009	167	STORET		X	X	X	X		X	X	X
			2010	3	1	6/11/2010	9/5/2010	155	STORET	X	X	X	X	X		X	X	X
			2011	3	4	6/11/2011	9/4/2011	84	STORET			X	X	X		X	X	X
IL_QM-08	EVSOUTH	South Boulevard Beach	2007	15	1.7	7/29/2007	7/29/2007	1	STORET									
			2008	19	1.9	6/14/2008	8/31/2008	151	STORET		X	X	X	X		X	X	X
			2009	8	1.25	6/13/2009	9/4/2009	168	STORET		X	X	X	X		X	X	X
			2010	8	2.8	6/11/2010	9/5/2010	155	STORET	X		X	X	X		X	X	X
			2011	6	1	6/11/2011	9/4/2011	84	STORET		X	X	X	X		X	X	X

2.2 Current E. coli Conditions

All 13 impaired shoreline segments/beaches within suburban Cook County are monitored on weekdays (at least 4 days) by IDPH and local park management districts from approximately early/mid June until the beginning of September. In a few cases, monitoring begins in late May. The daily *E. coli* concentration measures are compared to the single sample maximum (SSM) and geometric mean (GM) WQS in **Table 2-6**. **Figure 2-7** provides a visualization of monitored *E. coli* levels versus the SSM across five beach seasons for the impaired segments. Corresponding beach closures/swim bans were presented in Tables 2-1 through 2-5 in terms of number of closures and average duration of the closures.

All shoreline segments addressed in this TMDL have experienced exceedances of the SSM in the past 5 years. Five years are assessed to provide a range of interannual variation such as wet and dry years and to more fully characterize source interactions. In addition, in suburban Cook County the impaired segments within Evanston, except for Northwestern University Beach, have been monitored for hydrometeorologic conditions and presence of gulls on days with water quality monitoring since at least 2009 (Northwestern University Beach was monitored for the additional data beginning in 2011). In terms of the number of SSM exceedances, none of the beaches show a clearly improving trend over the past 5 years. In all cases except Glencoe Park, Winnetka Maple Park, and Winnetka Elder beaches, 2011 saw an improvement over 2010 in the number of SSM exceedances. However, correspondence with the actual number of closures, which are typically based on single daily samples, instituted at each beach is somewhat mixed. There are a number of reasons for this lack of relation, including the time delay in sampling for *E. coli* and the reporting of the concentration (typically 18 hours), the practice of putting an advisory or closure in place after sustained rainfall regardless of monitoring, and multi-day closures, which may cover any number of SSM exceedances.

Exceedances of the GM differentiate more easily between the highly impaired beaches. Use of the GM gives less weight to a few elevated concentration values and differentials between sporadic exceedances and sustained water quality issues. The GM is more suited to assess long-term use impairment, while the SSM measures public health risk on a daily increment. This distinguishes the water quality targets needed for TMDL development and restoring designated uses from targets needed for daily beach management focused on the public. Comparisons between the SSM and GM exceedances highlight four beaches with likely continuous impairment sources rather than sporadic exceedances: Winnetka Elder Park, Evanston Lee, Northwestern University, and Evanston South. Two additional beaches appeared to have been under sustained impairment in 2008 only: Evanston Greenwood and Evanston Clark.

Table 2-6. 5-year Monitored Exceedances of the WQS

Beach	Year	Count of Single Samples	SSM Exceedances	Count of 30-day GM Calculations	GM Exceedances
Glencoe Park Beach	2007	1	1	0	0
	2008	53	5	24	0
	2009	87	13	58	0
	2010	90	6	58	0
	2011	56	16	28	0
Winnetka Tower Beach	2007	70	11	41	0
	2008	65	7	36	0
	2009	79	8	50	0
	2010	71	8	42	0
	2011	77	6	46	0
Winnetka Lloyd Park Beach	2007	65	6	36	0
	2008	66	2	36	0
	2009	78	4	49	0
	2010	71	8	42	0
	2011	80	5	51	0
Winnetka Maple Park Beach	2007	61	9	32	0
	2008	73	5	44	0
	2009	77	9	48	0
	2010	71	5	42	0
	2011	78	6	49	0
Winnetka Elder Park Beach	2007	66	29	37	37
	2008	67	22	38	12
	2009	76	30	46	33
	2010	72	44	43	43
	2011	77	40	48	27
Kenilworth Beach	2007[1]	N/A	N/A	N/A	N/A
	2008	79	5	50	0
	2009	84	6	52	0
	2010	87	7	57	0
	2011	88	5	59	0
Wilmette Gillson Park Beach	2007	38	4	1	0
	2008	100	7	71	0
	2009	108	4	79	0
	2010	100	10	71	0
	2011	100	13	71	0
Evanston Greenwood Beach	2007	4	0	0	0
	2008	79	15	50	0
	2009	84	7	55	0
	2010	84	6	53	0
	2011	84	4	54	0

(continued)

Table 2-6. 5-year Monitored Exceedances of the WQS (continued)

Beach	Year	Count of Single Samples	SSM Exceedances	Count of 30-day GM Calculations	GM Exceedances
Evanston Lee Beach	2007	4	0	0	0
	2008	79	16	50	1
	2009	84	9	55	0
	2010	83	12	52	0
	2011	84	4	54	0
Evanston Lighthouse Beach	2007	4	0	0	0
	2008	79	8	50	0
	2009	84	9	55	0
	2010	82	9	51	0
	2011	83	9	53	0
Northwestern University Beach	2007	3	1	0	0
	2008	58	18	28	16
	2009	36	7	11	0
	2010	43	16	18	18
	2011	54	9	26	7
Evanston Clark Beach	2007	3	1	0	0
	2008	79	9	50	0
	2009	84	7	55	0
	2010	84	8	53	0
	2011	83	4	52	0
Evanston South Beach	2007	1	1	0	0
	2008	79	29	50	45
	2009	84	15	55	0
	2010	83	29	52	41
	2011	84	11	54	0

[1]No data for 2007 at Kenilworth Beach

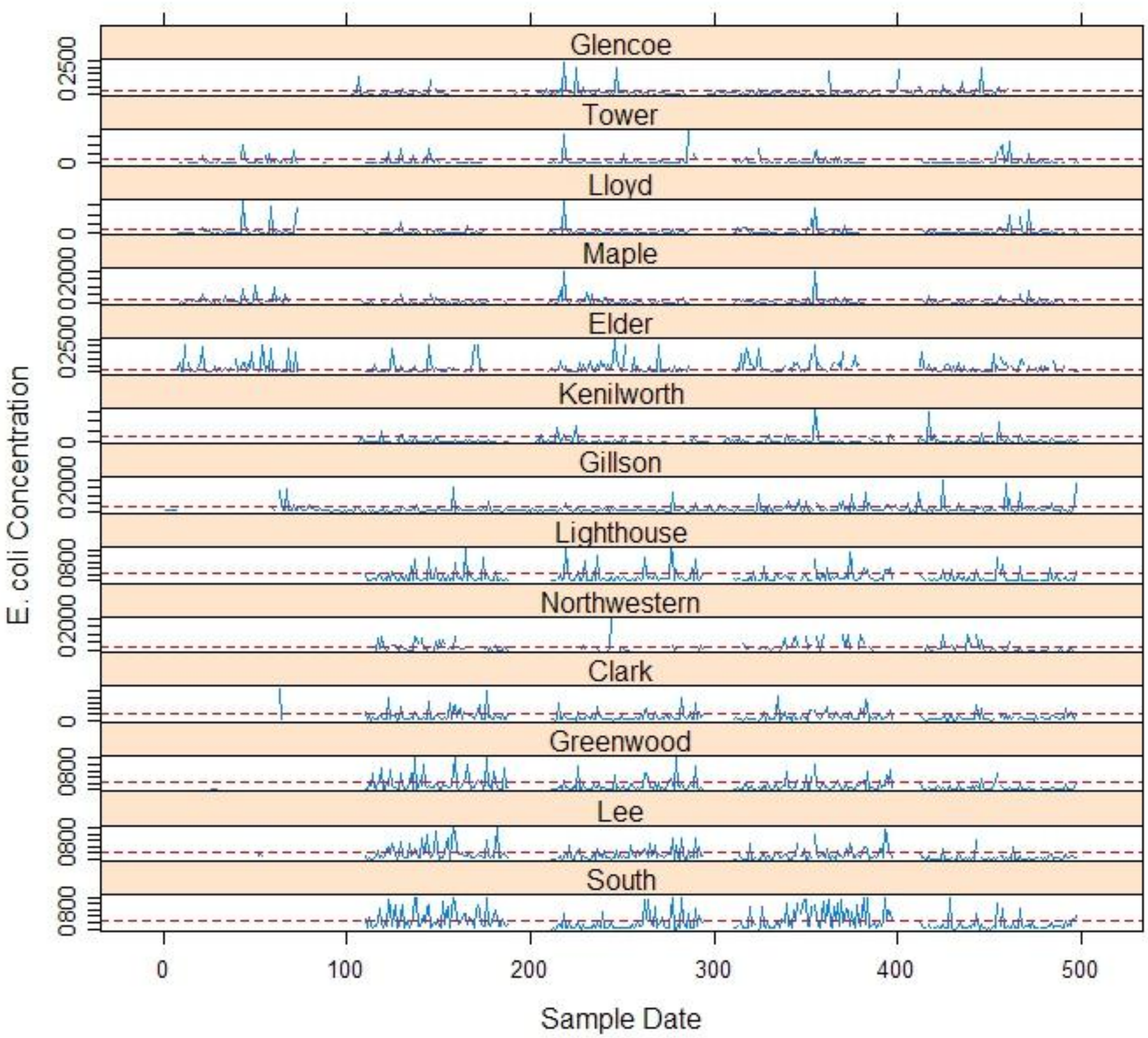


Figure 2-7. Monitored *E. coli* Levels in Suburban Cook County as Compared to the SSM WQS (red line) for May 2007–September 2011

3. Problem Statement

All 13 of the suburban Cook County impaired segments are in non-attainment of their designated use of primary contact recreation. According to Illinois WQS, "primary contact" means ...*any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing*" (35 Ill. Adm. Code 301.355). All shoreline segments in this TMDL have a designated use of primary contact recreation.

The Illinois 303(d) list report describes the guidelines for assessing attainment of primary contact use at Lake Michigan beaches. A Lake Michigan beach is *listed as impaired* if, over a three-year period:

1. On average, one or more beach closures occurred per year lasting less than a week, or
2. On average, less than one beach closure occurred per year, but the average closure duration was one week or greater.

For beaches identified as not-supporting primary contact use, *E. coli* is identified as. the pollutant causing recreational impairment if at least one of the bathing beach closures per year is due to an observed *E. coli* concentration above the WQS (as opposed to closures from dangerous swimming conditions, for example) (**Table 3-1**).

Table 3-1. Guidelines for Identifying Potential Causes of Impairment of Primary Contact (Swimming) Use in Lake Michigan Beaches and Open Waters[1]

Potential Cause	Basis For Identifying Causes - Numeric Standard[2]
Escherichia coli	On average, at least one bathing beach closure per year based on *E. coli* bacteria

[1] Excerpt from the Draft 2010 Illinois Integrated Report (IEPA, 2010).

[2] Department of Public Health Bathing Beach Code (77 Ill. Adm. Code 820.400): An *E. coli* count of 235 cfu/100 mL in each of two samples collected on the same day shall require closing the beach. Note: beaches in suburban Cook County are closed when one sample exceeds 235 cfu/100 mL. The 235 cfu/100 mL value is also consistent with the federal WQSs for Coastal and Great Lakes Recreation Waters.

Swim bans implemented by beach authorities are not equivalent to IEPAs definition of beach closure when IEPA assesses attainment. A *swim ban* or *advisory* occurs when *E. coli* exceeds 235 cfu/100 mL in each of two samples collected on the same day. In Cook County swim bans occur when one sample exceeds 235 cfu/100 mL. IEPA considers a *beach closure* as the consecutive number of days that swim bans are in place. Thus, in some instances, the SSM can be exceeded at a beach by some amount and still be in full support of the primary contact use under IEPAs listing methodology.

IEPA looked at swim bans and their duration according to their assessment methodology and found that all beaches met criteria to be listed as impaired. A summary of swim ban data, from Tables 2-1 through 2-5, collected for the TMDL illustrate that individual swim bans occur at a high enough rate for the waters to be listed as impaired on IEPAs 303(d) list (**Table 3-2**).

Table 3-2. Swim Ban Statistics for Impaired Segments Based on Reporting to the U.S. EPA's PRAWN System

Impaired Segment Name	Metric	Year	Number
Glencoe Beach	5-Year Average	N/A	10.5[1]
	Minimum	2010	5
	Maximum	2011	18
Tower Beach	5-Year Average	N/A	4.8
	Minimum	2009	1
	Maximum	2007	7
Maple Beach	5-Year Average	N/A	4.4
	Minimum	2009	1
	Maximum	2007	8
Lloyd Beach	5-Year Average	N/A	2.75[2]
	Minimum	2009&2011	0
	Maximum	2010	7
Elder Beach	5-Year Average	N/A	11.2
	Minimum	2009	2
	Maximum	2007	17
Kenilworth Beach	5-Year Average	N/A	4.8
	Minimum	2009&2011	4
	Maximum	2007	6
Gilson Beach	5-Year Average	N/A	5.2
	Minimum	2009	2
	Maximum	2011	7
Lighthouse Beach	5-Year Average	N/A	7.2
	Minimum	2010	1
	Maximum	2008	12
North-western University Beach	5-Year Average	N/A	6.2
	Minimum	2009&2010	3
	Maximum	2008	13
Clark Beach	5-Year Average	N/A	8.2
	Minimum	2010&2011	4
	Maximum	2008	13
Greenwood Beach	5-Year Average	N/A	7
	Minimum	2011	1
	Maximum	2008	16
Lee Beach	5-Year Average	N/A	7
	Minimum	2010&2011	3
	Maximum	2008	13

(continued)

Table 3-2. Swim Ban Statistics for Impaired Segments Based on Reporting to the U.S. EPA's PRAWN System (continued)

Impaired Segment Name	Metric	Year	Number
South Boulevard Beach	5-Year Average	N/A	11.2
	Minimum	2011	6
	Maximum	2008	19

[1] Average is based on 4 years of data for Glencoe Beach because PRAWN does not have any listing for 2010.

[2] Average is based on 4 years of data for Lloyd Beach because PRAWN does not have any listing for 2008.

3.1 WQS and TMDL Targets

There are both fecal and *E. coli* water quality criteria that are in place to protect recreational users of Lake Michigan Beaches within Illinois (**Table 3-3**). There are also two values for each of these parameters, one is a measure of central tendency (a GM), and the second is an upper limit (SSM). IEPA considered all of these criteria and selected the GM for *E. coli* over a 30-day rolling period as the TMDL target. The bacteria criteria and the rationale for this selection are discussed further below.

Table 3-3. Applicable Water Quality Standards for Bacteria at Lake Michigan Beaches in Illinois

Bacteria Water Quality Standards	
State Standard (From IL Admin. Code Sec. 302.505)	
Fecal Coliform (cfu/100 mL)	▪ Must not exceed a geometric mean of 200 cfu/100 mL ▪ More than 10% of the samples during any 30-day period shall not exceed 400 cfu/100 mL
Federal Standard (From 40 CFR Part 131 Part II. Final Rule. Water Quality Standards for Coastal and Great Lakes Recreation Waters. 16 Nov 2004.)	
E. coli (cfu/100 mL)	▪ Must not exceed a geometric mean of 126 cfu/100 mL[1] ▪ Single sample maximum of 235 cfu/100 mL (for designated bathing beaches)[2]

[1] The duration of time is not specified in the Federal Rule, but the U.S. EPA's 1986 bacteria criteria document, from which these values were taken, indicates that generally not less than 5 samples evenly spaced over a 30-day period should be used to calculate the geometric mean. From the Federal Rule (at Page 67224), "EPA expects from current practice by States and Territories that they will compute the geometric mean on either a monthly or recreation season basis."

[2] The single sample maximum (SSM) values are intended for use in making beach notification and closure decisions. (At P. 67225 of Federal Rule) The SSM may, but need not, also play a role in implementing other CWA programs.

State criteria for fecal coliform for non-open waters in Lake Michigan are found in Illinois Administrative Code Title 35 Section 302.505. Federal criteria for *E. coli* were promulgated for Great Lakes coastal recreation waters in 2004 in the *Final Rule for Water Quality Standards for Coastal and Great Lakes Recreation Waters* and are codified in 40 CFR 131.41 Subp. D. The 2004 Federal *E .coli* criteria apply to the Illinois Lake Michigan beaches (and other coastal and Great Lakes waters) that are designated for swimming, bathing, surfing, or similar water contact activities. The federally promulgated standards also apply to existing State bacteria standards for recreation waters. While both standards in Table 3-3 apply to the Lake Michigan shoreline segments addressed in this TMDL, IEPA selected the *E. coli* criteria for use in developing the TMDL.

The *E. coli* standard was selected for the TMDL for multiple reasons. First, beach managers monitor for and make swim ban decisions based on Federal *E. coli* standards. Second, the *E. coli* and fecal coliform numerical criteria are based on detectable effects between decreasing water quality and increasing risk to gastrointestinal illness. When the 1986 criteria values were developed for *E. coli* the illness rate associated with the GM was determined to be 8 out of 1000. However, studies indicate illness rates are more accurately predicted by *E. coli* than fecal coliform (Dufour, 1984). Lastly, it can be reasonably assumed that corrective actions to reduce bacteria at beaches will reduce both *E. coli* as well as fecal coliform counts, given that *E. coli* is one of many fecal bacteria comprising the fecal coliform group.

Next, in selecting how to apply the *E. coli* criteria as a target for the TMDL, IEPA considered both the SSM and the GM (assuming a 30-day period) criteria. The GM was selected as the target for the TMDL. Under this target some percent of samples might exceed the SSM and still meet the GM over a 30-day period; based on data collected at these beaches, it was estimated that the SSM would not be exceeded by more than 10% of samples collected. IEPA selected this approach because it provides illness rate protection that is equivalent to what was intended by the bacteria criteria when they were developed, and it is consistent with the U.S. EPA's position as described in its promulgated federal criteria (Pages 67224-5 of Federal Register Notice, November 16, 2004).

The GM and SSM bacteria criteria applicable to these beaches were promulgated by U.S. EPA in 2004 and are based on EPA's 1986 criteria values. When the 1986 criteria values were developed, a GM of 126 cfu/100 mL was the GM of the water quality distribution that showed a significant correlation between decreasing water quality and increasing risk to gastrointestinal illness. The illness rate associated with the GM was estimated to be 8 out of 1000. An upper limit was also calculated as part of the standard in order to reduce the chance of an unnecessary beach closure based on a single sample. This upper limit was 235 cfu/100 mL and represents the 75% confidence interval from the dataset whose GM was 126 cfu/100 mL[1]. Thus the SSM and GM are linked to the same dataset and same illness rate, but the SSM provides a value to base beach closure decisions on a single sample with a given level of confidence in that decision.

The TMDL target for the Illinois Lake Michigan Beaches TMDL was set at the GM criterion with a given level of SSM exceedance, on the basis that the GM criterion is the more relevant measure to develop allocations and that SSM was not necessarily intended for use as a never to exceed value in TMDLs. This is consistent with EPA's 2004 promulgation of bacteria criteria which clarified U.S. EPA's expectations regarding the use of SSM: "geometric mean is the more relevant value to protect and improve water quality because it is a more reliable measure, being less subject to random variation...." [2] Also, a TMDL based on the SSM as a never to exceed criterion could lead to unnecessarily restrictive allocations, as it may be possible that exceedance of the SSM can occur and a water could achieve the same level of health protection if bacteria levels met a GM of 126 cfu/100 mL (8 out of 1000 illness rate). Using a GM as the target may allow for large spikes in *E. coli* to occur but the TMDL would still be met if these spikes occurred at a low enough frequency that the GM is not exceeded; this is a function of the way a GM is calculated (as evidenced in Table 2-8). This allows for a TMDL to be written that results in achievable reduction strategies and will still meet standards that are applicable to "other Clean Water Act applications" (Page 67224 of the Final Rule).

Use of the GM for the TMDL does not change, or in any way undermine, current beach monitoring efforts. Beach monitoring is conducted by local entities (e.g., IDPH, LCHD, and CPD) and makes use of the SSM to help identify public health risks related to swimming on a particular day, whereas the TMDL study is undertaken to assess sources and assign allocations in order to improve water quality and restore designated uses.

---

[1] The 2012 recommendations use a 90th confidence interval which is 410 cfu/100 mL

[2] Pages 67224-5 of Federal Register Notice, November 16, 2004

In November 2012 U.S. EPA released recommendations for Recreational Water Quality Criteria (2012 RWQC). The Beach Act directs States and Tribes to adopt and submit to U.S. EPA the RWQC for Beach Act waters. Although the Illinois Lake Michigan beaches TMDL target was based on the 2004 Federal *E. coli* criteria, which was the applicable criteria at the beginning of the assessment, the target still provides at least equivalent protection as would be provided by the 2012 RWQC. The 2012 RWQC recommend that *E. coli* should meet a GM of 126 cfu/100 mL over a 30-day period and that an upper statistical threshold value (STV) of 410 cfu/100 mL is not to be exceeded by more than 10% of the samples. The TMDL target, by comparison, is set so that the GM of 126 cfu/100 mL is met over a 30-day period, and where the 30-day GM is achieved, the Illinois Lake Michigan beaches were estimated to be greater than the SSM of 235 cfu/100 mL by no more than 10% of the samples. Thus when bacteria criteria based on the 2012 RWQC become applicable to these waters, this TMDL would still provide at least the equivalent level of health protection. This does not indicate that the 2012 RWQC provide less protection than the 2004 and 1986 bacteria criteria; in this instance, site-specific data are being used to estimate how often the SSM would be exceeded, and the SSM was not intended to be a value not to be exceeded by 10% (i.e., it was calculated as the 75th confidence interval about the GM criteria). In the 2012 RWQC a beach action value (BAV) replaces the concept of the SSM in the 2004/1986 criteria. BAVs are provided for informational purposes only and for use in beach notification decisions if the state chooses. If, in the future, it becomes apparent that the TMDL does not provide equivalent protection according to newly adopted criteria, the TMDL may be modified.

Employing a margin of safety (MOS), a required element of the TMDL, within the allocation calculation is one way to demonstrate how the probability of exceeding the SSM will also be lowered when using the geometric mean as the TMDL target. This selected target applies on any given day, relying on the previous 30 days of water quality measures to form a GM, to assure achievement of the bacteria whenever the WQS are in effect (i.e., swimming season). An MOS may be implicit or explicit based on the selected application and method of calculation.

Although a TMDL is typically defined in terms of a loading (mass per day) instead of a concentration (mass per volume), IEPA believes that for bacteria along the Lake Michigan shoreline the concentration-based TMDL is the most useful format for guiding both remediation and protection efforts at these impaired segments. Also, a concentration target is more readily understandable to the public, and allows interested citizens and/or watershed groups to determine easily whether any particular source is exceeding its allocation.

3.2 Linkage Analysis

In order to identify the sources of bacteria to the impaired segments, given no sources are immediately identified in the 303(d) listing, research was conducted into studies of beach contamination in the area and over swimming beaches in general. Then, any data on identified potential sources were gathered from the available site-specific data provided by local beach managers, federal data repositories, and beach monitoring groups (e.g., Alliance for the Great Lakes' Adopt-a-Beach program). These data were screened to provide a daily time series of any available monitored source or other environmental parameter with a corresponding bacteria measurement. The environmental parameters include measurements that may be considered a surrogate measure of a potential bacteria source, such as magnitude of precipitation as a surrogate for stormwater. Finally, these time series were used in a statistical method (described in **Section 4.8**) to determine which monitored sources or other environmental parameters were best correlated with the daily monitored bacteria concentration.

Direct linkages between sources of bacteria and pathogens and water quality along the shoreline are typically unclear due to the highly dispersed nature of the shoreline hydrology and varied overland drainage surrounding a beach/shoreline segment. For the logical, implied sources such as wildlife and stormwater, there is often little published information on actual quantifiable impacts. There is also often a lack of quantified and monitored point-source discharges or other easily identifiable sources directly along the shoreline where water quality is an issue. When available, studies on sources of bacterial water quality impairments to bathing beaches are often highly site specific, although the findings may be generalized to a larger number of locations. For instance, studies at the embayed 63rd Street Beach in Chicago point to entrainment of bacteria and water under certain lake current conditions that leads to greatly reduced water quality (Ge et al., 2010). A similar finding can likely be extrapolated to other embayed beaches.

Using published literature, a number of potential bacteria sources were identified for the shoreline areas. Several studies along the shoreline in Wisconsin provided guidance on how to examine the source of bacteria along the Illinois shoreline in the absence of source tracking studies for all sites. In one study, McLellan and Salmore (2003) conducted a detailed monitoring study of a public beach within Milwaukee that included both dry and wet weather sampling across multiple shoreline and offshore sites for *E. coli*. Their findings indicate that, for both wet and dry conditions, shoreline sites had significantly higher *E. coli* levels than offshore regions where the shoreline samples exceeded the SSM WQS 66% of the time. They also found that these high levels coincided with the presence of birds and stormwater at the swimming beaches, but that the high levels were not correlated with *E. coli* levels in a connecting harbor. The authors concluded that local, persistent contamination is likely the major source of high *E. coli* levels over regional sources. Similarly, Scopel and others (2006) determined that the major water quality impacts at a local beach in Bayview, WI, were from delivery of pollutants from the adjacent shore following rain events rather than from a CSO to the north of the beach. Combining knowledge gained in the intensive study of the Wisconsin shoreline, it has been proposed by local experts that a point source of bacteria can impact water quality along the shoreline within a distance of approximately 500 m of the discharge (i.e., the BPA). Outside of this boundary, lake dynamics lead to dispersal and mixing of pollutants, rarely allowing a specific source beyond this range to be identified among the other sources as a contributor to poor water quality at the shoreline segment of interest (Scopel et al., 2006).

Given this information, this TMDL analysis has attempted to gather and quantify any potential source variables or surrogate variables identified within 500 meters along shore/into the lake (i.e., the BPA) and within the beachshed or to a channel that discharges within the BPA or the beachshed. Figure 2-1 provided a map illustrating the 500-m distance along the shoreline known as the BPA. **Table 3-4** lists the different source variables and surrogate variables identified in the analysis. Surrogate variables are measurable values that can be used to quantify or qualify a source of bacteria or a factor that may contribute to increases or decreases in bacteria concentrations along the shoreline.

The following sections provide information on the data sources used to quantify and identify each of the potential sources of bacteria or surrogate variables.

Table 3-4. Source Parameters as Used in the Multi-Level Modeling for TMDL Development and Potential Management Methods

Surrogate	Metric	Surrogate For	Manageable Parameter	Method
Known/Assumed Sources				
Number of gulls	Count	Bacteria in bird fecal matter	X	Egg oiling; dog patrol
Number of beach goers	Count	Human sources; disturbance of sediments	X	Fees; restrictions?
Area of specific land use class (e.g., area of high density residential land)	Area	Depending on land use bacterial sources	X	Sewering; Best Management Practices (BMPs); Ravine restoration
Point source loading	Magnitude	Direct source loading	X	Load reductions
River reversal events (i.e., Locks opening after large storm event)	Type or Magnitude	Direct source loading; accounted for in monitored water quality when available		Other actions (see **Section 4.1.3**); Operated by the U.S. Army Corps of Engineers (USACE)
Physical Influences				
Beach slope	Magnitude	Potential for greater swash zone	X	Grading
Embayment	Type	Effects of hydrodynamics	X	Alteration of jetties, walls, etc.
Substrate	Type	Potential for bacterial attachment and growth	X	Beach supplementation
Hydrometeorological Influences				
Precipitation magnitude (e.g., previous 24 hours)	Magnitude	Washoff	X	Green infrastructure such as porous pavement and rain gardens. Stormwater BMPs
Hours since rain event	Temporal	Build-up	X	Stormwater BMPs, street sweeping, and beach grooming
Air and water temperature	Magnitude	Bacterial growth and die-off		
Wind speed	Magnitude			
Wind direction	Type	Influence of Lake Michigan off-shore waters		
Lake Influences				
Wave height	Magnitude	Resuspension from slosh zone		
Current velocity	Magnitude	Influence of Lake Michigan off-shore waters		
Current direction	Type	Influence of Lake Michigan off-shore waters		

3.2.1 The Great Lakes Coastal Forecasting System

To estimate the lake effects on beach water quality such as wave action and current directions, model estimates from the National Oceanic and Atmospheric Administration's (NOAA's) Great Lakes Coastal Forecasting System (GLCFS) were used. The GLCFS is a numerical model that calculates waves, currents and temperatures for each of the Great Lakes based on available observational data systems (e.g., buoys). The GLCFS Nowcast runs four times per day and provides estimates of conditions at the time the model is run. The GLCFS Forecast runs twice per day and predicts conditions 60 hours into the future. GLCFS data are stored on the Great Lakes Observation System (GLOS) THREDDS server after each run of the model. Archives of Nowcast results are created for each completed calendar year beginning with 2006.

Two sets of model results are created during each run, one defining conditions on the surface (two-dimensional) and one that defines circulation within the lake (three-dimensional). Within Lake Michigan results are produced on a 2-km grid scale. For this analysis a latitude and longitude point nearest each beach was identified within the interior of the local GLCFS grid cell. Each point was then used within the GLCFS data download point query available through NOAA's website to obtain all available data for the corresponding grid cell. **Table 3-5** identifies the parameters utilized from the GLCFS download. Although the available data are reported at 15-minute intervals every day, the values for the 15-minute interval closest to the *E. coli* sampling time is used as the corresponding measure to the water quality sample.

Table 3-5. Fields in GLCFS Data

GLCFS Parameter
Bathymetry (m)
Model Water Level (m)
Eastward Water Velocity at Surface (m/s)
Northward Water Velocity at Surface (m/s)
Water Velocity at Surface (m/s)
Water Velocity at Surface Direction (degree)
Significant Wave Height (m)
Wave Direction (degree)
Wave Period (s)

m/s = meters per second

One example of the lake effects on water quality at a swimming beach is illustrated in **Figure 3-1** using log-normalized *E. coli* concentrations (i.e., the log-normalized SSM WQS is 5.5, whereas the log-normalized GM WQS is 4.8). Using a compilation of data from suburban Cook County beaches, the influence of wave action on *E. coli* concentrations is clear; rough wave action can be correlated with higher *E. coli* concentrations along the shoreline. Other impacts from water velocity and wave activity are also shown to have some impact on the bacterial water quality at the impaired segments, as described later in this document.

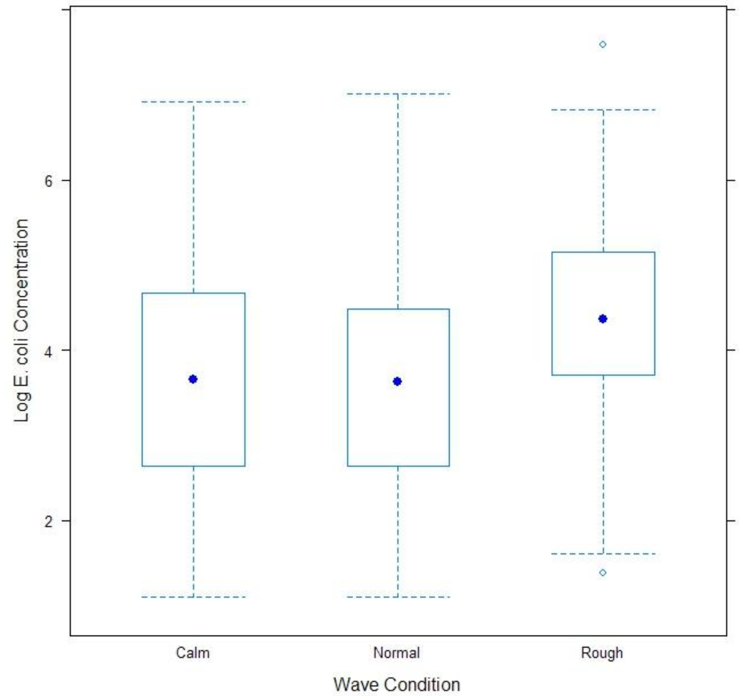


Figure 3-1. *E. coli* Concentrations by Wave Condition

3.2.2 Precipitation

Precipitation in itself is not a cause of water quality impairment by bacteria. However, when precipitation falls on the land surface, it gathers bacteria that have built up during dry weather, and the water flows downhill toward a receiving water. Along the Illinois shoreline, the receiving water may be a stormwater catchment basin, a stream, a ravine, or even the shoreline itself. To account for this stormwater influence, hourly precipitation measures from several local weather stations were gathered and analyzed to determine precipitation conditions corresponding to each *E. coli* water sample available. Three different precipitation measures were assessed for their correlation to water quality:

- Hourly amount
- Past 24-hour total
- Hours since last rain event

As noted earlier, stormwater has been demonstrated to contribute to impaired water quality at numerous beaches in the Great Lakes. In a general analysis of all suburban Cook County beaches, the *E. coli* concentrations on days with rain during the past 48 hours (**Figure 3-2**) were greater than on days with no rain. The relationship found at suburban Cook County beaches indicates that expected concentrations of *E. coli* rise as precipitation amounts increase. In addition, the impacts of precipitation may be compounded on those beaches with hardened structures, either by focusing and exacerbating the stormwater impact or by sheltering the beach from what could otherwise be larger stormwater impacts.

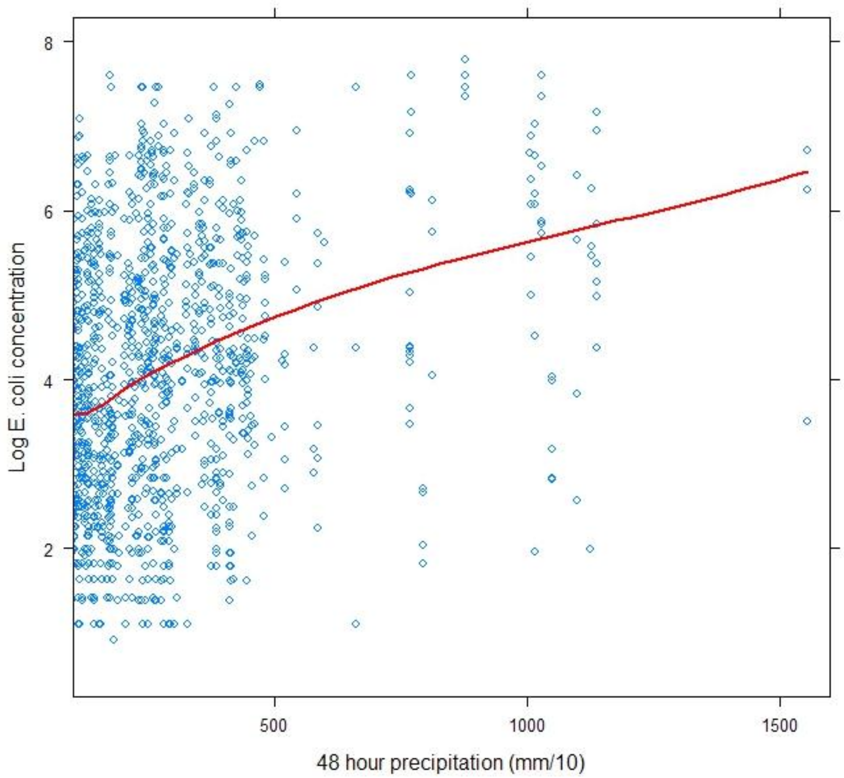


Figure 3-2. Influence of 48-hour Precipitation on Water Quality (2007–2011)

3.2.3 Land Use/Cover

The land cover layer for Cook County is based on the 2006 National Land Cover Database (NLCD) layer. The 2006 NLCD layer is a 30-by-30 m land cover grid; it contains 8 major land cover classifications and 28 specific land cover classifications. A few of the specific categories were reclassified or renamed to produce a more comprehensive land cover map (**Figure 3-3**). **Table 3-6** describes the 11 land cover classifications used for the Cook County Land Cover Map in more detail.

Table 3-6. Major Land Use and Land Cover Classifications in the 2006 NLCD

Land Cover Class	Description
Open Water	All areas of open water, generally with less than 25% cover of vegetation or soil
Developed Open Space	Less than 20% impervious surface, mostly covered by lawn or grass, includes large single family housing, parks, golf courses and other recreation
Low-Density Urban	Areas with 20-49% impervious surface, mostly single family housing units
Medium-Density Urban	Areas with 50-79% impervious surface, mostly single family housing units
High-Density Urban	Areas with 80-100% impervious surface, includes apartments, row houses and commercial/industrial land use
Barren Land	Barren areas of bedrock, sand dunes or any other area where vegetation is less than 15% of the total cover
Forest	Includes deciduous, evergreen and mixed forest cover
Grassland	Areas dominated by herbaceous vegetation
Pasture	Areas of grasses, hay or legumes for livestock grazing or the production of seed crops
Agriculture	Cultivated crop areas used for the production of corn, soybeans, tobacco, cotton or other annual crops
Wetland	Includes woody, palustrine, estuarine and emergent herbaceous wetlands

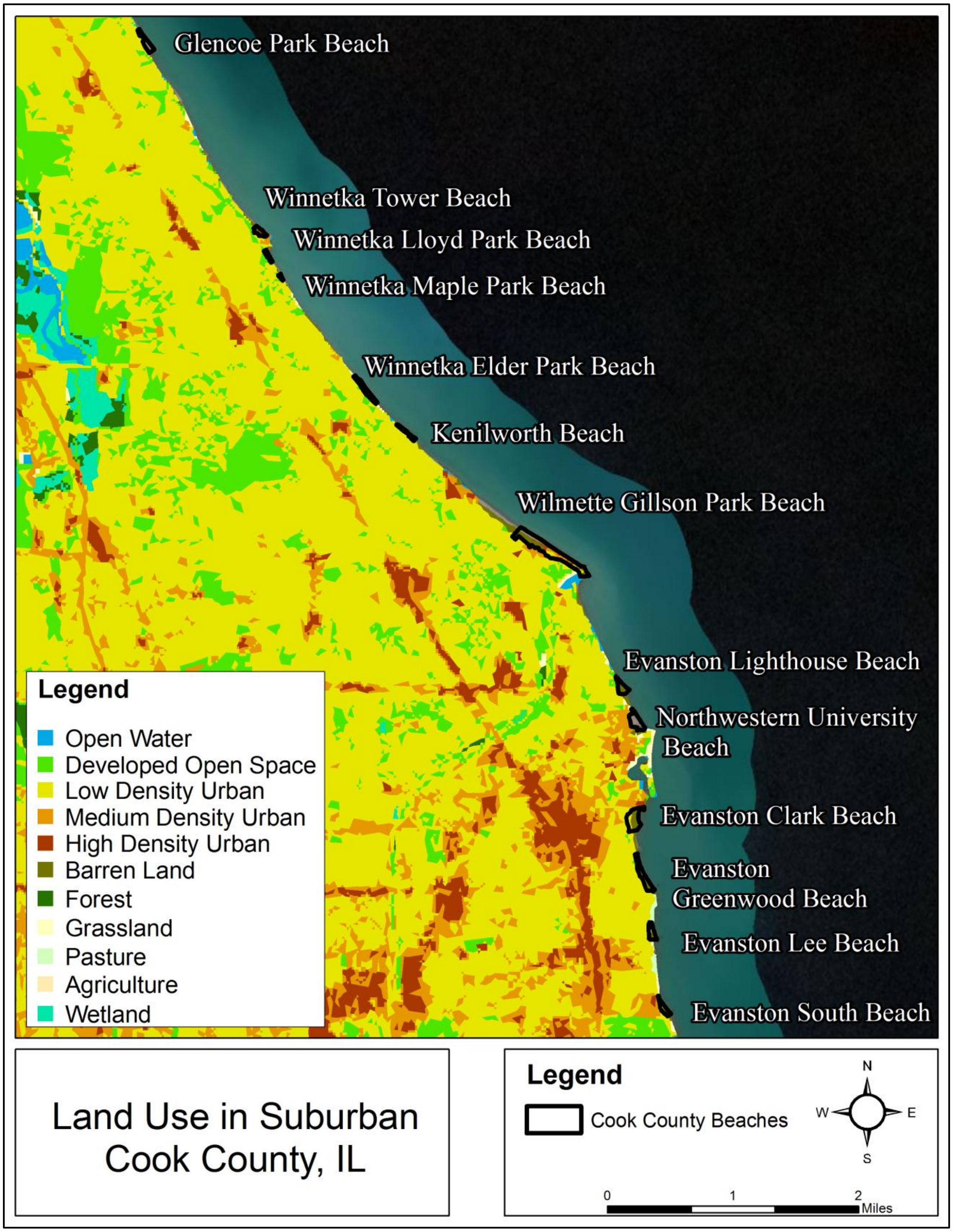


Figure 3-3. Land Use along the Shoreline in Suburban Cook County

3.2.4 Substrate

Spatial coverages of macro- and micro-substrate within southwestern Lake Michigan were compiled by Creque and others (2010) using information gathered over 72 years for Illinois waters. The researchers used sediment data for 1682 sites within a GIS and applied natural neighbor interpolation to predict sediment type in areas lacking data. Sediment data points were most concentrated within the nearshore area.

Figure 3-4 displays the micro-substrate along the Illinois shoreline. Substrate types vary from pebble to coarse and medium sands near the impaired shoreline segments. Comparison of monitored *E. coli* levels in suburban Cook County support findings in peer-reviewed research that finer substrates are more likely to harbor and allow build-up of bacteria than coarser, looser substrates.

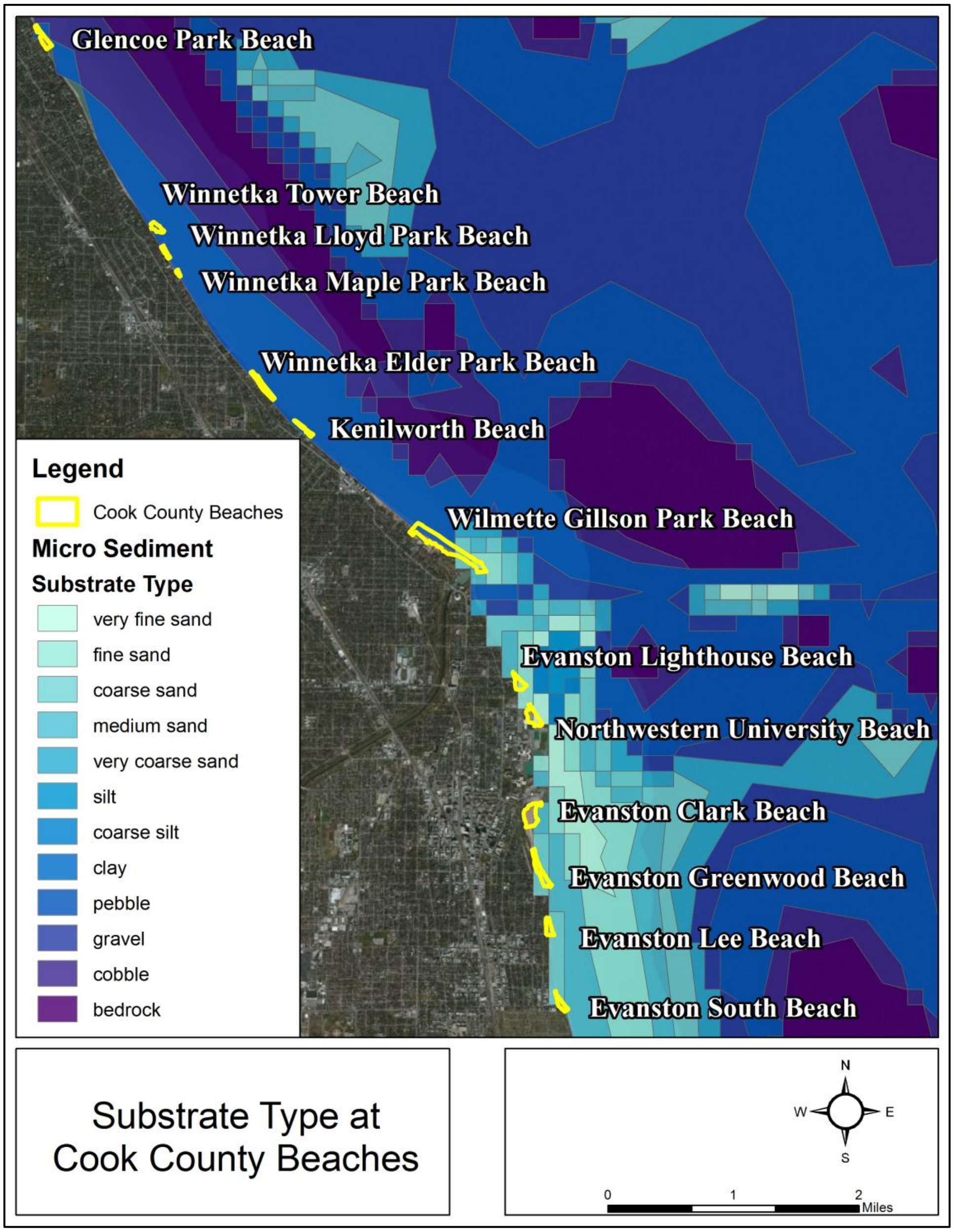


Figure 3-4. Substrate along the Shoreline

3.2.5 Shoreline Physical Characteristics

The physical characteristics of an impaired segment can vary greatly from one another, and these characteristics have varying impacts to beach water quality. Along the Illinois shoreline, the impaired segments under study vary from unprotected straight segments, to curved segments with barriers on each end. **Figure 3-5** provides an aerial look at two of the different structures of interest to this analysis because of the way these features permit or block the circulation of water, sediment, and bacteria from entering and staying within the impaired water areas.

Figure 3-5. Example of Physical Structures at Shoreline Segments

Therefore, to understand the impacts of the different physical features of each segment, satellite imagery from Google Earth was used to examine each segment in detail. The following determinations were applied where applicable:

- Embayment morphology refers to a beach with a "C" shape enclosure (generally due to hardened structures such as jetties, groynes) that isolates the site from long shore currents.
- "Channel" indicates if there is a tributary/ravine discharging directly to the beach. Whether the channel was to the north, south, or on either end of a segment was noted.
- General hardened structures (e.g., groynes) were identified and located (north, south, along, segmenting) within each segment.

In an analysis separate from review of aerial images, we also used LIDAR to determine the average slope of each shoreline segment.

3.2.6 Ravines

The ravine structures in the northern portion of suburban Cook County have developed over time due to the unique geology of the Lake Border Upland region near the coast of Lake Michigan. Ravines are present within the drainage area for Glencoe Park Beach with the most southern ravine drains an area just to the north of the BPA for Winnetka Tower Beach (**Figure 3-6**). The ravines were created gradually as rainwater eroded the land along the bluffs as it traveled toward the lake. Eventually, the gradual erosion caused by rainwater was balanced by the establishment of trees and plants whose root systems helped to stabilize the banks. The shape and location of the ravines have created a unique microclimate that supports tree and plant species that are usually found in colder, moister, and more northern climates.

More recently, the ravines have been affected by the growing urban development that surrounds them. Urban regions have large areas of impervious surface that generate great volumes of runoff during a rain event. The high volume and velocity of surface water runoff has increased erosion along the ravine banks and has inhibited the establishment of tree and plant species. Furthermore, numerous stormwater outfalls from both residential properties and stormwater transmission systems directly drain to ravines, and this additional quantity of water compounds the rate of bank erosion. Typically, residential drainages are small pipes 6 inches or less in diameter that are unpermitted and drain properties surrounding the ravine banks. The stormwater outfalls can be 12 inches or larger in diameter and may transmit stormwater from any large areas of the lands in the vicinity of the ravine. The resulting rapid bank erosion threatens the establishment and well-being of the rare tree and plant species that make these ravine ecosystems so unique (Alliance for the Great Lakes, 2009).

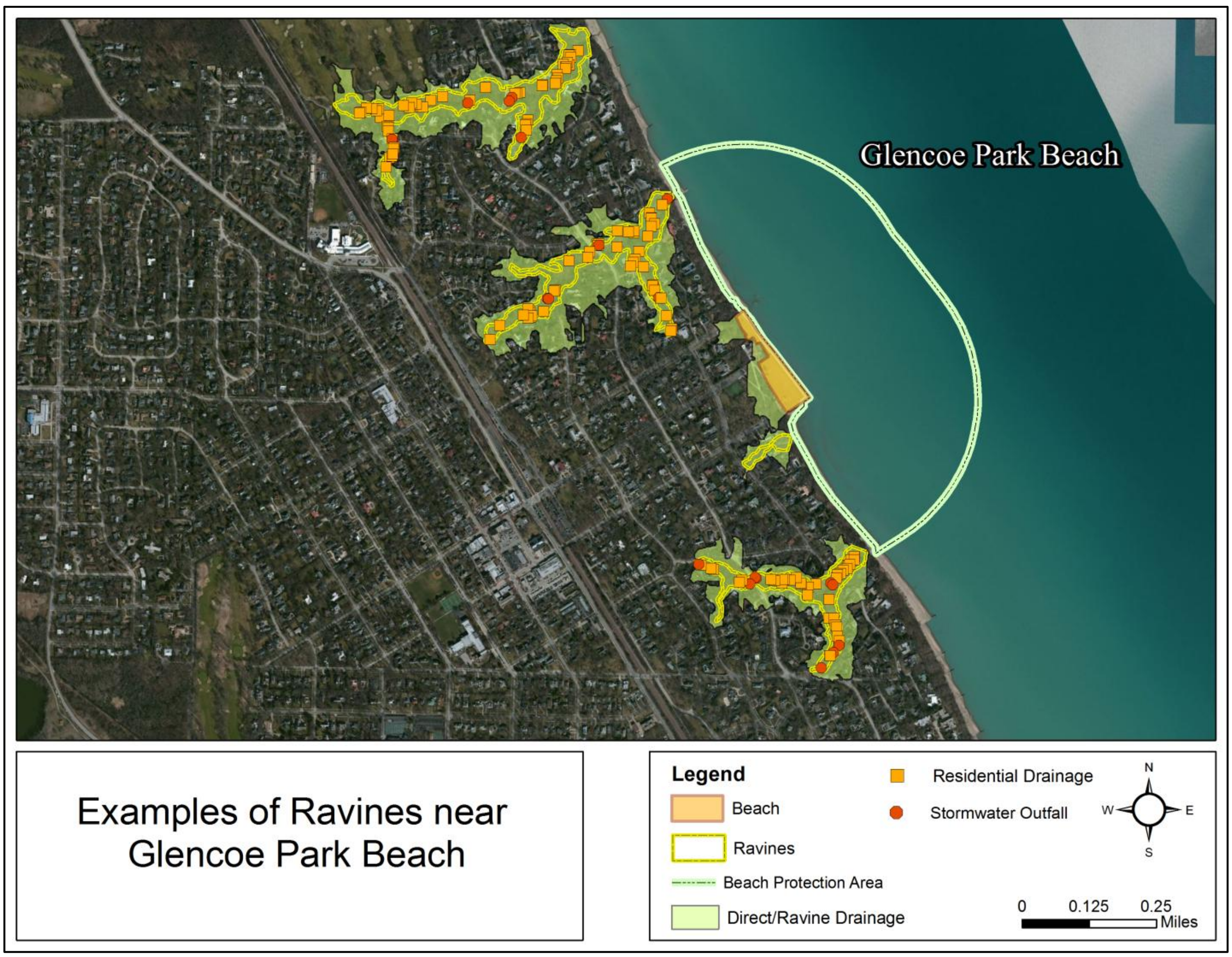


Figure 3-6. Ravines along the Shoreline in Lake County

3.2.7 Chicago Area Waterway System (CAWS)

The CAWS, under control of the MWRDGC, consists of 78 miles of man-made canals and modified river channels that support commercial navigation. Over 70% of the river volume originates from the discharge of treated municipal wastewater effluent (i.e., point source) from four water reclamation plants (WRPs). Additionally, it receives storm water, tributary streams, and runoff from urban and rural areas. CSOs discharge from Chicago systems (200), suburban systems (89), and the MWRDGC system (27). It also supports recreational activities (e.g., boating, fishing, streamside recreation) and provides habitats for wildlife (MWRDGC, 2008). The CAWS was designed to divert water from Lake Michigan into the Des Plaines and Calumet rivers rather than having the rivers flow into the lake. By U.S. Supreme Court Decree, the District is allowed specific volumes of Lake Michigan water as discretionary diversion. Currently this volume is 270 ft^3/s. This diversion is used primarily in the critical summer months to improve the water quality of the District waterways.

However, reversals from the CAWS back into Lake Michigan can also occur under very rare extreme wet weather events. The discharge during these events is the product of multiple point and nonpoint sources. The number of reversals from the CAWS to Lake Michigan was reduced through the implementation of the Tunnel and Reservoir Plan (TARP) in 1972. The three lock structures through which reversals may occur include the Wilmette Pumping Station, the Chicago River Controlling Works, and the O'Brien Lock and Dam. Authority to control the lock structures resides with the USACE. Only the Wilmette Pumping Station is within suburban Cook County at the south end of Wilmette Gillson Beach (see Figure 2-5).

3.3 Loading Capacity and Existing Load

Development of TMDLs for the shoreline of Lake Michigan presents differences compared with the typical determination of a loading capacity for an impaired segment corresponding to a lake or stream. First, the impaired shoreline segments do not have a single identifiable flow regime. These segments are under the influence of three-dimension currents and tides. Second, there is not a defined point in the geography over which the volume of water may be measured to compute a reliable loading off of the concentration measures available from monitoring. Finally, loadings of bacteria, which depend on a volume of flow, are less likely to directly correlate with measured concentrations at a beach due to the high variability in the bacterial water quality over time and between sources. For these reasons, the loading capacity used to develop these TMDLs is concentration-based and set at the WQS.

In simplified terms, the standard formula changes to the following:

$$\text{TMDL} = \text{Loading Capacity} = \text{Water Quality Standard}$$

With this decision for the loading capacity, the TMDL/WQS is then applied to the wasteload allocations (WLA) for allowable regulated sources as well. Point sources must now meet the WQS at the point of discharge. This WLA does not account for mixing, die-off, and lake effects on that source once it enters the nearshore waters. Thus, the bacteria TMDLs represent conservative TMDL target-setting, which provides some implicit MOS, as well as a high level of confidence that the TMDLs established are consistent with WQSs.

4. Total Maximum Daily Loads Development

The loading capacity (LC) is the total amount of a pollutant that can be assimilated by the receiving water while still achieving WQSs. The loading capacity is composed of the sum of individual WLAs for regulated sources and load allocations (LAs) for unregulated sources and natural background levels. In addition, the TMDL must include a MOS, either implicitly or explicitly, and a reserve capacity (RC). The

MOS accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. The RC allows for further development that may occur within the watershed. Conceptually, this is defined by the equation:

$$TMDL = \sum WLA + \sum LA + MOS + RC$$

When prepared for conventional pollutants, such as phosphorus or suspended sediment, the LC is expressed as a load (i.e., pounds per day). However, bacteria are not a conventional pollutant that can be expressed in terms of mass. Bacteria are expressed in terms of colony-forming units (cfu) per unit volume rather than in mass per unit volume. In addition, the impaired waterbodies associated with this TMDL are shoreline segments, not lakes or streams. Therefore, total volume cannot be quantified with sufficient certainty due to the variability of in-lake hydrodynamic impacts at each individual beach.

As such, the TMDLs for suburban Cook County impaired segments are expressed in terms of concentrations. Concentration-based LC, WLA, and LA allow for easier implementation because they

- Provide a direct link to existing water quality conditions and numeric WQSs;
- Apply to a range of flow and environmental conditions;
- Minimize the uncertainty associated with determining the volume of water contributing to the loading of bacteria to the beaches along Lake Michigan, which in turn minimizes the uncertainty in load allocation and reduction strategies; and
- Are more meaningful to beach managers and other stakeholders who may play a role in meeting the WLAs and LAs.

As described in **Section 3.1**, the water quality target selected for the LC for each impaired segment is 126 cfu/100 mL based on the GM WQS.

4.1 Pollutant Source Assessment

The potential sources of *E. coli* impacting the impaired segments include urban runoff impacted by illicit or failing sewer connections; pet, avian, and wildlife feces; and contaminated sediment. Other *E. coli* sources potentially impacting the impaired segments and occurring at the beach are direct deposition of feces from gulls, pets, and bathers, and re-suspended sand in the swash zone.

There are several traditional *E. coli* sources that are not relevant to the impaired segments: untreated CSOs, SSOs, partially treated flow from wastewater treatment plants, failing septic systems, and impact from agricultural sources. There are no untreated CSOs or SSOs discharging to Lake Michigan or its tributaries. (Note that river reversals are considered separately from CSOs.) There are no or minimal septic systems in the urban and suburban environments of suburban Cook County and no agricultural land uses. Therefore, these sources are not considered further in this TMDL.

As authorized by the federal CWA, the NPDES permit program controls water pollution by regulating wastewater and stormwater discharges from industrial and municipal facilities to waters of the United States. The impaired waters are potentially impacted by stormwater discharged from municipal storm sewers as well as CAWS reversals in which locks are opened to permit flow to Lake Michigan during severe storm events. These sources are described in detail in the following sections.

4.1.1 Sewage Treatment Plants

There are no sewage treatment plants expected to contribute *E. coli* to impacted beach segments under Cook County authority. There are no outfalls from the local plants within any of the beachsheds, BPAs, or surrounding areas of Lake Michigan.

4.1.2 Stormwater

Stormwater is likely to have a large impact on the impaired beach segments. Surface runoff from near-beach environments may contain *E. coli* from sources such as pet, avian, and wildlife feces or contaminated sediment (Reeves et al., 2004). In addition, relict pipe infrastructure, connections intended for sanitary sewers within storm sewer systems, or ex-filtration from improperly maintained sanitary sewers may result in surface water contamination.

In Cook County, stormwater management activities have been under the general supervision of the MWRDGC since 2004. Stormwater from the areas surrounding the impaired segments is captured by 5 systems, each covered by an NPDES MS4 permit (**Table 4-1**). MS4 permits require municipalities to implement measures to reduce pollutants in stormwater from illicit discharges and construction sites; to provide public education and allow public participation; to minimize pollutants from municipal operations; and to address post-construction runoff. The determination of which municipalities are required to obtain MS4 permits involves a combination of population, proximity to large, urbanized areas, and the water quality of receiving streams. All of the areas abutting Cook County impacted segments are permitted MS4s. No discharge data were available; however, researchers have found *E. coli* values as high as 250,000 cfu/100 mL at stormwater outfalls near beaches in Wisconsin (McLellan, 2012). Researchers have also observed stormwater flowing into nearshore Lake Michigan beach water (Whitman and Nevers, 2008). The impaired beach segments within suburban Cook County are therefore likely to be impacted on some level by near-shore surface runoff.

Table 4-1. MS4 Permitted Discharges within Impaired Suburban Cook County Beachsheds/BPAs

Facility Name	Permit Number	Receiving Water	Beachshed/BPA
Evanston, City of	ILR400335	CAWS; Lake Michigan	Lighthouse, Northwestern University, Clark, Greenwood, Lee, South
Glencoe Village	ILR400198	CAWS	Glencoe Park
Wilmette, Village of	ILR400473	CAWS	Gillson Park
Winnetka, Village of	ILR400476	CAWS; Lake Michigan	Tower, Lloyd, Maple, Elder Park, Kenilworth
Kenilworth, Village of	ILR400214	CAWS	Elder Park, Kenilworth

In addition, the region contains two industrial facilities with a NPDES permit for stormwater discharges as shown in **Table 4-2**. Similar to MS4s, runoff from these facilities may be impacted by *E. coli*. However, discharge from Northwestern University is not expected to contribute *E. coli* as it is permitted as non-contact cooling water and not stormwater.

Table 4-2. Permitted Industrial Stormwater Discharges near Suburban Cook County Impaired Segments

Facility Name	Outfall[1]	Description	Receiving Water	Permit No.	Beachshed/BPA
Winnetka Water & Electric	0010	Condenser and Equipment Cooling Water; Stormwater	Lake Michigan	IL0002364	Tower, Lloyd, Maple
Northwestern University	0010	Non-Contact Cooling Water	Lake Michigan based on GIS location	IL0066541	Not expected to contribute *E. coli*

[1] One or more outfall discharges stormwater from each facility.

Although not a direct source of *E. coli*, runoff from construction sites can contain sediment which may harbor *E. coli* in storm sewers. During the period of 2007–2011 there were two stormwater permits for construction activities issued within the study area (**Table 4-3**). During rain events, contaminated sediment can be re-suspended and discharged to Lake Michigan. Because MS4 permits require municipalities to reduce pollutants from construction sites, an independent WLA was not needed for construction sites for bacteria. Furthermore, construction activity during the project period is low in the drainage areas relevant to the beaches. If stormwater prevention practices onsite fail and sediment (that could harbor bacteria) leaves the construction site, stormwater within this project area would drain to the MS4 conveyance or to streams. Sources of bacteria via these pathways are covered in this TMDL by the MS4 WLA and through the model used to generate LAs. If construction activity is found to be a persistent and readily identifiable source of bacteria impairments at the beaches, the TMDL may be modified.

Table 4-3. Applicable Construction Stormwater Permits in Cook County from 2007 to 2011

Construction Address	City	County	Acres	Completion Date	Receiving water
595 Sheridan Road	Winnetka	Cook	3.03	08/10/07	Lake Michigan
Southwest Corner Ridge and Elmwood	Wilmette	Cook	2.774	03/01/07	Lake Michigan

4.1.3 CAWS reversals

CAWS reversals occur during periods of high precipitation. There are two types of reversals: gate reversals and lock reversals. Gate reversals occur adjacent to the lock structure and involve small volumes of discharge. Lock reversals occur when the locks are opened during extreme precipitation events (MWRDGC, 2010); for the period analyzed in this study, lock reversals occurred each year from 2007 to 2010 (**Table 4-4**). Observed *E. coli* concentrations in discharged water can be high (**Table 4-5**). For suburban Cook County beaches, only reversals from the Wilmette Lock complex are expected to impact water quality at the surround beaches of Gillson Park Beach to the north and to Evanston Lighthouse Beach and Northwestern University Beach to the south. Given the infrequent, unpredictable, and unmanageable nature of reversals, these events were not found to be significant in the model using a parameter formatted as a binary indicator (yes or no) to indicate days with or the day after a reversal. However, it should be noted that these reversals are inherently included in the model through the regular daily monitoring data on which the models are based. For instance, in June 2009, there was a reversal from the Wilmette Sluice Gate from June 18th to 19th. MWRDGC monitored *E. coli* at the surrounding beaches on June 19th and 20th and found elevated concentrations (through the Most Probable Number [MPN] method) at Lighthouse and Northwestern beaches on the morning of the 20th and reduced, non-exceeding concentrations by the afternoon of the same day (MWRDGC, 2010). Correspondingly, the regular monitoring data collected by the City of Evanston at Lighthouse beach and several surrounding beaches showed elevated concentrations for the days following the reversal event. Therefore, modeled concentrations do implicitly account for these events.

Table 4-4. CAWS Reversal Volume Summary

Year	Total Volume (MG)	Number of Reversals	Volume per reversal (MG)
2006	0	0	—
2007	224	1	224
2008	11,530	2	5,765
2009	414	3	138
2010	6,535	1	6,535

Table 4-5. CAWS Reversal Data for Study Period

Year	Date	O'Brien Lock *E. coli* concentration (cfu/100 mL)	CRCW *E. coli* concentration (cfu/100 mL)	Wilmette *E. coli* concentration (cfu/100 mL)	Total Volume (MG)
2006	None				0
2007	8/23–24/07			224	224
2008	9/13–16/08	2,669	5,438	2,942	11,049
2009	6/19/2009			192	192
2010	7/24/2010		5,785	750	6,535

Flow reversals from the CAWS are the product of multiple point and nonpoint sources, and a single WLA would not appropriately address this complexity. Under normal conditions, the point sources are permitted to discharge to the CAWs and not to Lake Michigan. IEPA is working on TMDLs for portions of the CAWS, which will be completed at a future date. Further, lock openings and reversals into Lake Michigan from the CAWS are not point sources under the CWA and are not regulated under the NPDES program. Authority to control the lock structures resides with the USACE, and a WLA for these events is not within EPAs jurisdiction under this circumstance.

Revised water quality standards for the CAWS will result in disinfection at three of the four MWRDGC facilities in the CAWS in order to meet newly revised and approved recreation criteria for bacteria. The disinfection of MWRDGC wastewater effluent is expected to have the effect of significantly reducing bacteria levels in the CAWS. Additionally, U.S. EPA and IEPA have negotiated a consent decree with MWRDGC addressing CSO controls, which has been lodged in Federal Court. The consent decree as of this date has not been entered by the Court. If approved, the decree would require MWRDGC to finish the TARP and to work with collaborating partners to implement green infrastructure (GI) practices within the MWRDGC service area. The reservoirs to be completed as part of the remaining phases of TARP implementation will greatly increase the capacity of the MWRDGC facilities to store wet-weather flows and help reduce flooding, thereby reducing the likelihood of reversal occurrences. Other measures, such as GI, may also help to reduce peak volumes to the CAWS, and on-site filtration of wet-weather flows through GI measures may also improve the quality of stormwater and CSOs discharged to the CAWS.

4.1.4 Other Sources

As identified in Table 3-4 through the listing of surrogate variables other potential *E. coli* sources at impaired Cook County beach segments include:

- Feces from gulls, dogs, and other wildlife (Levesque et al., 2000; Wright et al,. 2009);
- Bather load (Elmir et al., 2007); and
- Wave action against beach sands in the swash zone and subsequent re-suspension of resident *E. coli* populations (Alm, 2003; Skalbeck, 2010; Whitman and Nevers, 2003).

4.2 Pollutant Allocations

Two allocations of pollutant sources are evaluated in TMDL development: WLAs and LAs. The WLA is the allowable amount of the pollutant that can be assigned to regulated sources. For this TMDL, regulated sources include sewage treatment facilities and municipal and industrial stormwater discharges. Regulated entities that discharge within the beachshed/drainage area or within the BPA will receive a WLA.

The LA is the allowable amount of the pollutant that can be assigned to unregulated sources. For this TMDL, unregulated sources include direct fecal input from gulls, dogs and wildlife, re-suspended sand in the swash zone, and *E. coli* transported from outside the beachshed by lake currents.

4.2.1 Wasteload Allocations

Municipal stormwater permittees that discharge to Lake Michigan were given a WLA of 126 *E. coli* cfu/100 mL as a GM (**Table 4-6**).

The Winnetka Water and Electric facility was given a WLA of 126 *E. coli* cfu/100 mL as a GM (Table 4-6). The Northwestern University facility was not given a WLA since it is not expected to contribute *E. coli*.

The construction stormwater permits are considered a negligible source of bacteria to the beaches and are not given a specific WLA because they are not considered to be a direct source of *E. coli*. These sites would have existing coverage if the MS4 permit in which they fall if stormwater migrates from the construction site.

Table 4-6. WLAs for Suburban Cook County

NPDES Permittee	Permit No.	WLA (cfu/100 mL)
Municipal Stormwater		
Evanston, City of	ILR400335	126
Glencoe Village	ILR400198	126
Wilmette, Village of	ILR400473	126
Winnetka, Village of	ILR400476	126
Kenilworth, Village of	ILR400214	126
Industrial Stormwater		
Winnetka Water & Electric	IL0002364	126

The goal of the TMDLs is to ensure compliance with the bacteria water quality criteria at the point of discharge for point sources in order to meet WQSs at the nearby beaches/impaired segments. In this setting, point-source discharges are impacting the impaired segment on a different time scale than the predictor variables identified in the model (e.g., precipitation, wave action, gulls counts); their contributions to the *E. coli* impairment are assumed to occur on an infrequent, non-daily time scale (i.e., when storms occur). Inclusion of these point sources into the model used to assess reductions for nonpoint sources (**Section 4.8**) would have introduced uncertainty into model results due to the difference in data availability and the time and scale at which these sources contribute. Therefore to account for all sources and ensure that point sources will not cause or contribute to an exceedance at the beach, the WLA for point sources would be equal to the GM WQS as shown in the table above.

4.2.2 Load Allocations

The LA for this TMDL is set as a GM of 126 cfu/100 mL. This covers discharges from unregulated sources, including direct deposition from gulls, dogs, and wildlife; re-suspended beach sand; and possible transport from long shore currents, e.g., nonpoint sources of *E. coli* that do not have localized points of release to the shoreline segment.

LAs are set as the WQS because there is no direct monitoring which provides the concentration and/or load of *E. coli* directly related to each of these sources. For nonpoint sources hypothesized to contribute to the impairment, surrogate variables were used within the multi-level analysis to determine any correlation between the source and the *E. coli* concentration and to provide the reduction required from each source to achieve the TMDL.

4.3 Margin of Safety

The MOS, which may be explicit or implicit, accounts for uncertainty that will be contained in the resultant allocations for the TMDL when the WQSs are attained. Uncertainty can stem from a lack of supporting information or data to link the allocated sources with the water quality impairment. By using a concentration-based TMDL, there is an implicit MOS because all sources are set to less than or equal to the WQS and any mixing, dilution, settling, or die-off impacts are excluded from the allocations. Therefore, the allocations and any load reductions calculated from the allocations are conservative.

An additional element of the implicit MOS arises from the methodology used to determine the reductions in nonpoint sources (**Section 4.8**). Using a modeling method that simulates the distributions of monitored *E. coli* levels, the load reductions were calculated by shifting the predicted distributions until there was a negligible probability that the estimated GM or SSM (depending on the analysis) would exceed the WQS. With this method, all ranges of concentrations experienced within the existing monitoring data (and therefore it is assumed all beach conditions) are accounted for and lowered to WQS levels by instituting the calculated reductions. Requiring all point sources meet the WQS (i.e., the WLA) further assures that the TMDL will be met.

4.4 Seasonal Variation

The federal promulgated *E. coli* standard is being used to develop the TMDL, but an explicit time period for the recreation season was intentionally not promulgated in the federal rule. (This acknowledges and allows states to select recreation seasons that are applicable to their climate and geographic area). To determine which season is applicable for this TMDL, IEPA examined their state WQSs. IL Title 35 section 302.309 describes general use WQSs for fecal coliform as applicable from May to September. Therefore, it was reasonably assumed that the federal *E. coli* standards for this TMDL could be applied for a recreation season from May to September. In the future, if non-recreation season water quality exceedances become a routine public health issue which may demonstrate that primary contact recreational use is not being supported, then the TMDL may be modified. It is assumed that the variation over the summer season can currently be modeled to adequately address seasonal variation that occurs within the recreation season and thus addresses TMDL requirements.

Inter-annual variation was also accounted for by considering recreational season *E. coli* concentrations from 2007–2011 and BSS data from 2009–2011. These timeframes help ensure that the TMDL incorporates variability due to seasonal and annual effects. For instance, average precipitation data from the four National Climatic Data Centers (EVANSTON 1.2, EVANSTON 1.4, GLENCOE 0.1, and CHICAGO BOTANICAL) used in this study indicate that both wetter (2008) and drier (2009) years occurred during the assessment period (**Table 4-7**).

Table 4-7. May–September Cook County Precipitation, Average of Four Stations

Year	Precipitation (in)
2008	28.14
2009	20.95
2010	24.38
2011	25.71

4.5 Critical Conditions

As specified in the CWA, critical conditions must be considered in the TMDLs. Critical conditions refer to periods in which the greatest reductions are needed. Critical conditions are those that can be anticipated to generate the poorest water quality conditions and also conditions that lead to the greatest pollutant loading. Due to the complex hydrology associated with a beach, there is no one single critical condition for these TMDLs. Analysis of existing monitoring data shows that exceedances occurred under a variety of conditions due to a variety of sources, all of which are considered by basing reduction goals on the full range of monitored conditions. However, the period of record for the dataset used in this study contains many extreme observed values that reflect "critical conditions"; these observations, which co-occur with measured *E. coli* concentrations at or near the upper detection limit, have been documented at all impacted beach segments (**Table 4-8**). Variables representing critical conditions include high gull counts (nonpoint source); wave energy, period, and eastward direction (re-suspension of resident *E. coli* populations in swash zone); and 24-hour rainfall total (transport of *E. coli* in surface runoff from near-beach environment). Since the modeling process incorporates data from conditions that are expected to be critical, the final modeled distributions can reasonably be described as accounting for critical conditions.

Table 4-8. Examples of Critical Conditions in Cook County 2009–2011 BSS Dataset

Beach	Wind Speed (mph)	Wind Direction	Rain Intensity	Wave Intensity	Bird Count	48 Hour Rain (in)	*E. coli* (cfu/ 100 mL)
Greenwood	5	N	Heavy	Rough	42	0.93	601
Lighthouse	26	NE	Heavy	Rough	7	0.46	1,986
Lee	3	SW	Heavy	Normal	55	0	629
Northwestern University	10	NE	Light	Rough	50	0.43	602
Clark	23	NE	Heavy	Rough	43	0.46	920.8
South Boulevard	4	W	Heavy	Calm	150	0.40	722

4.6 Reserve Capacity

RC represents some *E. coli* allocation that has been set aside to accommodate future growth and development rather than allocating it to existing sources. The RC for each impaired segment is zero. Application of the WQS as the WLA and LA requires that any changes within the contributing area (e.g., urban development within an MS4 municipality that discharges to a beach) must maintain discharges that meet the WQS and therefore the TMDL.

4.7 Total Maximum Daily Loads

To summarize, if the source of the bacteria load is allowable, the WLA or LA is set equal to the applicable WQS for bacteria in the receiving water. If the source of the bacteria load is prohibited or reductions cannot be achieved from that source or surrogate source, then the WLA and LA are set to zero. For example, discharges of untreated wastewater to any surface water from sources such as illicit discharges to stormwater systems, boats, and failed septic systems are prohibited and would receive bacteria load allocations of zero. **Table 4-9** provides the WLAs and LAs by category of source for the TMDLs for the nine impaired segments of interest in this study.

The underlying assumption in setting a concentration-based TMDL for bacteria is that if all sources are less than or equal to the WQS, then the concentration of bacteria within the receiving water will attain WQS. This methodology implies a goal of meeting bacteria standards at the point of discharge for all sources.

Table 4-9. Summary of Allocations by Category

NPDES Permittee	Allocation (cfu/100 mL)
Waste Load Allocations	
Municipal Stormwater	126
Industrial Stormwater	126
Untreated wastewater	0
Load Allocations	
Gulls, dogs, wildlife, resuspended beach sand, long shore currents, and other non-specific loading sources to nearshore waters (i.e., river reversals)	126

4.8 Load Reduction Calculation Methods

In order to utilize all the available monitoring data from each of the beaches managed within suburban Cook County (which correspond with the impaired segments), a statistical framework was employed to calculate the impacts of each of the source and surrogate variables available on *E. coli* concentrations. For nonpoint sources hypothesized to contribute to the impairment, surrogate variables were used within a statistical analysis to determine any correlation between the source and the *E. coli* concentration and to estimate the source reductions required to achieve the TMDL. The method is explained through three steps beginning with initial data exploration and ending with calculating the reductions needed to meet the WQS in the different parameters used in the model. Further details on the method used can be found in **Appendix I**.

4.8.1 Step 1: Data Collection and Initial Analysis

Measured *E. coli* concentrations for suburban Cook County beaches were obtained for the years 2007 to 2011. Where present, the average daily concentration (from two or more samples taken at the same time) was chosen as the daily *E. coli* value for each beach. In some cases, only a single measurement was reported.

In addition, 2009–2011 BSS data were obtained for Evanston beaches. This dataset includes both sanitary data and measured *E. coli* concentrations. However, AM and PM sampling concentrations were reported for some beaches. In order to be consistent with other sampling programs, which generally report morning *E. coli* concentrations, only AM samples were considered.

Information that might predict *E. coli* concentrations at suburban Cook County beaches (predictor variables) was then collected from a number of different sources. These variables were chosen based on information in the scientific literature and stakeholder input. Examples of predictor variables tested in this analysis include information on lake conditions, precipitation, beach characteristics, and watershed characteristics. In addition, the Evanston 2009–2011 BSS dataset contains information not obtainable from other sources, such as bird counts, algae presence, bather load, etc. Two distinct datasets were analyzed for suburban Cook County beaches: *E. coli* data from 2007–2011, along with predictor variables derived from public information; and the 2009–2011 Evanston BSS dataset.

Both datasets were then examined to check model assumptions and to look for relationships between *E. coli* concentrations and the predictor variables. Both visual methods (graphs) and formal statistical tests were used.

4.8.2 Step 2: Initial Model Fitting

The variables identified in Step 1 were then used as the starting point for several multilevel regression models. These models were used to estimate relationships between the predictor variables and *E. coli* concentrations at suburban Cook County beaches. Predictor variables were added to the models in a stepwise manner, and the explanatory power of each model was evaluated. All variables were tested, and the selection of variables in the final models was based on explanatory power and statistical significance.

Once fitted, statistical assumptions were checked to make sure the use of the models was appropriate. Four final models were chosen; one model for the 2009–2011 BSS data; and three models representing three different beach groups in the 2007–2011 dataset (**Table 4-10**).

Table 4-10. Suburban Cook County Beaches with Similar Distributions of *E. coli*, by Model

Model	Beach Groups
2009–2011 BSS Data	Lighthouse, Northwestern, Clark, Greenwood, Lee, South Boulevard
2007–2011 Cook Group 1	Elder, Northwestern, South Boulevard
2007–2011 Cook Group 2	Glencoe, Gillson, Lighthouse, Clark, Greenwood, Lee
2007–2011 Cook Group 3	Tower, Lloyd, Maple, Kenilworth

4.8.3 Step 3: Simulation

Both manageable and non-manageable variables were included in the final models (**Tables 4-11 through 4-14**). Manageable variables are those that can be influenced by beach managers (i.e., bird count), while non-manageable variables are those that cannot be easily changed (i.e., wave direction), but which still impact water quality. Reductions for sources necessary to meet the TMDL were therefore limited to variables representing manageable sources. The relationships between these predictor variables and *E. coli* concentrations were quantified in Step 2. Because there is uncertainty associated with these estimated relationships, statistical simulation was used to identify the impact of changing a manageable variable (i.e., keeping the number of birds below a certain threshold). In model simulation, many predictions are made and the “average” predicted value for a specific combination of predictor variable values is obtained. Manageable variables in the model were then manipulated until all average predicted values were below the TMDL water quality target. The predictor variable thresholds required to meet the target were then used as the recommended management goals.

More specific information on methodology and statistical approaches can be found in **Appendix I**, while final model parameter values can be found in **Appendix II**.

Table 4-11. Cook County BSS Predictor Variables

Variable	Statistically Significant	Correlation with *E. coli* Concentration	Physical Interpretation	Manageable Parameter
Bird Count	Yes	Positive	Fecal source	Yes
Wave Intensity	Yes	Positive	Estimate of wave energy; resuspension in swash zone	No
Beach Orientation	Yes	Negative	Exposure to long shore current and wave energy; larger degrees equals orientation towards southeast or south	No
Weather	Depends on level	Depends on level	Cloud cover; proxy for temperature; impact of solar radiation	No
Sample Year	Yes	Depends on level	Captures unexplained year to year variation	No
Sample Month	Yes	Positive	Slight rise in concentrations as summer progresses	No
48-hour Rainfall	Yes	Positive	Transport mechanism via runoff and sand infiltration	Yes
Water Temperature	Yes	Negative	Research indicates higher E. coli survival times in cooler water (Sampson et al. 2006)	No

Table 4-12. Cook County Group 1 Predictor Variables

Variable	Statistically Significant	Correlation with *E. coli* Concentration	Physical Interpretation	Manageable Parameter
Percent Impervious Surface	Yes	Positive	Increases runoff; build-up of animal wastes	Yes
Water Level	Yes	Positive	Storm proxy	No
24-hour Rainfall	Yes	Positive	Transport mechanism via runoff and sand infiltration	Yes
Sample Year	Depends on level	Depends on level	Captures unexplained year to year variation	No
Sample Month	Depends on level	Positive	Slight rise in concentrations as summer progresses	No
Orientation	Yes	Positive	Exposure to long shore current and wave energy; larger degrees equals orientation towards southeast or south	No

Table 4-13. Cook County Group 2 Predictor Variables

Variable	Statistically Significant	Correlation with *E. coli* Concentration	Physical Interpretation	Manageable Parameter
Water Level	Yes	Positive	Storm Proxy	No
Sample Month	Depends on level	Depends on level	Slight rise in concentrations as summer progresses	No
48-hour Rainfall	Yes	Positive	Transport mechanism via runoff and sand infiltration	Yes
Sample Year	Yes	Depends on level	Inter-year variation not captured by other predictors	No
Wave Height	Yes	Positive	Direct measure of wave energy	No
Hours Since Precipitation	Yes	Negative	Drier conditions associated with lower concentrations	No

Table 4-14. Cook County Group 3 Predictor Variables

Variable	Statistically Significant	Correlation with *E. coli* Concentration	Physical Interpretation	Manageable Parameter
Water Level	Yes	Positive	Storm Proxy	No
East Surface Water Velocity	Yes	Negative	Eastward currents assist with flushing near beach water column	No
48-hour Rainfall	Yes	Positive	Transport mechanism via runoff and sand infiltration	Yes
Wave Period	Yes	Positive	Proxy measure of wave energy	No
Sample Year	Yes	Depends on level	Inter-year variation not captured by other predictors	No

4.9 Final Reductions

The predictor variables in the final suburban Cook County models were chosen for explanatory value, physical interpretation, and management value (Tables 4-10 to 4-14). Most, but not all, of the variables achieved statistical significance; variables that did not meet the standard 5% p-value statistical significance threshold were included if they greatly enhanced the explanatory power of the model or if they were consistent with current scientific understanding of the fate and transport of *E. coli* at freshwater beaches.

The physical interpretation of the model is consistent with the view that beach *E. coli* concentrations are influenced by nearshore conditions – wave energy, beach orientation, nearshore surface runoff, and bird presence. Due to the existence of multiple storm sewer systems, beach drainage areas were based solely on fine scale topographic data (i.e., LIDAR). In general, variables collected at larger spatial scales were not statistically significant in predicting *E. coli* concentrations. This finding, along with support in the literature, suggests that localized sources and transport mechanisms are the key predictors of beach *E. coli* concentrations (McLellan et al., 2003; Whitman and Nevers, 2008). Precipitation may increase water column concentrations either by washing source loads (e.g., gulls feces, trash) to the beach through stormwater runoff or by percolating into beach sands and transporting resident *E. coli* colonies into the water column. Impervious surface areas (i.e., sidewalks, retaining walls, roof surfaces, parking lots, etc.) within direct beach drainage increase the amount of surface runoff available to transport wildlife feces and sediment-attached *E. coli*; these surfaces also allow for the build-up of *E. coli*, which are then washed off by precipitation events (Kleinheinz et al., 2009). However, this variable only proved to be significant for Group 1 beaches and the impervious area identified within the direct beach drainage was small.

Lake conditions indicative of storm events or changes in long shore current (e.g., wave characteristics, lake water level, eastward current velocity) were also predictive of *E. coli* conditions. Wave and storm energy can re-suspend resident *E. coli* populations in swash zone sediment, while eastward current velocity can act as a flushing mechanism for the nearshore water column.

4.9.1 Distributional Groups

An important consideration when analyzing data from units that differ on spatial (physical locations) and/or temporal (time of observations) dimensions is whether the distribution of the variable of interest (in this case, *E. coli* concentration) is similar across different units. There are at least two reasons to examine this issue. First, we need to verify that the distribution of *E. coli* at each beach meets the requirements of the parametric regression approach used in this study. Second, in terms of prediction and simulation, we do not want to apply relationships based on an average *E. coli* concentration to beaches that are statistically above or below the average; this approach is likely to result in predictions that are below or above the observed patterns at these sites, respectively. When comparing distributions, we want to examine both mean values as well as the 'tail' regions (i.e., probabilities associated with observing a value that is much higher or much lower than the average).

In order to compare mean values, a stepwise multiple comparison (Tukey's Honestly Significant Difference [HSD]) analysis was used to contrast mean *E. coli* concentrations across all sampling locations. The results of this analysis revealed that several pairwise beach comparisons in both the BSS and 2007–2011 datasets exhibit statistically significant differences in mean *E. coli* concentration. However, Tukey's HSD examines differences in mean value only. Beaches that have similar average *E. coli* concentrations can differ greatly in the probabilities of very high or very low concentration values. For this reason, a non-parametric test that considers the probabilities of all concentration values was also calculated (Kolmogorov-Smirnov [K-S] test). The results of this test indicated that there were three broad beach groups within the 2007–2011 dataset (Table 4-10). These groups share commonalities in the overall probabilities of observed *E. coli* concentrations. For the suburban Cook County TMDL, a separate statistical model was fit for each of these groups (**Figures 4-1 through 4-3**). The beaches for which monitoring results were provided in the BSS dataset did not exhibit differences in the distributions of *E. coli* and were modeled together (**Figure 4-4**). Grouping beaches based on similar distributions helps minimize the risk of under or over predicting *E. coli* concentrations during simulation (**Section 4.8.3**).

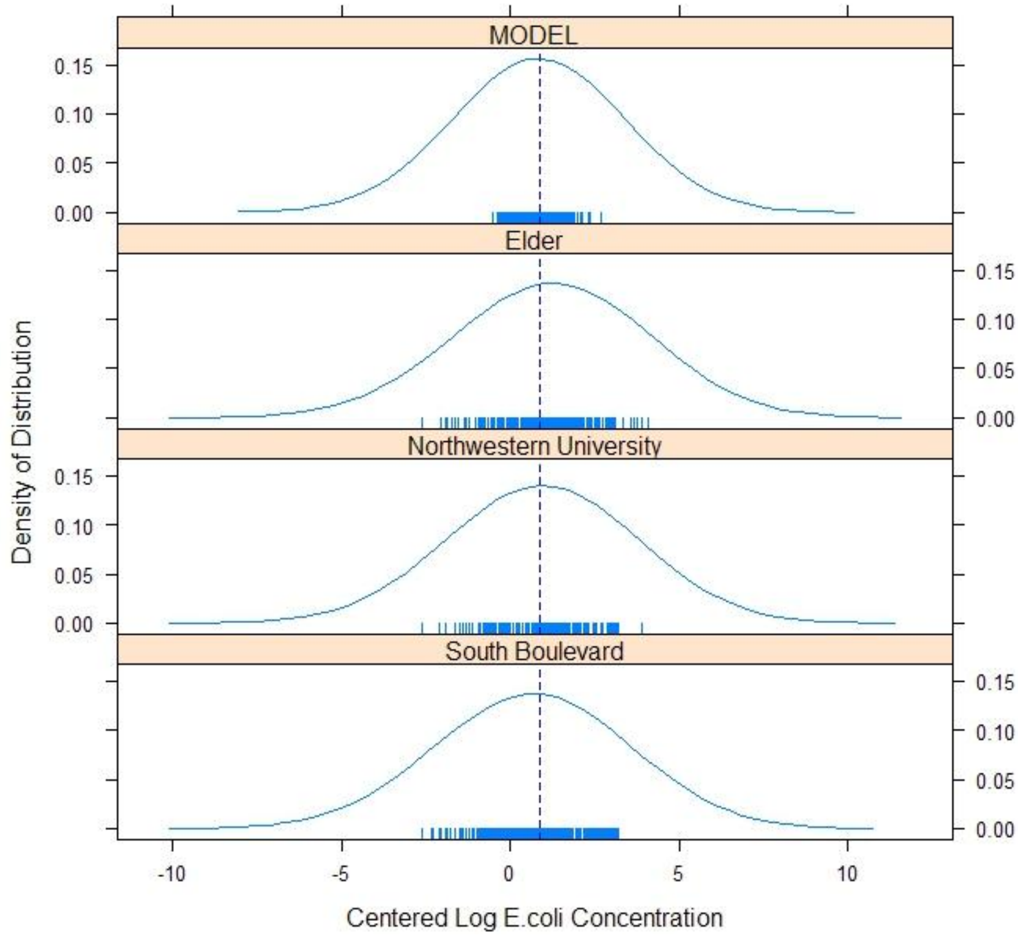


Figure 4-1. Predicted Distributions of *E. coli* at Cook County Group 1 Beaches (top panel) Versus Monitored Distributions at Individual Segments for 2007–2011 Dataset (lower panels)

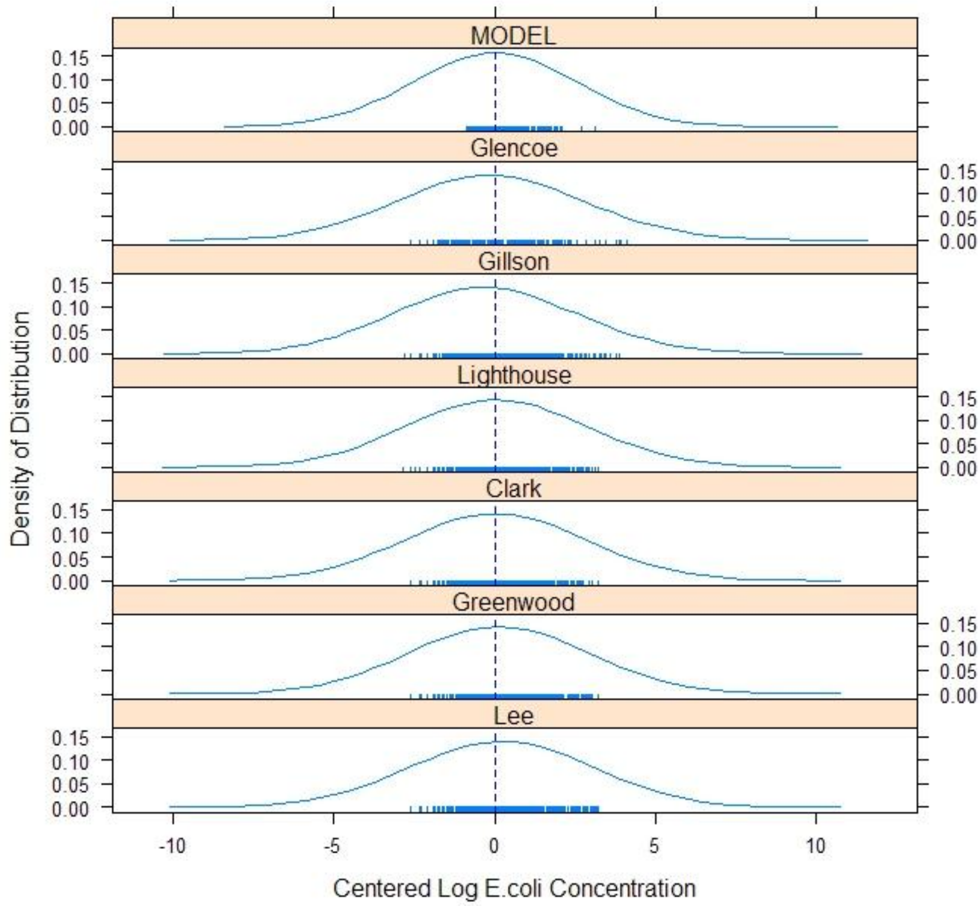


Figure 4-2. Predicted Distributions of *E. coli* at Cook County Group 2 Beaches (top panel) Versus Monitored Distributions at Individual Segments for 2007–2011 Dataset (lower panels)

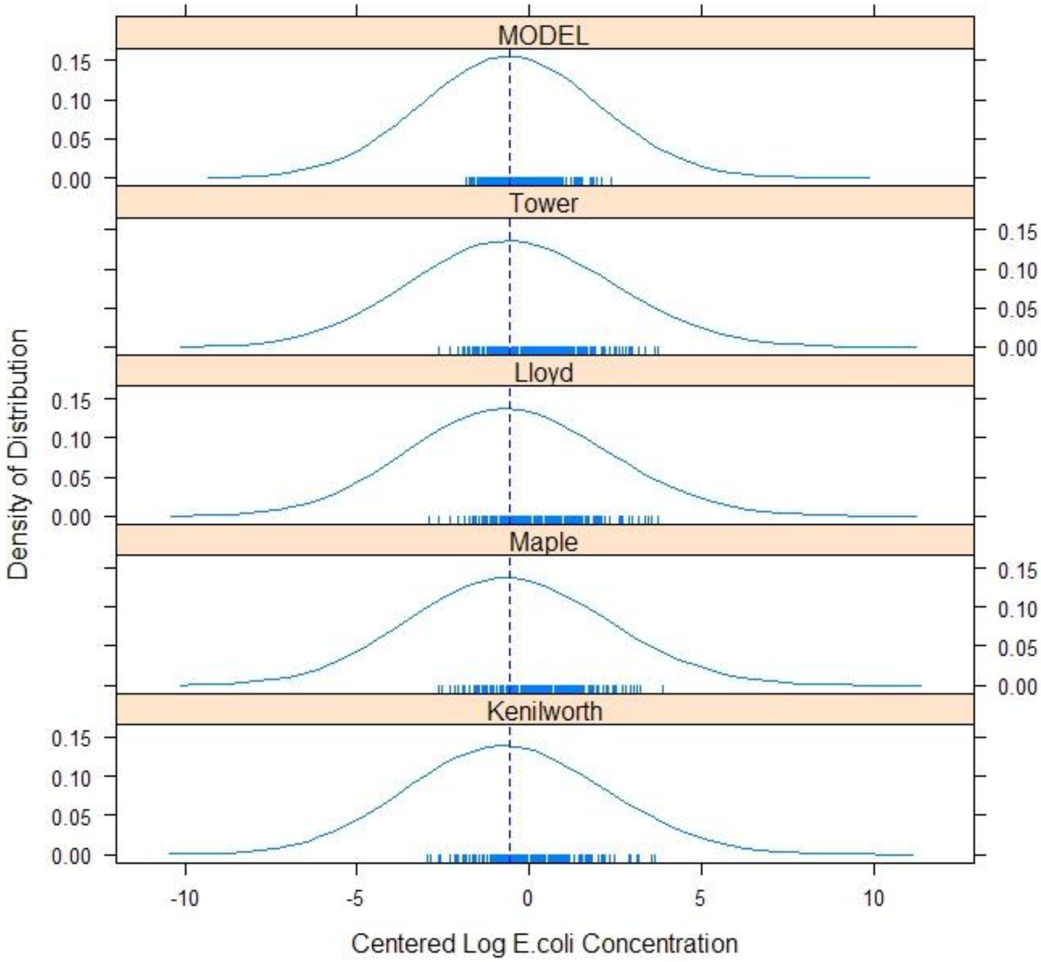


Figure 4-3. Predicted Distributions of *E. coli* at Cook County Group 3 Beaches (top panel) Versus Monitored Distributions at Individual Segments for 2007–2011 Dataset (lower panels)

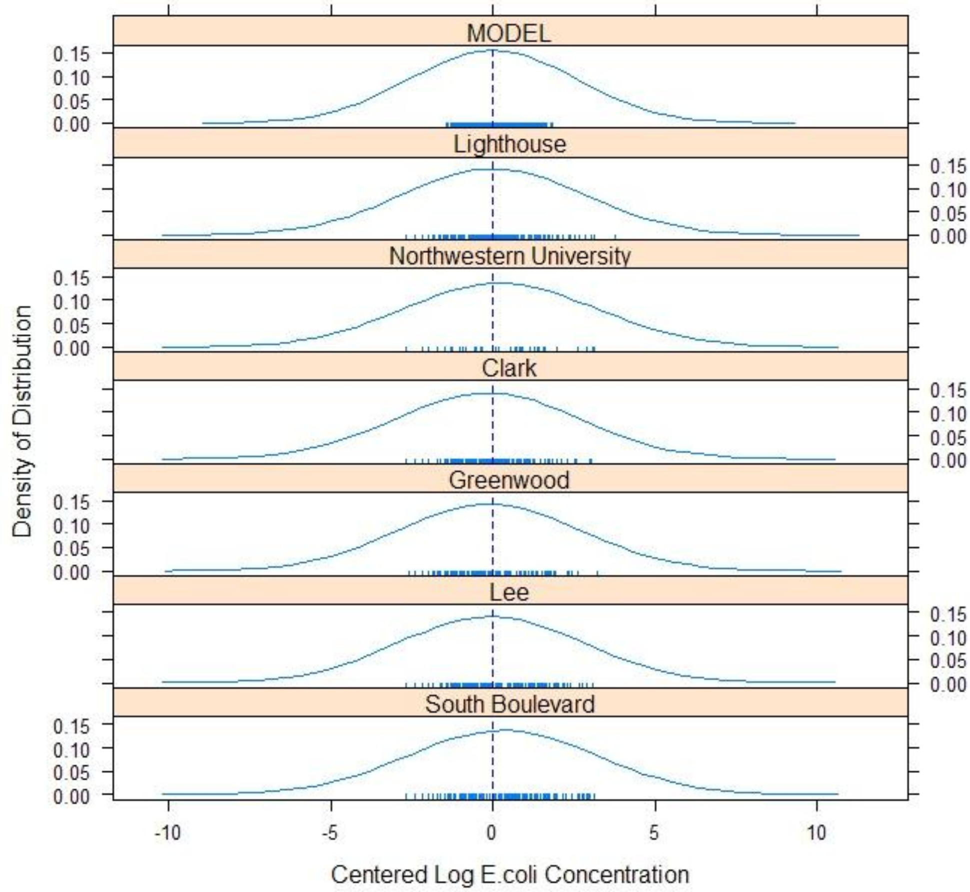


Figure 4-4. Predicted Distributions of *E. coli* at All BSS Segments (top panel) Versus Monitored Distributions at Individual Segments for 2009–2011 (lower panels)

4.9.2 Analysis

Of the predictor variables included in the final models (see Tables 4-11 through 4-14), four were considered to be readily manageable: bird count, 24-hour precipitation, 48-hour precipitation, and impervious surface area. As described in **Section 4.8.3**, these variables were subset in iterative statistical simulations to provide a predicted daily *E. coli* distribution that achieves either the SSM or the GM WQS in successive analyses. The TMDL target is set at the GM; however, the SSM was also examined when estimating load reductions for informational purposes as the SSM values are used for making beach notification and closure decisions based on public health concerns. GM TMDL targets are designed to consistently achieve the GM with some predicted percent of SSM exceedance. SSM informational targets are designed so that a SSM is not exceeded.

As a general rule, the management action that would be necessary to meet a SSM standard would be more stringent than what is required to meet a GM-based standard. Because the GM is based on an average value (30-day moving average), individual exceedances of the SSM WQS can occur even if the GM WQS is still met. **Tables 4-15 through 4-17** present the thresholds of the 4 manageable variables that must be met in order to achieve concentrations at or below the SSM throughout the beach season and, alternatively, to achieve a 30-day GM. The thresholds are determined using the distributional groups previously described, so that the same variable adjustments are required to attain the WQS for beaches in the same group.

One issue with the assignment of management targets is the limited coverage of bird data. While birds are known to be a source of *E. coli* (**Section 4.1.4**), the only available observed bird data tied to daily *E. coli* measurements for suburban Cook County beaches is for 2009–2011 within the City of Evanston. Since birds are a recognized nonpoint source for the TMDL, the bird management targets determined for the Evanston beaches should be applied to all remaining suburban Cook County impaired segments. This conservative step was designed to ensure that all potential sources are addressed in the TMDL. From this baseline, additional bird data collection efforts can be undertaken and used to inform future beach management decisions. Thus all impaired segments have been assigned the bird management targets modeled with the Evanston BSS data (Table 4-15).

Table 4-15. Manageable Variable Thresholds Required to Meet the Load Allocation for the 2009–2011 Cook County BSS Dataset Model

Beaches Represented in Analysis	SSM Informational Target[1]		GM TMDL Target		
	Reduce Daily Bird Count Below	Reduce 48-hour Rainfall Below[2] (in)	Reduce Daily Bird Count Below	Reduce 48-hour Rainfall Below (in)	Predicted Percent of SSM Exceedances when GM is Attained
Lighthouse, Northwestern, Clark, Greenwood, Lee, South Boulevard	30	0.6	50	0.8	10%

[1] The SSM targets provided in this series of tables are for informational purposes only. The GM targets correspond to the thresholds needed to meet the TMDL LAs.

[2] Reduction in rainfall below a certain amount equates to capturing any rainfall in excess of that amount through stormwater BMPs so that runoff and other surface flows do not directly impact the beach

Table 4-16. Manageable Variable Thresholds Required to Meet the Load Allocation for the 2007–2011 Cook County Group 1 Model

Beach/Distributional Group	SSM Informational Target		GM TMDL Target		
	Reduce 24-hour Rainfall Below (in)	Decrease in Impervious Area (%)	Reduce 24-hour Rainfall Below (in)[2]	Decrease in Impervious Area (%)	Predicted Percent of SSM Exceedances when GM is Attained
Elder, Northwestern, South Boulevard	N/A[1]	N/A	0.4	15%	8%

[1] Because of high observed *E. coli* concentrations, attainment of the SSM WQS with an acceptable level of exceedances could not be attained through adjustments to the manageable variables for this modeling group

Table 4-17. Manageable Variable Thresholds Required to Meet the Load Allocation for the 2007–2011 Cook County Groups 2 and 3 Models

Beach/Distributional Group	SSM Informational Target	GM TMDL Target	
	Reduce 48-hour Rainfall Below (in)	Reduce 48-hour Rainfall Below (in)	Predicted Percent of SSM Exceedances when GM is Attained
Group 2: Glencoe, Gillson, Lighthouse, Clark, Greenwood, Lee	0.9	1.35	8%
Group 3: Tower, Lloyd, Maple, Kenilworth	1.05	1.5	6%

When comparing the thresholds required to attain the SSM and those required to attain the GM, greater actions are required to achieve the SSM. For instance, for the suburban Cook County Group 3 beaches, the SSM requires managers to arrange for stormwater management when the 48-hour rainfall total is above 1.05 inches. If they manage precipitation at these sites to achieve the GM, they will experience approximately 7% SSM exceedances; however, they only need to manage stormwater when the observed total 48-hour rainfall is above 1.5 inches. A 6% chance of exceeding the SSM equals approximately 6 days with an exceedance during the beach season (assuming a 100-day beach season).

To assess the magnitude of the necessary changes, the thresholds can be compared to the observed values of these variables over the study periods (**Tables 4-18 and 4-19**). Attempts were made when modeling to determine the thresholds to keep them within observed limits so that implementation activities could likely be used to achieve the required levels.

Table 4-18. Observed Bird and 48-hour Rainfall Data Summaries, Suburban Cook County BSS Dataset

Beach/Distributional Group	Birds			Previous 48-hour Rainfall (in)		
	Median	Mean	Max	Median	Mean	Max
Lighthouse, Northwestern, Clark, Greenwood, Lee, South Boulevard	20	39	400	0.05	0.3	2.3

Table 4-19. Observed 48-hour Rainfall Data and Impervious Area Summaries, 2007–2011 Dataset, Suburban Cook County Impaired Segments

Beach/Distributional Group	Previous 48-hour Rainfall (in)			Impervious Area (%)
	Median	Mean	Max	
Group 1: Elder, Northwestern, South Boulevard	0.03	0.3	6.2	0.1 – 9.6
Group 2: Glencoe, Gillson, Lighthouse, Clark, Greenwood, Lee	0.03	0.32	6.2	N/A
Group3 : Tower, Lloyd, Maple, Kenilworth	0.03	0.30	4.5	N/A

In order to provide a point of reference for the 24- and 48-hour rainfall thresholds presented as load reduction scenarios, May to October rainfall events from 2007–2011 were examined from the four rainfall monitoring stations used in the analysis: EVANSTON 1.2, EVANSTON 1.4, GLENCOE 0.1, and CHICAGO BOTANICAL. As indicated in Table 4-7, this time frame includes both relatively dry (2009) and wet (2008) years. **Table 4-20** presents the average percentage of rainfall events that fall above a range of threshold values across these years.

Table 4-20. Relative Occurrence of Rainfall Events Reaching Proposed Reduction Thresholds[1]

Threshold for Previous 48-hour Rainfall (in)	Percent of Rainfall Events	Percent of All Days, May to October
0.4	42	18
0.9	20	9
1.0	17	8.5
1.3	10	7.6
1.5	9	4

[1] Percentages based on May-October rainfall events for the years 2007–2011

5. Implementation and Monitoring Recommendations

5.1 Implementation Plan

Modeling results and input from local beach managers indicate that seagulls, imperviousness, and precipitation are the primary manageable factors impacting *E. coli* concentrations at the Cook County beaches. Gulls add *E. coli* directly to the beach via fecal droppings. If the droppings are buried in the beach sand—for instance, by wind action, beachgoers, or wave action—*E. coli* can be trapped in the sand, survive, and be resuspended by runoff or wave action. Reducing the number of gulls at the beach has been correlated with reduced *E. coli* levels in the water column (Engeman et al., 2012). Standing water at the beach will keep sand moist, which can positively influence *E. coli* concentrations in the water column. Pools of water also provide an area for gulls to congregate. Runoff, driven by precipitation, will pick up bacteria from land areas, such as parking lots, ponded areas, and beach sand, and transport it down gradient to the beach or percolate into the sand and release resident bacteria to the water column. Minimizing runoff at or near the beach will reduce *E. coli* concentrations.

Each of these factors (gull count, imperviousness, and precipitation) can be managed by local, state or federal agencies provided that appropriate funding is available. Other factors shown to impact *E. coli* conditions include beaches located in embayed areas, wind direction, and wave energy, but these factors were not considered to be manageable and therefore were not directly addressed in this implementation plan.

A list of BMPs for reducing *E. coli* concentrations at a beach was developed based on controlling (1) the contributing factors (gulls, imperviousness, and rainfall) and (2) those variables that could not be modeled due to lack of information. These unmodeled variables include stormwater quality impacts from improperly disposed pet waste, resuspended sediment from eroded stream banks, illicit connections to storm drains, or exfiltration from sanitary sewers. Although these variables were not modeled, they are typically present in urbanized areas and therefore are included in this discussion.

Several beach managers have or are implementing some of the listed BMPs through pilot projects funded by the U.S. EPA. Through these projects, researchers, and beach managers are determining the effectiveness of these BMPs on reducing *E. coli* concentrations. For example, a study in the Chicago area was just completed that showed that the number of gulls found at several beaches was reduced after eggs found at two nesting sites were oiled over a 3-year period. The egg oiling was likely a beneficial factor in the improved *E. coli* conditions found at several area beaches (Engeman et al., 2012). In another study, a bioretention cell was installed in an urban area of Charlotte, NC, to capture and infiltrate stormwater. In this case, researchers observed *E. coli* reductions of 71% (n=14) during several small storm events (precipitation < 42mm) when comparing treated and untreated flow (Hunt et al., 2008). Other BMP case studies can be found in *A Review of Best Management Practices Benefiting Great Lakes Recreational Waters: Current Success Stories and Future Innovations* (Koski and Kinzelman, 2010).

In addition, the U.S. EPA has produced a video demonstrating the utility of BSS in identifying pollution sources affecting beaches. The DVD highlights nine beach restoration projects that have been undertaken in Wisconsin to control *E. coli* and improve beach water quality. The video provides examples of several BMPs, including rain gardens to retain surface runoff and stormwater, and manufactured dunes and vegetation enhancements to create barriers to prevent sand migration and decrease the width of the beach in areas where gulls tend to congregate. A copy of the DVD can be obtained at no charge by contacting the U.S. EPA at Wirick.Holiday@epa.gov or can be viewed at https://www.youtube.com/user/EPARegion5Training/feed?feature=context-cha.

5.1.1 Description of BMPs

Based primarily on the experiences of others in the Great Lakes Region, the most appropriate BMPs for mitigating these factors have been identified as shown in **Table 5-1**. These BMPs focus on both source control and mitigation of *E. coli* present in the environment and are divided into the following categories: source assessment, stormwater management, gull management, beach management, public education, and ordinances. A description of several of the listed BMPs is provided after Table 5-1. These descriptions include the level of effort in terms of hours or cost and the recommended frequency for many of the BMPs.

Table 5-1. Best Management Practices to Address *E. coli* Impairments

Best Management Practice	Corresponding Contributing Factor
Source Assessments	
Conduct beach sanitary surveys	Not modeled
Conduct illicit discharge surveys	Not modeled
Stormwater Management (at the beach or in the upstream drainage area)	
Infiltration basins, install and maintain	Rain
Bioretention/rain gardens, install and maintain	Rain
Vegetated swales/bioswales, install and maintain	Rain
Pervious pavement, install and maintain	Rain
Install green infrastructure, not sure type	Rain
Redirect runoff away from beach	Rain
Buffer/Filter strips, install and maintain	Not modeled
Stormwater filter devices in storm sewer, install and maintain	Not modeled
Gull Management	
Utilize harassment measures such as border collies, predator models or calls	Gulls
Create natural areas to discourage gulls	Gulls
Conduct egg oiling to reduce hatchlings	Gulls
Beach Management	
Employ deep beach grooming measures	Gulls, Slope
Increase slope of the swash zone	Slope
Waste receptacles, supply and maintain	Gulls
Restrooms, supply and maintain	Not modeled
Pet waste stations, install and maintain	Not modeled
“Don’t Feed the Birds” signage, install	Gulls

(continued)

Table 5-1. Best Management Practices to Address *E. coli* Impairments (continued)

Best Management Practice	Corresponding Contributing Factor
Public Education - Personal Habits	
Support/prepare print ads, handouts, websites, signage regarding wildlife feeding	Gulls
Support/prepare print ads, handouts, websites, signage regarding littering	Gulls
Support/prepare print ads, handouts, websites, signage regarding pet waste cleanup	Not modeled
Support/prepare print ads, handouts, websites, signage regarding illegal dumping	Not modeled
Ordinances	
Implement/enforce local ordinance regarding wildlife feeding	Gulls
Implement/enforce local ordinance regarding littering	Gulls
Implement/enforce local ordinance regarding pet waste cleanup	Not modeled
Implement/enforce local ordinance regarding illicit discharge elimination	Not modeled

5.1.1.1 Source Assessments

Two types of source assessments are discussed: BSSs and illicit discharge surveys.

Beach Sanitary Survey. As the name implies, BSSs are conducted at the beach to identify the potential sources and magnitude of fecal pollution impacting beach water quality. The type of data collected by a BSS include number/type of birds at the beach, slope of the beach, location and condition of bathrooms, amount of algae on the beach, tributary land use, location of storm water outfalls, surface water quality, etc. Microbial source tracking can be utilized as part of an expanded BSS, especially if bacterial sources are elusive.

The U.S. EPA has developed survey forms to allow for consistent collection of data in a well-organized format. One form is used for routine surveys and the other is used for annual surveys (U.S. EPA, 2008a). These surveys are typically conducted by beach managers. More information can be found in the U.S. EPA's *Great Lakes Beach Sanitary Survey User Manual* (U.S. EPA, 2008b): http://water.epa.gov/type/oceb/beaches/sanitarysurvey_index.cfm.

Annual survey
Effort: 20 hours Frequency: once a year

Routine survey
Effort: 30–60 minutes Frequency: each time water quality samples are collected

Illicit Discharge Survey. An illicit discharge survey should be conducted on storm sewers and surface waters discharging to Lake Michigan. Priority should be given to those discharges occurring within 500 meters of the beach along shore or within the lake (i.e., the BPA) or within the beachshed. This survey is typically conducted by municipal public works personnel or a consultant. The survey involves a systematic screening of stormwater outfalls to determine the presence of an illicit discharge and is required by Illinois' General Permit for Discharges from Small MS4s. The screening includes a physical inspection of the outfall, surrounding area and discharge, and sampling of the discharge for pollution indicators. Following the outfall survey, follow-up investigations are conducted in the stormwater conveyance system to narrow down and locate the source of the illicit discharge. Follow-up investigations can include visual observations, sampling, microbial source tracking, televised sewer inspections, smoke testing, or dye testing. More information can be found in the Center for Watershed Protection's *Illicit Discharge Detection and Elimination Manual:* http://cfpub.epa.gov/npdes/stormwater/idde.cfm.

Outfall Survey
Effort: 15–30 minutes/outfall Frequency: once a year (IEPA, 2009)

Follow-up Investigations
Effort: variable Frequency: as needed, immediately following the outfall survey

5.1.1.2 Stormwater Management

Stormwater management relies on the use of various BMPs to intercept rainfall and snow melt and allow for some treatment prior to discharge to surface waters. Many stormwater BMPs call for the use of GI, also called low-impact development, which are techniques to infiltrate, evapotranspirate, and reuse stormwater on the land where it is generated. These techniques include the use of infiltration basins, bioretention/rain gardens, vegetated swales/bioswales, and pervious pavement. A brief description of select GI techniques follows to aid managers in determining the best approach for their beach. More information on these techniques can be found on the U.S. EPA's website: http://water.epa.gov/polwaste/green/index.cfm, while detailed design criteria can be found in the *Low Impact Development Manual for Michigan: A Design Guide for Implementers and Reviewers*: http://www.semcog.org/LowImpactDevelopment.aspx. In order to make design cost estimates, the Center for Neighborhood Technology has developed on online tool for use by engineers and planners. The Green Values® Stormwater Management Calculator can be found at http://greenvalues.cnt.org.

Infiltration Basins. Infiltration basins are subsurface areas located in permeable soils that capture, store and infiltrate runoff into the surrounding soils. These basins are typically used for drainage areas between 5 and 50 acres with land slopes less than 20%. Pretreatment of runoff in some areas may be necessary in order to minimize clogging of the soils.

Cost: Variable depending on excavation size, plantings, and piping (SEMCOG, 2008)

Bioretention. Bioretention areas (also called rain gardens) are shallow surface depressions planted with specifically selected vegetation (preferably native plants) to capture and treat stormwater runoff from impervious surfaces. These areas allow stormwater to temporarily pool and then infiltrate to reduce the transport of pollutants, including *E. coli*, found in runoff. Like all GI techniques, bioretention areas require routine maintenance with more intensive efforts needed prior to plant establishment.

Cost: $5 to $7/cubic foot of storage (construction only) (SEMCOG, 2008)

Vegetated Filter Strips. Vegetated filter strips are permanent, maintained strips of vegetation designed to slow runoff velocities and filter out stormwater pollutants. They are gently sloping areas that use grasses and other dense vegetation to treat sheet flow. They are used to treat runoff from parking lots, roadways, and other impervious surfaces and are often used in conjunction with other BMPs.

Cost: $0 to $50,000/acre depending on site conditions (SEMCOG, 2008)

Vegetated Swales. Vegetated swales (also called bioswales) are shallow surface channels that are densely planted with grasses, shrubs and/or trees and are designed to slow, filter, and infiltrate runoff. They can treat up to a 5 acre area with slopes less than 6%. Swales provide less treatment than other infiltration

BMPs, but can be useful, especially in lieu of concrete pipe. Periodic maintenance is required to remove built up sediments and reestablish the drainage slope.

Cost: $4.50 to $20/linear foot (construction only) (SEMCOG, 2008)

Pervious Pavement. Pervious pavement (including porous asphalt, pervious concrete, permeable pavers, and reinforced turf) is another infiltration technique that uses structural surfaces, subsurface storage, and uncompacted soils to capture and treat stormwater runoff. This technique is well suited for parking lots, alleys, playgrounds, and sidewalks. These systems require periodic cleaning, potentially using a vacuum sweeper, in order to maintain their effectiveness.

Cost: Porous Asphalt without infiltration bed: $4 to $5/square foot or 15–25% higher than standard asphalt (SEMCOG, 2008)
Pervious Concrete without infiltration bed: $4 to $6/square foot (SEMCOG, 2008)

The Delaware Department of Natural Resources and Environmental Control gathered information on the effectiveness of BMPs in bacteria concentrations. It should be noted that lower levels of efficiency are seen when incoming bacterial concentrations are low. This information is summarized in **Table 5-2** (Boyer, accessed 2012).

Table 5-2. Bacteria Reduction from Stormwater BMPs

BMP	Bacteria Reduction (%)
Bioretention/Rain gardens	>99
Buffer Strips	43–57
Constructed Wetlands	78–90
Sand Filters	36–83
Wet Detention Ponds	44–99

Stormwater Treatment Devices. Various commercially available stormwater treatment devices have been developed to treat nonpoint-sources pollutants, and a few of them are reported to remove bacteria. These devices can be installed within storm sewers or catch basins to treat piped or overland flow. They vary in size and function, but all utilize some form of settling, filtration using specially designed media, or hydrodynamic separation to remove trash, sediment, oil, and other pollutants. Those designed to be installed in catch basins are easy to retrofit in urban areas (SEMCOG, 2008). However, the effectiveness of these BMPs in removing fecal indicator bacteria (FIB) should be carefully evaluated and possibly field tested before purchased.

Cost: $250 and up per catch basin insert; much higher costs for inline treatment devices

5.1.1.3 Gull Management

Gull Harassment. Multiple techniques are available to reduce beach water quality impacts caused by excessive gull populations. These techniques include active and passive harassment measures and population reduction measures. Active harassment measures include the use of dogs, animal models, predator calls, or pyrotechnics to prevent gulls from loafing or roosting on the beach. Many of these measures work for a period of time, until the birds become conditioned to them. The use of multiple techniques and moving the location of the models can increase effectiveness. Noise calls, used in a study conducted in Ontario, were initially effective; however, the gulls returned after a short period of time (Koski and Kinzelman, 2010).

In another study, gulls were chased from a Lake Michigan beach using specially trained dogs, and water quality improvements were quantified. Average daily gull counts fell from 665 before to 17 during intervention. *E. coli* densities were also significantly reduced during gull control (p = 0.012). Linear regression results indicate that a 50% reduction in gulls was associated with a 29% decrease in *E. coli* density. Potentially human pathogenic bacteria were significantly reduced (p = 0.005) with the bacteria detected on 64% of days prior to gull control and absent during gull intervention. This study demonstrates that dog harassment can be a highly successful measure to improve beach water quality impacted by gulls (Converse et al., 2012).

Cost: $17,000 for the Lake Michigan study mentioned above which covered 15 days, night-time laser sweeps and dawn to dusk dog presence (Converse, 2012).
Generally speaking, the cost is variable based on site conditions (terrain, hours, and type and extent of bird problem)

Flight interruption devices may also be an effective gull management measure. These rotating devices reflect sunlight in a manner that disorients birds in flight by limiting their vision. This causes birds to change their flight pattern. Once such flight interrupting device, the Eagle Eye, claims an 80% deterrent rate and has a range of 150 feet horizontally and 30 feet vertically. It can be powered by wind, solar or standard 110 volt outlet and requires periodic maintenance (http://www.eagleeyebird.com).

Cost: ~$1,200 for a solar unit plus installation

Eagle Eye Flight Interrupter
Source: www.eagleeyebird.com

Naturalized beach areas have also been used as a passive gull exclusion measure. Gulls will not loaf near areas with dune grass due to fear of predation. Daily bird counts were significantly less along beach transects that near naturalized areas when compared to those transects in open beach areas (Koski and Kinzelman, 2010). A 10.4 acre dune was installed at Chicago's 63rd Street Beach and an evaluation of impacts to bird count and water quality is underway.

Egg Oiling. Gull population reduction measures, such as egg oiling, have also been successfully employed to improve beach water quality. Egg oiling was conducted at two Chicago gull colonies to reduce production and the influx of hatch-year (HY) gulls using Chicago's beaches. From 2007 to 2009, 52, 80, and 81%, of nests at the two primary nest colonies had their eggs rendered unviable by corn oil application. HY counts declined at all 10 surveyed beaches from the initial year (52% nests with oiled eggs) to subsequent years with 80% of nests oiled. Overall, HY gulls numbers on beaches decreased 86% from 2007 to 2009. Decreases in beach usage by after hatch-year gulls were not detected. Compared to pretreatment, the number of beaches with improved water quality test rates increased each year through the course of the study. The frequency of water quality tests showing bacterial exceedances compared to 2006 declined at 18 of 19 beaches by 2009. Egg oiling resulted in fewer HY gulls using Chicago's beaches and was likely a beneficial factor for reduced frequencies of swim advisories and swim bans (Engeman et al, 2012).

Cost: $250,000 via Great Lakes Restoration Initiative grant

5.1.1.4 Beach Management

Beach Grooming. "Beach grooming is practiced at many locations to provide aesthetics by removing waste left by previous beach goers and to help remove potentially dangerous object from the sand (glass, metal and wood debris). Not only does beach grooming improve ambiance, but it can have additional benefits such as the removal of food sources for nuisance wildlife and potentially reduce the amount of bacteria in beach sand. In Racine, WI, deep grooming (7-10 cm) without leveling and compacting of the beach sand was shown to decrease bacteria content when sediments were described as wet to moist (Kinzelman et al., 2004). Multiple factors may be responsible for this decrease in FIB, including increased UV exposure and increased amount of sand surface area exposed to the atmosphere, reducing sand drying times. Fecal indicator density in beach sands has been shown to be a function of moisture content (Beversdorf et al., 2006; Yamahara et al., 2009). Shallow beach grooming has been shown to positively influence FIB densities in sand; it is uncertain if this an artifact of mechanical perturbation of FIB sources in the sediments, such a seagull fecal material being more amalgamated or if conditions are made more hospitable for FIB survival (Kinzelman et al., 2003). The CPD has developed mechanical beach grooming equipment improvements in conjunction with manufacturer H. Barber based on the Racine, WI, study. Dubbed the 'Chicago Rake,' this modification allows for deeper grooming (30 cm) and increases the amount of sand exposed to the sun" (Koski and Kinzelman, 2010).

Beach Grading. "Beach grade improvements are used to prevent standing water from being retained on the shore. Standing water keeps sediments moist, which can positively influence bacteria in beach sands. It is also a potential area for wildlife to congregate, which can contribute to direct fecal loading. Water retained in swales or depressions on beach sands does not circulate and can have elevated levels of FIB made available for transport to nearshore waters via precipitation events or wave encroachment. Sources of standing water can vary, including water trapped behind the berm crest from intense wave action, stormwater outlets, and capillary rise from groundwater (Land and Water Magazine, 2009). Beach sand nourishment programs or reengineering of the beach slope may serve to remove depressed areas in which water accumulates. Naturalized beach mitigation measures, including beach grade improvements, have been proposed for Egg Harbor, WI" (Koski and Kinzelman, 2010).

The availability and maintenance of various beach facilities should help control direct fecal inputs from beachgoers, dogs, and wildlife, which will be beneficial for water quality. These facilities include

- Public restrooms,
- Covered waste receptacles to reduce the supply of food sources for gulls and other wildlife, and
- Pet waste stations at beaches that allow dogs.

5.1.1.5 Public Education

A robust public education campaign should be implemented to educate citizens on how their actions can impact beach water quality. Such a campaign could include signage, public service announcements, and print advertisements to discourage wildlife feeding, littering, and illegal dumping, and encourage pet waste cleanup as appropriate for individual beaches. The Watershed Center of Grand Traverse Bay, in cooperation with Michigan State University, implements a well-executed public education campaign to improve beach water quality. Their Healthy Beach campaign targets littering, waterfowl feeding, and pet waste management—all of which are relevant for the Lake Michigan beaches. One of their radio public service announcements to discourage waterfowl feeding can be found at http://www.gtbay.org/wp-content/uploads/2010/09/Dont_Feed_the_Ducks.mp3

Source: The Watershed Center of Grand Traverse Bay

More information on their program can be found at http://www.gtbay.org/our-programs/healthy-beaches/ Local ordinances should also be enacted and enforced to discourage or encourage these activities, as appropriate. The effectiveness of these public education BMPs has not been documented. Nonetheless, there is sufficient anecdotal evidence to suggest that they should be instituted as part of a multi-tiered approach to improve water quality (Koski and Kinzelman, 2010).

5.1.2 Management Strategy

In general, BSSs (routine and annual) should continue and improve as long as the source of the water quality impairment is unknown. The BSSs should be summarized on an annual basis and include an interpretation of the findings. The results of the sanitary surveys should be shared with local municipal staff (ex: public works, beach managers, maintenance staff) at least on an annual basis, so they can understand their role in keeping the beaches open.

If stormwater is a suspected *E. coli* source at a beach—as it is at all of the suburban Cook County segments—illicit discharge surveys should be conducted annually for those discharges occurring within the beachshed and the BPA. If potential human sewage discharges are identified, follow-up investigations should be initiated immediately and resolved as soon as practical.

Gull management efforts should be conducted at most of the suburban Cook County beaches. The local communities should collaborate with Lake County, CPD, U.S. Department of Agricultural (USDA) and/or the Illinois Department of Natural Resources (IDNR) to conduct population control measures, such as locating additional nesting sites and oiling eggs to reduce the number of gull hatchlings. Harassment measures could also be undertaken to reduce the number of gulls loafing at the beaches.

Public education efforts should be improved throughout the county to limit littering and the feeding of gulls, geese and other wildlife at the suburban Cook County beaches. This could include improved signage at the beach, awareness and enforcement of local ordinances, and print and internet outreach. These efforts should focus on the connection between wildlife feeding/litter and beach closures.

Based on the modeling results and local input, known and suspected sources of the water quality impairments were identified and BMPs were suggested for each of the impaired segments as described below.

Glencoe Park Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from three stormwater outfalls. (s)
- Excessive gull population. (s)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in nearby storm sewers.
- Mitigate stormwater flow to nearby storm sewers or from direct drainage areas by using GI measures.
- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.

Winnetka Tower Beach

Known (k) or suspected (s) issues:

- Stormwater runoff. (s)
- Excessive gull population. (s)

Suggested solutions:

- Conduct both routine and annual BSSs to determine potential sources of *E. coli*.
- Mitigate runoff from impervious surfaces direct connected to the beach.
- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.
- Plant dune grasses to discourage gull loafing.

Winnetka Lloyd Park Beach

Known (k) or suspected (s) issues:

- Stormwater runoff. (s)
- Excessive gull population. (s)

Suggested solutions:

- Conduct both routine and annual BSSs to determine potential sources of *E. coli*, including some sampling north of the beach to determine if the neighboring industrial facility is impacting *E. coli* conditions. This sampling is suggested based on aerial photographs that show a sediment plume near the cooling ponds associated with this facility.
- Mitigate runoff from impervious surfaces direct connected to the beach.
- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.
- Plant dune grasses to discourage gull loafing.

Winnetka Maple Park Beach

Known (k) or suspected (s) issues:

- Stormwater runoff. (s)
- Excessive gull population. (s)

Suggested solutions:

- Conduct both routine and annual BSSs to determine potential sources of *E. coli*.
- Mitigate runoff from impervious surfaces direct connected to the beach.
- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.
- Plant dune grasses to discourage gull loafing.

Winnetka Elder Park Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from a stormwater outfall at the beach (k). Recent illicit discharge investigations identified several illicit connections and infiltration from sanitary sewers. These issues have been resolved, but further investigations may be warranted if *E. coli* levels persist.
- *E. coli* impacted stormwater flow from direct drainage area. (s)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in nearby storm sewer.
- Mitigate stormwater flow to nearby storm sewers or from direct drainage areas by using GI measures.

Kenilworth Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from a stormwater outfall that discharges north of the northern jetty. (s)
- *E. coli* impacted stormwater flow from direct drainage area. (s)
- Moderate gull population. (s)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in nearby storm sewer.
- Mitigate stormwater flow to nearby storm sewers or from direct drainage areas by using GI measures.
- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.
- Supplement beach sand to improve drainage.
- Plant dune grasses to discourage gull loafing.

Winnetka Gillson Beach

Known (k) or suspected (s) issues:

- Excessive gull population. (s)
- *E. coli* impacted stormwater flow from direct drainage area. (s)

Suggested solutions:

- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.
- Supplement beach sand to improve drainage.
- Plant dune grasses to discourage gull loafing.
- Mitigate stormwater flow from direct drainage areas by using GI measures.

Evanston Beaches

All of the City of Evanston's impaired beaches (Lighthouse, Northwestern University, Clark, Greenwood, Lee, South Boulevard) are groomed daily, have trash containers that are collected daily and have lifeguards on duty. The City has not historically conducted gull harassment or population reduction activities. Dogs are not allowed on Evanston's impaired beaches. There needs to be more enforcement of the City's littering and wildlife feeding ordinances. In addition, the City's beach-grooming practices should be evaluated to determine if improvements could positively influence water quality conditions as discussed in **Section 5.1.1.4**.

Evanston Lighthouse Beach

Known (k) or suspected (s) issues:

- Excessive gull population. (k)
- Shallow beach with a lot of exposed sand. (k)
- Algae build up along the shoreline. (k)

Suggested solutions:

- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.
- Re-slope beach sand to improve drainage.
- Plant dune grasses to discourage gull loafing.
- Continue beach grooming to remove algae.

Northwestern University Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from a stormwater outfall just north of the beach near the Evanston Water and Sewer Department complex. Repeated sampling in 2011 indicated fairly high *E. coli* concentrations at this outfall. (k)
- *E. coli* impacted stormwater flow from direct drainage from the parking lot and from ponded areas at the northwest and south ends of the beach, which overflow to the beach. (k)
- Excessive gull population. (k)

Suggested solutions:

- Conduct illicit discharge investigations for sewage sources in nearby storm sewer.
- Mitigate stormwater flow direct drainage areas by using GI measures such as bioswales or pervious pavements to eliminate ponding and drainage to the beach.
- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.
- Supplement beach sand to improve drainage.
- Continue beach grooming.
- Plant dune grasses to discourage gull loafing.

Evanston Clark Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from direct drainage from the parking lot at the north end of the beach and from a ponded area, which overflows to the beach. (k)
- Excessive gull population. (k)
- Excessive littering occurs at this beach. (k)
- Water temperatures 6 – 8°F warmer than other beaches for unknown reasons. (k)

Suggested solutions:

- Mitigate stormwater flow from direct drainage areas by using GI measures such as bioswales or pervious pavements to eliminate ponding and drainage to the beach.
- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.
- Plant dune grasses to discourage gull loafing.
- Increase litter pick-up frequency. Perhaps collaborate with the Alliance of the Great Lakes to conduct more frequent beach clean-ups (http://www.greatlakes.org/home).

Evanston Greenwood Beach

Greenwood Beach is bordered by Dog Beach to the north where there is a blatant disregard to the City's pet waste cleanup ordinance. Although there are signage and waste receptacles at Dog Beach, the area is frequently littered with dog waste. Often patrons collect their pet's waste in a bag, but dispose of it on the ground or tie it to a fence. These activities may be impacting the water quality at Greenwood Beach.

Known (k) or suspected (s) issues:

- Improper disposal of pet waste at Dog Beach. (k)
- Shallow beach with a lot of exposed sand. (s)

Suggested solutions:

- Better education and enforcement of the City's pet waste ordinance at Dog Beach, including how actions may be impacting water quality in the neighboring swimming beach. A few strategically placed surveillance cameras may assist with this effort.
- Re-slope beach sand to improve drainage.

Evanston Lee Beach

Known (k) or suspected (s) issues:

- Shallow beach with a lot of exposed sand. (k)

Suggested solutions:

- Re-slope beach sand to improve drainage.

Evanston South Boulevard Beach

Known (k) or suspected (s) issues:

- Excessive gull population. (k)
- *E. coli* impacted stormwater flow from direct drainage area. (s)
- Shallow beach with a lot of exposed sand. (k)

Suggested solutions:

- Conduct gull population reduction measures in cooperation with neighboring municipalities or conduct gull harassment.
- Supplement beach sand to improve drainage.
- Plant dune grasses to discourage gull loafing.
- Mitigate stormwater flow from direct drainage areas by using GI measures.
- Reslope beach to limit gull loafing.

5.1.3 Implementation

A schedule for implementation of the suggested measures is not appropriate in this document. The impaired beaches are managed by various entities and there are practical, political, and financial limitations that potentially need to be considered and overcome by the local beach managers before some of the BMPs are undertaken. Nonetheless, it is recommended that each community prioritize their beaches and the recommended strategies to determine the most feasible options at the most impacted beaches. If deemed helpful for the community, a community beach improvement plan should be developed if not already incorporated into a community's master planning documents.

Through IEPA's Resource Management Mapping Service (http://www.rmms.illinois.edu), a tracking tool is being developed to measure TMDL implementation successes. This tool will track the BMPs that are implemented to reduce pollutant loads to impaired waters with established TMDLs. During the first stage of development, nitrogen, phosphorus, and total suspended solid load reductions will be tracked for BMPs implemented to control nonpoint-source pollution (i.e., LAs). During future upgrades to the tool, additional parameters will be added and load reductions associated with point sources (i.e., WLAs) will be tracked.

5.1.4 Funding Opportunities

The most likely funding sources to implement the BMPs described previously are the Great Lakes Restoration Initiative (http://greatlakesrestoration.us/index.html), the Illinois GI Program for Stormwater Management (www.epa.state.il.us/water/financial-assistance/igig.html) and Nonpoint Source Section 319 grants (http://www.epa.state.il.us/water/financial-assistance/non-point.html). However, there are multiple other programs can aid in funding measures to reduce *E. coli* as shown in **Table 5-3**.

Table 5-3. Funding Opportunities for Implementing Selected Options to Achieve the TMDLs

Funding Opportunity	Description
U.S. Environmental Protection Agency	
Great Lakes Restoration Initiative	This funds various projects, including a program area aimed at improving beach water quality.
Five Star Restoration Challenge	This brings together community groups to restore streambanks and wetlands.
Priority Lake and Watershed Implementation Program	This funds implementation of protection/restoration practices that improve water quality.
U.S. Department of Agriculture, Natural Resource Conservation Service	
Streambank Stabilization Restoration Program	This develops and demonstrates vegetative, stone-structure and other low-cost bio-engineering techniques for stabilizing streambanks.
U.S. Department of the Interior, Fish and Wildlife Service	
Land and Water Conservation Fund	This provides funds to states and localities for park and recreational land planning, acquisition, and development.
National Oceanic and Atmospheric Administration	
Coastal Zone Management Program	This assists states in implementing Coastal Zone Management programs approved by NOAA. Funding for watershed projects in Illinois is expected in upcoming years, following program adoption and establishment by the state.
Coastal Services Center Cooperative Agreements	These provide technical assistance and project grants through arrange of programs and partnering arrangements, all focused on protecting and improving coastal environments.
U.S. Department of Transportation	
Transportation Enhancement Program	This funds projects that may include control technologies to prevent polluted highway runoff from reaching surface water bodies, scenic easements, pedestrian and bicycle trails, and wetland mitigation efforts.

(continued)

Table 5-3. Funding Opportunities for Implementing Selected Options to Achieve the TMDLs (continued)

Funding Opportunity	Description
Illinois Environmental Protection Agency	
Illinois Green Infrastructure Program for Stormwater Management	Grants are available to local units of government and other organizations to implement green infrastructure BMPs to control stormwater runoff for water quality protection in Illinois. Projects must be located within a MS4 or CSO area. Funds are limited to the implementation of BMPs.
Nonpoint Source Section 319 Grants	Grants are available to local units of government and other organizations to protect water quality in Illinois. Projects must address water quality issues relating directly to nonpoint source pollution. Funds can be used for the implementation of watershed management plans, including the development of information/ education programs and for the installation of BMPs.
Illinois Department of Natural Resources	
Conservation 2000	This supports nine conservation programs across three state agencies and provides financial and technical support to groups (ecosystem partners) that seek to maintain and enhance ecological and economic conditions in key watersheds of Illinois.
Water Resources Small Projects Fund	This provides assistance to rural and smaller urban communities to reduce stormwater-related damages by alleviating local significant drainage and flood problems.
Illinois Department of Agriculture	
Streambank Stabilization & Restoration Program	This supports naturalized stream bank stabilization practices in rural and urban communities.
Other Funding Sources	
The Great Lakes Basin Program for Soil Erosion and Sediment Control	This supports projects that protect Great Lakes water quality, such as by controlling erosion and sedimentation.
Coastal Services Center Cooperative Agreements	These provide technical assistance and project grants through a range of programs and partnering arrangements, all focused on protecting and improving coastal environments.

5.2 Reasonable Assurance

The U.S. EPA requires reasonable assurance that TMDLs will be achieved and WQS will be met. Reasonable assurance that the WLAs will be implemented is provided by regulatory actions. According to 40 CFR 122.44(d)(1)(vii)(B), NPDES permit effluent limits must be consistent with assumptions and requirements of all WLAs in an approved TMDL. IEPA implements its storm water and NPDES permit programs and is responsible for making the effluent limits consistent with the WLAs in this TMDL. Effluent and in-stream monitoring is reported to IEPA and should provide reasonable assurance that WQS will be met. This strategy will be undertaken for the excess flow facilities identified in this study as well as revisiting the other NPDES-permitted dischargers.

The primary strategy for attaining WQSs along the Illinois Lake Michigan shoreline is to implement BMPs aimed at reducing stormwater runoff to the beaches themselves and to the surface ravines and tributaries transmitting water the lake on or within a half kilometer of the beaches along the shoreline. BMPs will be used to address the stormwater and physical beach characteristics that were identified as large contributors to the WQS exceedances at the beaches.

A number of watershed and beach-specific activities exist or are underway along the shoreline thanks to funding from the Great Lakes Restoration Initiative (**Table 5-4**). Several of these activities directly relate to the identified nonpoint sources in the TMDL analysis (e.g., gulls).

For this TMDL analysis, an additional level of reasonable assurance is provided by making the statistical models for load reductions based on measurable parameters available to the beach managers through a software program. The graphical user interface for this program is intended to provide beach managers with a tool that will allow them to examine the impact of various mitigation strategies on predicted *E. coli* concentrations. Users will be able to vary both manageable and non-manageable variables while selecting from pre-set scenarios for average or critical conditions to assess the range and sensitivity in results. For instance, managers could predict the impact of restricting gull counts to a specific number or examine how varying 24 hour precipitation amounts alter predicted *E. coli* concentrations under average or critical conditions. As model variables are changed, the appropriate beach-specific model will recalculate predicted concentrations; this function will allow users to compare the impact of mitigation strategies under a range of different conditions.

In addition, a survey on preferred and available implementation options was distributed to local beach managers, municipal stormwater engineers, and other applicable parties so that the options most likely to be implemented were included in the segment-specific plans developed for this TMDL. Beach managers and local stormwater officials were able to identify projects that they were favorable, able, or planning to put into place in their managed areas. Therefore, the implementation plans are based on current state of practice and consider local conditions and managerial climates.

Table 5-4. Existing Activities within the Lake Michigan Shoreline Watershed that Support Attainment of the WQS

Project Title	Abstract	Recipient Organization or Lead Agency	GLRI Award Amount	Fiscal Year
Ring-billed Gull Management for Lake Michigan Beach Health	The objectives of the Chicago Ring-Billed Gull Damage Management Project were to reduce the local production of ring-billed gulls, to evaluate the affects limiting gull production has on gull use of beaches, and to reduce the severity of conflicts with gulls, including the issuance of swim advisories and swim bans. Between 2007 and 2009, we applied corn oil to 52%– 80% of nests in two large gull colonies in Chicago and successfully reduced hatching success and subsequent fledging of 18,000 - 42,000 gulls per year without causing colony abandonment.	Chicago Department of Environment	$250,236	2010
A Comprehensive Communications Program for Chicago Beaches	This project will implement a comprehensive beach communications program that is designed to improve public understanding of beach water quality and beach health and to increase public notification of swimming bans and advisories for 21 of the 24 Chicago Beaches in Lake Michigan. The project will include signage, expanded electronic communications, staff training, and a new volunteer beach ambassadors program.	Chicago Park District	$99,340	2010
Modification of 63rd Street Beach to Improve Water Quality	CPD will use this grant to install a culvert through an existing pier on the south end of the 63rd Street Beach. The culvert will improve water circulation and reduce bacterial contamination levels at the beach, resulting in fewer beach closures and advisories and improved protection of public health.	Chicago Park District	$182,500	2011
A Protective Barrier to Improve Beach Safety in Chicago	CPD will install a protective barrier at Montrose Beach or Rainbow Beach to prevent nonpoint sources of pollution from outside the beach basin from impacting beach water quality in the swimming area. CPD will also conduct 45 days of intensive sampling and analysis of water and sand inside and outside the barrier area to determine the effectiveness of reducing bacteriological, algal and chemical contamination concentrations in the beach swimming area.	Chicago Park District	$243,465	2011
Development of SwimCast Models at Four Chicago Beaches	CPD proposes to begin development of new predictive models using SwimCast monitoring stations at Montrose Beach, Foster Beach and Calumet Beach. In addition, the Chicago Park District will continue to refine the existing predictive models at 63rd Street Beach. Technical assistance in analyzing data for the development of the models will be provided by the USGS. The USGS will use the data collected from the SwimCast stations to further work on a regional model.	Chicago Park District	$245,420	2010
Sanitary Surveys and Stormwater Impacts at Chicago Beaches	CPD proposes to conduct sanitary surveys at every Chicago beach and the catchment areas of storm drains that discharge into Lake Michigan. Samples will be collected directly from the stormwater outfalls to determine whether storm drains and urban runoff are contributing to fecal indicator bacteria levels at nearby Chicago beaches. Sources of fecal indicator bacteria will be characterized and will be used to develop evaluation and assessment protocols that can be used by beach managers in similar Great Lakes settings.	Chicago Park District	$250,000	2010

(continued)

Table 5-4. Existing Activities within the Lake Michigan Shoreline Watershed that Support Attainment of the WQS (continued)

Project Title	Abstract	Recipient Organization or Lead Agency	GLRI Award Amount	Fiscal Year
Enhancing Beach Management for Beach Safety in Chicago	CPD will reduce bacterial contamination from ring-billed gulls, litter, and organic material. CPD will groom 24 Chicago beaches seven days a week to reduce bacteria from sand and will begin a beach ambassador program to educate beachgoers and day camp children about beach health. CPD will collect data on algae mats and detritus to evaluate grooming effectiveness.	Chicago Park District	$749,121	2011
Illinois Lake Michigan Implementation Plan	IDNR will collaborate with the Alliance for the Great Lakes, Chicago Wilderness, and the Biodiversity Project to develop and implement an Illinois Lake Michigan Implementation Plan to guide resource allocations to protect the Illinois Lake Michigan watershed. The result will be improved prioritization and implementation of on-the-ground restoration projects in the Lake Michigan watershed and coastal zone and an increase in the number and diversity of stakeholders participating in Lakewide Management Plan priorities.	Illinois Department of Natural Resources	$226,950	2011
Illinois Beach Sanitary Surveys	IDPH will perform detailed surveys of swimming beaches and associated watersheds to identify sources of pollution contributing to water quality exceedances at 10 Lake Michigan beaches. The department will identify ways to eliminate pollution and disseminate findings.	Illinois Department of Public Health	$245,000	2010
Waukegan Harbor AOC-Glen Flora Tributary Hydrology Study	This project will include a detailed hydrologic study to identify existing flow patterns of water entering the Waukegan Harbor Extended Area of Concern (EAOC) from Glen Flora Tributary. By (1) identifying inundation frequency, inundation depth, and direction and quantity of flow into and through the EAOC; (2) determining the respective quantity of water in each flow path; and (3) determining the influence of Glen Flora Tributary on the hydrology of the EAOC, the project will form the basis of restoration and management decisions for wetlands and native plant communities for wildlife habitat in the EAOC and nearby buffer area.	Lake County Stormwater Management Commission	$118,500	2010
Dead Dog Creek Ravine/Stream Restoration Phase 2	The Lake County Stormwater Management Commission will implement the second and final phase of Dead Dog Creek stream restoration. Dead Dog Creek is a ravine system tributary to coastal wetlands and Lake Michigan. The restoration will implement in-stream, streambank, and riparian buffer water quality and sediment control on 3,950 feet of Dead Dog Creek. This restoration will prevent 67 tons of sediment and 73 pounds of phosphorus from reaching Lake Michigan.	Lake County Stormwater Management Commission	$675,401	2011
Kellogg Watershed-Dead Dog Creek/Water Quality BMPs Project	This project will implement in-stream, streambank, and riparian buffer water quality and sediment control bioengineering practices on Dead Dog Creek in Winthrop Harbor, IL. In addition, residential and business demonstration sites will be created with run-off reduction and water quality improvement practices. This project will restore hydrology and stabilize stream channels by reducing urban stormwater flows to Dead Dog Creek.	Lake County Stormwater Management Commission	$832,850	2010

(continued)

Table 5-4. Existing Activities within the Lake Michigan Shoreline Watershed that Support Attainment of the WQS (continued)

Project Title	Abstract	Recipient Organization or Lead Agency	GLRI Award Amount	Fiscal Year
Restoring Native Diversity to Aquatic Ravine Ecosystems	This project will restore natural stream conditions to improve fish habitat in Ravine Number 7L at Millard Park (a tributary of Lake Michigan, located in Highland Park, IL) to make it more suitable for the return of desirable cold-water fish such as brook trout, brown trout, lake chub and white sucker. A restored stream, with successfully reproducing stocks of native fish, will enhance the overall desirability of the Park, improve Great Lakes fish habitat and water quality, and provide a model of fish habitat restoration for future projects in the Lake Michigan ravine ecosystems.	Park District of Highland Park	$200,000	2010
63rd St. Beach and Dune Construction	The USACE has initiated construction of this project that will restore 21 acres of dune and swale habitat along Lake Michigan in Chicago, IL.	U.S. Army Corps of Engineers	$800,000	2010, 2011
Illinois Beach State Park Southern Buffer Restoration	This project will (1) restore and expand a green buffer to preserve vital habitat and water quality for nearshore species; (2) gather baseline biological data for the Waukegan Extended Area of Concern; (3) prevent erosion and sedimentation in the riparian nearshore, wetland and upland reaches of the Dead River watershed; and (4) provide greater infiltration and stabilization of at least 160 acres riparian inflows to Lake Michigan.	Waukegan Harbor Area of Concern Citizens Advisory Group	$1,433,350	2010
Dune and Beach Restoration for Lake Michigan Beach Health	LCHD will decrease gull habitat and increase biodiversity at North Point Marina in Lake County, IL. LCHD will restore and expand the dune and beach area, remove all invasive species, plant native species, monitor water levels, assess vegetation, and educate lifeguards about beach and dune health. This project is expected to reduce bacteria and other pathogens, improve water quality, and reduce swimming bans at North Point Marina.	Lake County Health Department and Community Health Center	$349,934	2011

5.3 Monitoring Recommendations to Track TMDL Effectiveness

BEACH Act funding currently supports water quality monitoring by local beach authorities at Lake Michigan Beaches. If this funding is maintained then pre- and post-water quality data sets will be available to track the effectiveness of the TMDL. Water quality monitoring for *E. coli* concentrations at the impaired beach segments is expected to continue during future swim seasons to ensure public health and verify models. It is also assumed, and recommended, that the hydrometeorological parameters monitored at each of the current beaches continue. Monitoring of this nature will allow for determination of the attainment of the WQS.

Additional monitoring will not be routinely conducted, except under specific BSSs, which would provide high levels of information to the tracking of the TMDL status focuses on identifying and quantifying stormwater loadings of bacteria. Identifying those locations that contribute stormwater runoff directly to the beaches or to one of the surface water tributaries and ravines will allow for event-based sampling to narrow down the locations at which stormwater with elevated *E. coli* concentrations originates. This process will help focus the suggested BMPs in the Implementation Plans.

6. Public Participation

A Technical Advisory Committee (TAC) was established that includes the project team (U.S. EPA, IEPA, and the contractor) and local stakeholders (CPD, LCHD, IDPH, MWRDGC, local municipalities, and non-profit groups). Regular participating members in the TAC are listed in **Table 6-1**. Input was sought from the TAC to (1) help the TMDLs and implementation plans best reflect local conditions; (2) ensure the TMDLs rely on the best available data; (3) build consensus amongst the stakeholders; and (4) determine how any ongoing or planned stakeholder activities can be leveraged in TMDL development or Implementation Plan guidance. The project team interacted with the local stakeholders by submitting data requests associated with the ongoing Beach BSSs and to review beach characterizations.

Four stakeholder meetings were held during TMDL development to present data analysis and project status and to allow stakeholders an opportunity to provide feedback:

- April 2011 – Review of project plan and available data
- March 2012 – Review of initial findings and required assumptions
- October 2012 – Discussion of implementation options and draft TMDL results
- January 2013 – Review of public notice draft TMDLs
- April 2013 – User interface demonstration

Table 6-1. Participating Members of the TAC

Contact	Agency
Holiday Wirick	U.S. EPA
Cathy Breitenbach	Chicago Park District
Mike Adam	Lake County Health Department
Geeta K. Rijal, Ph.D., NRCM	Metropolitan Water Reclamation District of Greater Chicago
Justin Dewitt, P.E., LEED AP	Illinois Department of Public Health
Lyman Welch	Alliance for the Great Lakes
Carl Caneva	Evanston Park District

In addition to the meetings with the TAC, two public notice meetings were held in Chicago and Lake Forest, IL. The first meeting in March 2012, outlined the project objectives, basic methods, and reliance on monitoring data. The second meeting, to be held in February 2013, during the public notice period, will review WLAs, LAs, load reductions, and implementation plans.

The U.S. EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). Before finalizing TMDLs, the public is notified that a comment period is open for at least 30 days. IEPA's public notices to comment on draft TMDLs are also distributed via mail and electronic mail to major stakeholders in the watershed or other potentially impacted parties. After the comment period closes, IEPA reviews all comments, edits the TMDL as is appropriate, writes a summary of response to comments, and includes this in their TMDL submission to the U.S. EPA for final review. **Appendix III** of this document contains the response to public comments received during the public notice period.

References

Abderholden, F. 2011. Beach at North Point Marina getting a makeover. *Lake County News-Sun.* August 22. Available at: http://www.itre.ncsu.edu/ADC10/PDFs/2007_Summer_Conference/EnvAnalysisTour/South_Lake_Shore_Drive_Reconstruction.pdf

Alliance for the Great Lakes. 2009. *Stresses and Opportunities in Illinois Lake Michigan Watersheds Strategic Sub-Watershed Identification Process (SSIP) Report*. Prepared for the Lake Michigan Watershed Ecosystem Partnership. Available at: http://www.greatlakes.org/Page.aspx?pid=881.

Alm, E., J. Burke, and A. Spain. 2003. Fecal indicator bacteria are abundant in wet sand at freshwater beaches. *Water Research 37*(16)*:*3978–3982.

Beversdorf, L.J., S.M. Bornstein-Forst, and S.L. McLellan. 2006. The potential for beach sand to serve as a reservoir for Escherichia coli and the physical influences on cell die-off. *Journal of Applied Microbiology 102*(5):1372–1381.

Boyer, A. n.d. Reducing Bacteria with Best Management Practices. Delaware Department of Natural Resources and Environmental Control. Undated. Available at: http://www.wr.udel.edu/ChristinaTribTeam/Fact%20Sheets/ReducingBacteria_wBMPs.pdf (accessed 9/20/2012).

City of Evanston. 2008. *Lakefront Master Plan.* City of Evanston, Parks/Forestry & Recreation Department, Evanston, IL.

City of Evanston. 2012. *Lakefront & Beaches*. Online information. City of Evanston, Parks, Recreation, and Community Services, Evanston, IL. Available at: http://www.cityofevanston.org/parks-recreation/lakefront-beaches/ (accessed May 2012).

Converse, R.R. 2012. "Study costs for gull management." Personal communication: R. Converse (U.S. EPA) with A. DeMaria (ECT). November 20.

Converse, R.R., J.L. Kinzelman, E.A. Sams, E. Hudgens, A.P. Dufour, H. Ryu, J.W. Santo-Domingo, C.A. Kelty, O.C. Shanks, S.D. Siefring, R.A. Haugland, and T.J. Wade. 2012. Dramatic improvements in beach water quality following gull removal. *Environmental Science and Technology 46*(18), 10206–13.

Creque, S.M., K.M. Stainbrook, D.C. Glover, S.J. Czesny, and J.M. Dettmers. 2010. Mapping bottom substrate in Illinois waters of Lake Michigan: Linking substrate and biology. *Journal of Great Lakes Research 36*:780–789.

Elmir, S., M. Wright, A. Abdelzahera, H. Solo-Gabrielea, L. Fleminga, G. Miller, M. Rybolowikc, M. Shih, S. Pillaid, J. Cooperd, and E. Quayed. 2007. Quantitative evaluation of bacteria released by bathers in a marine water. *Water Resources Research 41*(1): 3–10.

Engeman, R.M., J.W. Hartmann, S.F. Beckerman, T.W. Seamans, S. Abu-Absi. 2012. Egg oiling to reduce hatch-year ring-billed gull numbers on Chicago's beaches during swim season and water quality test results. *EcoHealth 9*(2):195–204.

Fornek, Kimberly. 2012. Winnetka's Elder Lane Beach may see fewer closures this year. *Glencoe News May 14, 2012*.

Ge, Z. R.L. Whitman, M.B. Nevers, M.S. Phanikumar, and M.N. Byappanahalli. 2012. Nearshore hydrogynamics as loading and forcing factors for *Escherichia coli* contamination at an embayed beach. *Limnology and Oceanography* 57(1): 362–381.

GPD (Glencoe Park District). 2012. *Glencoe Beach.* Online information. Glencoe Park District, Glencoe, IL. Available at: http://www.glencoeparkdistrict.com/facilities/glencoe-beach.aspx (Accessed May 2012).

Hunt, W., J. Smith, S. Jadlocki, J. Hathaway, and P. Eubanks. 2008. Pollutant removal and peak flow mitigation by a bioretention cell in Urban Charlotte, N.C. *Journal of Environmental Engineering 134*(5):403–408.

Huston, J.P. 2011. Village and park district to work together on beachfront contamination. *TribLocal Winnetka/Northfield July 1, 2011.*

IDNR (Illinois Department of Natural Resources). 2011a. *Illinois Beach State Park and North Point Marina Including the Dead River and Kellogg Creek Watersheds*. Illinois Coastal Management Program Issue Paper. Illinois Department of Natural Resources, Illinois Coastal Management Program, Springfield, IL.

IDNR (Illinois Department of Natural Resources). 2011b. *Ravine Systems in the Lake Michigan Watershed, Illinois*. Illinois Coastal Management Program Issue Paper. Illinois Department of Natural Resources, Illinois Coastal Management Program, Springfield, IL.

IDNR (Illinois Department of Natural Resources). 2011c. *Waukegan Harbor, Waukegan Lakefront and Waukegan Watershed*. Illinois Coastal Management Program Issue Paper. Illinois Department of Natural Resources, Illinois Coastal Management Program, Springfield, IL.

IDNR (Illinois Department of Natural Resources). 2012a. *Adeline Jay Geo-Karis Illinois Beach – State Park.* Online information. Illinois Department of Natural Resources, Northeast Region, Bartlett, IL. Available at: http://dnr.state.il.us/lands/landmgt/PARKS/R2/ILBEACH.htm (accessed May 2012).

IDNR (Illinois Department of Natural Resources). 2012b. *North Point Marina.* Online information. Illinois Department of Natural Resources, Northeast Region, Bartlett, IL. Available at: http://dnr.state.il.us/lands/landmgt/PARKS/NORTH_PO/INDEX.htm (accessed May 2012).

IEPA (Illinois Environmental Protection Agency). 2009. General NPDES Permit for Small Municipal Separate Storm Sewer Systems. February 20.

IEPA (Illinois Environmental Protection Agency). 2010. *Illinois Integrated Water Quality Report and Section 303(d) List – 2010*. Water Resource Assessment Information and Listing of Impaired Waters, Volume II: Groundwater. IEPA, Bureau of Water. April. Available at http://www.epa.state.il.us/water/tmdl/303-appendix/2010/2010-ir-volume-ii-groundwater-draft.pdf.

Illinois DPH (Department of Public Health). 2012. *Beachguard*. Online information. Illinois Department of Public Health, Environmental Health, Springfield, IL. Available at: http://app.idph.state.il.us/envhealth/ilbeaches/public/ (accessed May 2012).

Kinzelman, J., K. Pond, K. Longmaid, and R. Bagley. 2004. The effect of two mechanical beach grooming strategies on *Escherichia coli* density in beach sand at a southwestern Lake Michigan beach. *Aquatic Ecosystem Health and Management 7*(3):425–432.

Kinzelman, J., R. Whitman, M. Byappanahalli, E. Jackson, and R. Bagley. 2003. Evaluation of beach grooming techniques on *Escherichia coli* density in foreshore sand at North Beach, Racine, WI. *Lake and Reservoir Management 19*(4):349–354.

Kleinheinz, G.T., Colleen M. McDermott, Sarah Hughes, and Amanda Brown, “Effects of Rainfall on E. coli Concentrations at Door County, Wisconsin Beaches,” International Journal of Microbiology, vol. 2009, Article ID 876050, 9 pages, 2009. doi:10.1155/2009/876050

Koski, A., and J. Kinzelman. 2010. *A Review of Best Management Practices Benefiting Great Lakes Recreational Waters: Current Success Stories and Future Innovations*. International Joint Commission. April 27.

Land and Water Magazine. Bringing Back Our Beaches: A Naturalized Approach to *E. coli* Reduction. *Land and Water Magazine.* March/April 2009, 44–47. Available at http://map.co.door.wi.us/swcd/Beaches/BringingBackourBeacheslo-res.pdf.

Lerman, A. 2012. *Minutes of an Advisory Group Meeting of the Glencoe Beach and Lakefront Advisory Group of the Glencoe Park District.* Meeting Minutes. Glencoe Park District, Glencoe, IL.

Levesque, B., P. Brousseau, F. Bernier, E. Dewailly, and J. Joly. 2000. Study of the bacterial content of ring-billed gull droppings in relation to recreational water quality. *Water Research 34*:1089–1096.

McLellan, S. 2012. “Sources of *E. coli* to Lake Michigan beaches.” Personal communication: S. McLellan (University of Wisconsin) with M. Cutrofello (RTI) and M. Kamerath (U.S. EPA). June 28.

McLellan, S.L., and A.K. Salmore. 2003. Evidence for localized bacterial loading as the cause of chronic beach closings in a freshwater marina. *Water Research 37*:2700–2708.

MWRDGC (Metropolitan Water Reclamation District of Greater Chicago). 2008. *Description of the Chicago Waterway System for the Use Attainability Analysis*. Report No. 08-15R. Monitoring and Research Department. Chicago, IL. Available at:

http://www.mwrd.org/pv_obj_cache/pv_obj_id_ECEFE06C27756E8C4A4D233A95E69F52BD242200/filename/08-15%20Description%20of%20CWS%20Report%20for%20UAA.pdf.

MWRDGC (Metropolitan Water Reclamation District of Greater Chicago). 2010. *Microbiological Report of Bypass Samples in 2009*. Report No. 10-17. Monitoring and Research Department. Chicago, IL.

Northwestern University. 2012a. *Historic Moments: The Lakefill Expansion*. Online information. Northwestern University, Evanston, IL. Available at: http://www.northwestern.edu/about/historic-moments/campus/the-lakefill-expansion.html (accessed May 2012).

Northwestern University. 2012b. *North Beach Status.* Online information. Northwestern University, Evanston, IL. Available at: http://www.fitrec.northwestern.edu/facilities/beach/status.html (accessed May 2012).

Powers, J. 2011. High bacteria count closes Gillson Beach on Memorial Day. *Willmette-Kenilworth Patch June 1, 2011.*

Reeves, R.L., S.B. Grant, R.D. Mrse, C.M.C. Oancea, B.F. Sanders, and A.B. Boehm. 2004. Scaling and management of fecal indicator bacteria in runoff from a coastal urban watershed in southern California. *Environmental Science and Technology 38*:2637–2648.

Sampson, R.W., S.A. Swiatnicki, V.L. Osinga, J.L. Supita, C.M. McDermott, and G.T. Kleinheinz. 2006. Effects of temperature and sand on *E. coli* survival in a northern lake water microcosm. *Journal of Water and Health 4*(3):389–93.

Schulte, S. 2011. *Bad Beaches: Low Water Quality in Winnetka, Lake County*. Online information. ABC 7, Chicago, IL. Available at: http://abclocal.go.com/wls/story?section=news/local&id=8221689 (accessed May 2012).

Scopel, C.O., J. Harris, and S.L. McLellan. 2006. Influence of nearshore water dynamics and pollution sources on beach monitoring outcomes at two adjacent Lake Michigan beaches. *Journal of Great Lakes Research 32*:543–552.

SEMCOG (Southeast Michigan Council of Governments). 2008. *Low Impact Development Manual for Michigan: A Design Guide for Implementers and Reviewers*.

Skalbeck, J.D., J.L. Kinzelman, and G.C. Mayer. 2010. Fecal indicator organism density in beach sands: Impact of sediment grain size, uniformity, and hydrologic factors on surface water loading. *Journal of Great Lakes Research 36*:707–714.

U.S. EPA (Environmental Protection Agency). 2008a. *2007 Beach Sanitary Survey Great Lakes Pilot Project.* EPA 905-R-08-002. U.S. Environmental Protection Agency, Region 5, Chicago, IL.

U.S. EPA (Environmental Protection Agency). 2008b.*Great Lakes Beach Sanitary Survey User Manual*. EPA-823-B-06-001. U.S. Environmental Protection Agency, Office of Water. May.

Whitman, R.L., and M.B. Nevers. 2003. Foreshore sand as a source of Escherichia coli in nearshore water of a Lake Michigan beach. *Applied and Environmental Microbiology* 69:5555–5562.

Whitman, R.L., and M.B. Nevers. 2008. Summer *E. coli* patterns and responses along 23 Chicago beaches. *Environmental Science and Technology 42:*9217–9224.

Wilmette Harbor Association. 2012. *Wilmette Harbor Association.* Online information. Wilmette Harbor Association, Wilmette, IL. Available at: http://www.wilmetteharbor.com/WilmetteHarbor/index.htm (accessed May 2012).

Winnetka PD (Park District). 2011. *Winnetka Park District and the Village of Winnetka Work Jointly on Lakefront Bacteria Issues*. Press Release. Winnetka Park District, Winnetka, IL. June 30.

Wright, M., H. Solo-Gabriele, S. Elmir, and L. Fleming. 2009. Microbial load from animal feces at a recreational beach. *Marine Pollution Bulletin 58*(11):1649–56.

Yamahara, K.M., S.P. Walters, and A.B. Boehm. 2009. Growth of enterococci in unaltered, unseeded beach sands subjected to tidal wetting. *Applied and Environmental Microbiology 75*(6):1517–1524.

Appendix I: Load Reduction Calculation Methods

In order to utilize all the available monitoring data from each of the beaches managed by the agencies within Suburban Cook County, a statistical framework was employed to calculate the impacts of each of the source and surrogate variables available on *E. coli* concentrations. The method is explained through four steps beginning with initial data exploration and ending with calculating the reductions in the different parameters used in the model that are needed to meet the WQS.

Two datasets were obtained for Suburban Cook County beaches. *E. coli* data, including sample location, date, and time, were obtained for all available impaired segments for the years 2006–2011. Beach Sanitary Survey (BSS) data for Evanston beaches were obtained for the years 2009–2011; this dataset contains information on animal and human usage, beach and water conditions, and additional meteorological data, as well as measured *E. coli* concentrations.

A.1 Step 1: Exploratory Data Analysis – Response Variable

Purpose: Characterize distribution of *E. coli* concentrations at Suburban Cook County beaches; examine censored observations; check for temporal and/or spatial autocorrelation.

Measured *E. coli* concentrations for Suburban Cook County beaches were obtained for the years 2006 to 2011. Where present, the average daily concentration (from two samples taken at the same time) was chosen as the daily *E. coli* value for each beach. In some cases, only a single measurement was reported. Less frequently, a single beach had two or more samples taken at discrete periods during the same day; in these cases, the daily average concentration was calculated.

In order to be modeled using common regression techniques, the response variable must meet specific distributional requirements. Environmental concentrations frequently exhibit a log-normal distribution. Cook County Beach *E. coli* concentrations were log-transformed and examined for approximate normality using both formal and graphical means. The results indicate that the log-transformed values of *E. coli* concentrations across all beach sites are approximately normal.

Approximately 3% of the reported concentrations fell outside of the analytical reporting limits set by standard laboratory procedures. These limits are 1 and 2419.2 cfu/100 mL, respectively. As a general statistical rule, censored observations that make up less than 5% of a dataset can be safely ignored (Gilliom, 1986; Helsel, 2005). However, various exploratory data analyses were undertaken with the censored observations alternatively kept and removed and no significant differences were observed. The censored observations were therefore removed from the analysis.

Another important consideration is whether the response variable exhibits either temporal or spatial autocorrelation—in other words, whether knowing a concentration at a specific time and/or point in space provides information about concentrations at a different time and/or point in space. If autocorrelation is present, corrective steps must be taken to ensure accurate modeling. Temporal autocorrelation is generally assessed using the residuals (errors) of a fitted model. However, spatial autocorrelation can be checked by comparing the variances of *E. coli* concentrations at different sites as a function of the distance between sampling sites. Spatial autocorrelation was assessed using monthly average values for randomly selected months and years at all beach sites. The resulting plots, called semivariograms, did not indicate any consistent spatial correlation between *E. coli* concentrations at Suburban Cook County beaches.

A.2 Step 2: Exploratory Data Analysis – Predictor Variables

Purpose: Derive additional predictor variables associated with *E. coli* concentrations; identify likely predictor variables; make initial estimate of correlations and magnitudes

Predictor variables investigated during exploratory analysis were collected from a number of sources (Table 3-4). Derived variables were chosen based on information in the scientific literature. Variables were also selected to cover a wide range of spatial and temporal scales, from relatively static watershed-level variables to beach specific meteorological conditions that varied on a daily or hourly time step. These variables were linked by sample location, date, and/or time to the measured *E. coli* concentrations obtained for the years 2006 to 2011. Because of date restrictions on some predictor variables, the final dataset contains *E. coli* data from 2007 to 2011. Graphical approaches such as scatter plots, box and whisker plots, conditional plots, and time series plots were then used to look for general trends, correlations, conditional responses and interactions between the predictor variables and measured *E. coli* concentrations. Data mining techniques such as Classification and Regression Tree (CART) models and Random Forest partitioning algorithms were also used to identify important predictor variables. Once important predictor variables were identified, a stepwise linear regression was used to examine the significance, magnitude, and exploratory power of each variable. A single ordinary least squares (OLS) linear regression model with a single predictor was fitted for each variable under consideration and the p-value, adjusted r-squared, and estimated coefficient for each model were recorded and compared. The p-value of a test statistic is the probability of an observed result occurring by chance, assuming that the null hypothesis—in this case, that there is no relationship between a predictor variable and the response—is true. The accepted threshold for a statistically significant relationship is a p-value at or below 5%. However, predictor variables that do not meet the 5% threshold can be included in a model: This decision is generally guided by the overall goals and objectives of the study. The adjusted r-squared is a conservative estimate of how much of the variation observed in the response variable can be explained by the predictor variables included in a regression model. The coefficient of a predictor variable is the estimated impact of that variable on the response variable.

The 2009–2011 Evanston BSS dataset also underwent the same battery of exploratory analyses described in this section to identify trends and likely predictor variables for *E. coli* concentrations.

The goal of these analyses is to identify likely starting points for the main modeling exercise. Given the nature of the TMDL, as many manageable variables as possible were selected for inclusion based on statistical trends discovered during the exploratory analysis. Current scientific understanding as documented in peer-reviewed journal articles on freshwater beaches and *E. coli* concentrations were also used to guide variable selection and interpretation.

A.3 Step 3: Initial Model Fitting

Purpose: Estimate relationships between predictor variables and measured *E. coli* concentrations; interpret model output; check model assumptions.

A range of modeling options is available for log normal-response variables. One of the most commonly applied predictive statistical models for *E. coli* concentrations is multiple linear regression (MLR). This approach is well suited for single site studies using predictor variables that occur at the same spatial and temporal scale as the response variable. However, the literature on *E. coli* fate and transport at freshwater beaches indicates that larger scale phenomena—such as precipitation patterns and nearshore lake conditions—may drive pathogen indicator concentrations. In other words, *E. coli* concentrations may be driven by variables that occur at the same temporal and spatial scale as well as by variables that occur at different temporal and spatial scales. The context of the *E. coli* measurement (i.e., a sample nested within a beach, nested within a stretch of shoreline, nested within a particular near-shore watershed) therefore becomes critically important. However, when multiple measurement sites are included in order to increase sample size and characterize nuances in larger scale predictor variable behavior, MLR techniques run into at least two statistical issues. First, model errors across all sites are pooled in a single error term. This is an issue because sites with similar contexts are likely to have correlated errors, which violates one of the key assumptions of linear regression. Second, the inability to include group-level context results in a model that treats all regression coefficients as applying equally to sites that may have very different contexts. ANOVA or ANCOVA approaches to modeling address some of these issues, but other problems can remain (Luke, 2004; Qian, 2009, 2010). For these reasons, a multilevel regression was chosen to analyze the data from CPD beaches.

Multilevel models allow researchers to explicitly account for context by the specification of group-level variables; these group-level variables can help account for interdependent hierarchical (nested) relationships in data. In statistical terms, a multilevel model allows the user to vary the intercept and/or slope of the model by group level variables. For example, a researcher might allow the model's intercept to vary by the name of each sampling site, which effectively establishes a different baseline concentration for each site.

Variable selection in regression modeling is most often based on statistical significance and model explanatory power, although professional judgment and the overall use of the model also inform the process. For instance, models optimized for prediction frequently include variable which are not statistically significant, but which increase the predictive ability of the model. If the goal is to identify possible causal linkages, then statistical significance is likely to take precedence. Many models are designed to broadly accommodate both goals.

One important note: The estimation techniques used in classical regression discard observations with missing data. For instance, if half of all observations are missing a value for a predictor variable and that variable is included in a regression model, all of the observations with a missing value will be discarded; any additional information contained in the discarded observations will therefore not be used to inform the overall results. Because of this, a decision was made to build two statistical models: one using the 2007–2011 *E. coli* data and a second using the 2009–2011 Evanston BSS data, which contains important data not collected over the 2006–2011 *E. coli* sampling period. This approach allows the unique informational content of the 2009–2011 BSS to be incorporated into the TMDL process.

In multilevel modeling, variable selection is largely based on physical interpretation (do the estimated relationships between predictor and response variables make sense within the context of current scientific understanding) and increases in explanatory power as measured by criteria such as the Bayesian Information Criteria (BIC) or reductions in the Restricted Maximum Likelihood Estimator Deviance (REML). Based on the exploratory data analysis described above, likely predictor variables were added in a stepwise fashion to the Suburban Cook County models and the physical interpretation and explanatory power of the models were evaluated. Variables that were not identified as predictive during exploratory analysis were also added and evaluated. Finally, interactions and group-level variables were specified based on the findings from exploratory data analysis and scientific literature.

During model fitting, it was discovered that the distributions of observed *E. coli* concentrations were not always similar across beach sites in the 2007–2011 dataset; some beaches had above or below average concentrations when compared to the mean concentration of all Suburban Cook County sampling sites. Other beaches exhibited statistically significant differences in the probabilities of very high and/or very low concentrations. Three overall groups were identified within the 2007–2011dataset. Additional analyses indicated that the best predictive models were obtained by fitting separate models within each of the three groups. Using a single model to make predictions for beaches that have statistically different distributions of *E. coli* can lead to underestimation or overestimation for beaches that have higher or lower *E. coli* distributions, respectively. Grouping beaches that share commonalities in the overall probabilities of observed *E. coli* concentrations is one method for avoiding this problem.

Once the final models were fitted, various model assumptions were checked, including collinearity, residual normality, and temporal autocorrelation. Collinearity was assessed using three measures: kappa, variance inflation factor, and the degree of correlation among fixed effects. In multilevel modeling, correlations can often be reduced by centering and/or scaling the response and/or predictor variables. These transformations were therefore applied as needed to reduce collinearity in the final model.

Model residuals were checked for normality using both graphical (histogram and density plots) and formal (non-parametric K-S test) methods.

Finally, the possibility of temporal or seasonal impacts was assessed with a time series plot of model residuals. With this plot, any consistent seasonal trend in model error will be visible as a recurring pattern. In other words, does knowing the date of a sample provide any information on model performance? If the answer appears to be yes, then additional adjustments are required.

A.4 Step 4: Simulation for load reduction

Purpose: Model uncertainty in estimation; use modeled relationships to predict daily concentrations; shift distribution of predicted daily concentrations to meet the WQS.

The impact of a predictor variable on a response variable has two components: central tendency, or the average impact, and some measure of uncertainty. The estimated coefficient of a predictor variable is the average impact of that variable on the response. For example, a coefficient of 0.5 for predictor X1 indicates that, on average, the response variable increases by 0.5 units for every unit increase in predictor X1. Uncertainty regarding the impact of the predictor variable is estimated as standard error. In practical terms, this means that sometimes predictor X1 will have an above average or below average impact on the response. When using a statistical model to make predictions, it is important to account for this uncertainty in estimated response. We do this via the process of simulation.

In simulation, we create many thousands of predictions for a given set of observed variables and then average the results. The idea here, known as the law of large numbers, is that the results of many trials will approximate the expected or long run average outcome. For example, think of the difference between flipping a coin 5 times versus 1,000 times; the proportion of heads after 1,000 coin flips should be close to the expected value of 50%, whereas the proportion of heads after 5 coin flips is likely to be much different. Once averaged, the matrix of predictions can be used to create a statistical distribution that reflects the predicted daily *E. coli* concentration as a function of the statistical relationships found in the observed data. Since a single multilevel model was fitted for all sampling sites, this predicted distribution characterizes daily concentration values for all sites, with a mean that reflects the average value across all samples. However, beach-specific distributions may markedly vary from this overall distribution, just as the distribution of observed concentrations at a beach with many WQ exceedances will differ from the distribution of observed concentrations at a beach with no WQ exceedances. Using the overall predicted distribution to model these beaches, then, will tend to under predict values at the beach with above average concentrations and over predict values at the beach with below average concentrations. To correct this issue, the observed distributions of daily *E. coli* samples can be compared on a beach by beach basis to discover if any beaches share a similar distribution; beaches with comparable observed distributions can be modeled together. Two methods of pairwise multiple comparisons were used: Tukey's HSD and the K-S test statistic. Tukey's HSD requires a normality assumption and compares the means of distribution. The K-S test makes no distributional assumptions and tests for differences in both location and shape of distributions. This grouping procedure was employed separately for sites within the 2007 to 2011 dataset and sites within the 2009–2011 Evanston BSS dataset.

Once distributional groups were determined within each dataset, the predicted distribution for each model was shifted "to the left" by subsetting manageable variables in the original dataset and refitting the multilevel model. The idea here is that by removing the upper values of manageable variables with positive correlations—or removing the lower values of manageable variables with negative correlations—we can model the impact of various management strategies on the predicted daily concentration. For example, the original dataset could be limited to only those observations where the gull count is less than 60. Refitting the model and re-creating the predicted distribution with this subset dataset allows us to predict the impact of keeping gull counts below 60. Because the subset dataset contains fewer observations, we can bootstrap—or sample with replacement—in order to retain a robust sample size for both data subset by manageable variable and data subset by distributional group. Using a combination of distributional group specific manageable variables, we can shift the predicted distribution to the left so that the probability of exceeding the WQS becomes very small within each distributional unit (Figures 4-1 through 4-4). We estimate this exceedance probability by sampling the predicted distribution many thousands of times and computing the number of predicted observations that exceed the WQS. Both the SSM and GM can be modeled with this methodology.

Once a predicted distribution meets the WQS, we use the range of the subset manageable variables to set management targets.

References

Gilliom, R.J., and D.R. Helsel. 1986. Estimation of distributional parameters for censored trace level water-quality data. 1. Estimation techniques. *Water Resources Research 22*(2):135–146.

Helsel, D.R. 2005. More than obvious: Better methods for interpreting nondetect data. *Environmental Science & Technology 39*(20):419A–423A.

Luke, D. 2004. *Multilevel Modeling*. Thousand Oaks, CA: Sage Publications.

Qian, S.S. 2009. *Environmental and Ecological Statistics with R*. Baton Rouge: CRC.

Qian, S.S., T.F. Cuffney, I. Alameddine, G. McMahon, and K.H. Reckhow. 2010. On the application of multilevel modeling in environmental and ecological studies. *Ecology 91*:355–361.

Appendix II: Supplemental Model Parameter Information

Tables A.II-1 through A.II-3 provide estimates of the parameter coefficients from the statistical models. The tables also include standard errors, or uncertainty estimates, for each parameter. Table A.II-1 contains the parameter estimates for the fixed-effects in Cook County Group 1 multilevel-model; Table A.II-2 contains the parameters estimates for the Cook County Group 2 multilevel-model; and Table A.II-3 contains the parameter estimates for Cook County Group 3 multilevel-model. A t-value greater than 2 or less than -2 indicates statistical significance at the 0.05 threshold. The significance of a given predictor variable extends to all beaches included in the model. Beach specific differences were considered using a variety of techniques. Two interaction terms were included in the model to capture interactions between predictor variables; the predicted impact depends on the characteristics of individual beaches. In addition, the coefficients of variables marked with a '*' were allowed to vary on a beach by beach basis; these are known as 'random effects' and should be considered predictions of how the impact of a variable may change based on a group level variable (in this case, beach location).

Table A.II-4 provides the metadata for the observational data and GIS-derived beach characterizations used to provide model parameters.

Table A.II-1. Parameter Estimates (average impact) and Standard Errors (uncertainty) for Fixed-Effects in Cook County Group 1 Multilevel-Model

Variable	Estimate	Std. Error	t value
Intercept	2.778	0.953	2.915
Percent Impervious Surface	0.116	0.037	3.143
Water Level*	10.651	2.437	4.371
24 hour precipitation*	0.001	0.000	2.782
Sample Month - July	0.147	0.120	1.224
Sample Month - August	0.313	0.128	2.446
Sample Month - September	0.741	0.284	2.610
Beach Orientation	0.062	0.028	2.199
Sample Year - 2009	-0.658	0.126	-5.217
Sample Year - 2010	0.196	0.132	1.492
Sample Year - 2011	-0.591	0.140	-4.216

Table A.II-2. Parameter Estimates (average impact) and Standard Errors (uncertainty) for Fixed-Effects in Cook County Group 2 Multilevel-Model

Variable	Estimate	Std. Error	t value
Intercept	2.756	1.302	2.117
Previous 48 hour precipitation	0.002	0.000	10.815
Sample Year - 2008	-2.853	1.287	-2.216
Sample Year - 2009	-3.107	1.287	-2.413
Sample Year - 2010	-3.006	1.288	-2.335
Sample Year - 2011	-3.011	1.288	-2.338
Sample Month - June	-0.296	0.176	-1.681
Sample Month - July	0.085	0.174	0.490
Sample Month - August	0.168	0.176	0.956
Sample Month - September	0.561	0.205	2.730
Water Level*	3.885	1.521	2.554
Hours since precipitation	-0.001	0.000	-2.633
Significant wave height*	0.312	0.099	3.155

Table A.II-3. Parameter Estimates (average impact) and Standard Errors (uncertainty) for Fixed-Effects in Cook County Group 3 Multilevel-Model

Variable	Estimate	Std. Error	t value
Intercept	-0.604	0.132	-4.579
Water Level	17.264	2.259	7.643
Sample Year - 2008	-0.519	0.132	-3.931
Sample Year - 2009	-0.283	0.127	-2.238
Sample Year - 2010	-0.249	0.130	-1.918
Sample Year - 2011	-0.360	0.126	-2.867
East Water Current Velocity	-3.584	1.324	-2.707
Previous 48 hour precipitation*	0.003	0.000	11.083
Wave Period*	0.094	0.041	2.297

Table A.II-4. Metadata for Model Parameters

Data Set	Source Description	Variables	Coverage	Source/Availability
Lake County Beach Sanitary Survey Data	Surveys of 10 beaches across several swimming seasons for meteorology, lake conditions, and gull counts on a mostly daily basis	Rain (Y/N), Wind Direction, Wind Category, Wind Speed, Air Temperature, Water Temperature, Wave Condition, *E. coli*, Gull Count, Sample Date, Month, Year, and Time	June 2004 through September 2011	Lake County Department of Public Health
Chicago Parks Department *E. coli* Monitoring	Daily bacteria monitored at CPD beaches	*E. coli*, Sample Date, Month, Year, and Time	May 2006 through September 2011	http://www.epa.gov/ storet/
Cook County *E. coli* Monitoring	Daily bacteria monitored at suburban Cook County beaches	*E. coli*, Sample Date, Month, and Year	May 2007 through September 2011	http://www.epa.gov/ storet/
City of Chicago Beach Sanitary Survey Data	Surveys of 15 beaches during the 2011 swimming season for factors that can impact bacteria concentrations and public health concerns on a mostly daily basis	Turbidity, Wave Intensity, Wave Height, Floating debris, Algae in Water, Bird Count, Dog Count, Litter on Beach, Algae on Sand, Bather Load	June 2011 through September 2011	Chicago Park District
City of Evanston Beach Sanitary Survey Data	Surveys of 7 beaches across several swimming season for factors that can impact bacteria concentrations and public health concerns on a mostly daily basis.	AM/PM *E. coli*, Air Temperature, Wind Speed, Wind Direction, Rainfall, Rain Intensity, Weather Condition, Wave Intensity, Wave Height	June 2009 through June 2012	City of Evanston, Evanston Park District
Great Lakes Coastal Forecasting System (GLCFS)	The GLCFS is a numerical model that calculates waves, currents and temperatures for each of the Great Lakes based on available observational data systems.	Bathymetry, Model Water Level, Eastward Water Velocity at Surface, Northward Water Velocity at Surface, Water Velocity at Surface, Water Velocity at Surface Direction, Significant Wave Height, Wave Direction, Wave Period	2007 through 2011	http://www.glerl.noaa.gov/res/glcfs/
Lake County Land Use Data	2005 land use data set layer based on the 2000 land use inventory data set for Lake County, IL	8 major land cover classifications to characterize beach drainage areas	2005	Lake County Planning, Building and Development (PB&D)
National Land Cover Database 2006	Land Cover for Cook County (including Chicago) on a 30 by 30 meter grid	Digested into 11 land cover classifications (from 28 specific land cover classifications) to characterize beach drainage areas	2006	http://www.mrlc.gov/nlcd06_data.php

Data Set	Source Description	Variables	Coverage	Source/Availability
NOAA's Digital Coast 2008 USACE Great Lakes: Lake Michigan, Illinois Light Detection And Ranging (LIDAR) remote sensing data	Used to derive average slope and direct drainages	Average slope and direct drainage areas	2008	http://csc.noaa.gov/htdata/lidar1_z/geoid12a/data/563/2008_USACE_IL_metadata.html
Lake County Stormwater Management Commission Precipitation Monitoring Stations	Four rain gauges were assigned to the Lake County beaches by location (Zion, Waukegan, Lake Forest, Highland Park)	Sub-daily precipitation measures summarized to total daily precipitation	2007 through 2011	http://www.lakecountyil.gov/Stormwater/RainGauges/Pages/RainData.aspx
NOAA National Climatic Data Center (NCDC) Meteorological Stations	Six meteorological stations from the NCDC used to assess daily precipitation in Cook County (Glencoe 0.1/Chicago Botanical, Evanston 1.4, Evanston 1.2, Chicago 6.8, Chicago 4.7, Chicago 5.5)	Total daily precipitation measures were linked by sample date and geography. 48- and 24-hour total and number of hours since a precipitation event were calculated	2007 through 2011	http://www.ncdc.noaa. gov/
Alliance for the Great Lakes Ravines Data	Ravine location and extent; ravine pipe locations and descriptions	Ravine locations and extents for use in drainage area definitions and locating potential point sources	2009	Alliance for the Great Lakes. 2009. Stresses and Opportunities in Illinois Lake Michigan Watersheds Strategic Sub-Watershed Identification Process (SSIP) Report. Prepared for the Lake Michigan Watershed Ecosystem Partnership. Available at: http://www.greatlakes.org/Page.aspx?pid=881.
Geographic Information Systems (GIS) with ArcGIS map services World Imagery layer	Satellite imagery to hand digitize beach area and impervious surface within beach area	Beach areas, drainage areas, impervious areas	circa 2011	http://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9

Data Set	Source Description	Variables	Coverage	Source/Availability
Macro and micro substrate GIS data	Interpolated characterization of the macro and micro substrates along the Illinois Lake Michigan shoreline	Average substrate characteristics by beach	Compilation of 72 years of data	Creque, S.M., K.M. Stainbrook, D.C. Glover, S.J. Czesny, and J.M. Dettmers. 2010. Mapping bottom substrate in Illinois waters of Lake Michigan: Linking substrate and biology. Journal of Great Lakes Research 36:780–789.
Illinois National Pollutant Discharge Elimination System (NPDES) Permits	Listing of active NPDES permits with Illinois that may contribute bacteria to Lake Michigan	Permit type and location	N/A	IEPA
Illinois Municipal Separate Storm Sewer System (MS4)	Listing of active MS4 permits for municipalities that are located along the Lake Michigan Shoreline	Name of municipality and, potentially, listing of receiving water	N/A	IEPA

Appendix III: Response to Public Comments

1. TMDL is not precise enough to satisfy applicable water quality standards to support designated uses, and therefore to lead to eventual designation of the waters along these beaches as Category 1 or Category 2 segments in Illinois' integrated water quality report and section 303(d) list.

Response: TMDLs are required to meet applicable water quality standards. Each TMDL contains a LA and WLA for nonpoint and point sources, respectively, at each beach. Those allocations were set at a level that will achieve the applicable water quality standards. The allocations were derived from models that were developed utilizing standard statistical methods, which were tested to ensure that the methods met standard statistical assumptions (i.e., normality and variance). The confidence levels associated with these models have been added in **Appendix III** for Lake County TMDL and **Appendix II** in Suburban Cook County and Chicago TMDL documents. The allocations provided in the TMDL reports are designed to support recreational use and meet applicable water quality standards.

2. The draft Final TMDL improperly diverges from the WQS

A. **The draft final TMDL calibrates goals for bacteria concentrations based solely on a 30 day rolling maximum geometric mean ("GM") of 126 cfu/100 ml for *E. coli***

Response: The TMDL considers both the GM and SSM and provides allocations that will result in being at or below the GM as a rolling 30-day value, and predicts that the SSM will not be exceeded by more than 4–10% as presented in **Section 4.9.2** in each TMDL document (i.e., Lake County, Suburban Cook County, and City of Chicago). This is consistent with the applicable water quality criteria for this TMDL given that the GM must be met and the SSM (or an upper limit for fecal coliform) is not specified as a never to exceed value in the 2004 Federal *E. coli* criteria.

However in order to clarify the TMDL, we are providing information below to supplement **Sections 4.8** and **4.9** in each TMDL document, which discuss the comprehensive analysis completed to develop the model and derive the TMDL. The figures and tables below point out the difference between historical conditions and predicted TMDL conditions. The figure illustrates both the observed *E. coli* conditions from 2007–2011 (green curve in **Figure A.III-1**) and expected *E. coli* conditions when achieving TMDL conditions (blue curve color in **Figure A.III-1**). The allocations were derived by reducing bacteria source variables in the validated statistical model until that model predicted the *E. coli* conditions (blue curve) that would consistently achieve the GM and exceed the SSM only infrequently. The figures and tables below demonstrate the improvement in water quality that are expected to occur by achieving the TMDL. **Table A.III-1** reports expected water quality improvements by comparing SSM and GM exceedance frequencies that occurred at the beaches during 2007–2011 to the SSM and GM exceedance (or non-exceedance) expected to be achieved under the TMDL.

In further detail, Figure A.III-1 provides a visualization of the distribution of the 30-day GMs calculated from observed *E. coli* concentrations at Waukegan North Beach, from 2007–2011 (green curve) as compared to the 30-day GMs of predicted *E. coli* concentrations when achieving the management targets prescribed by the IL Beaches TMDL study (blue curve). This beach is characterized by a relatively high number of observed GM exceedances in the observed concentrations.

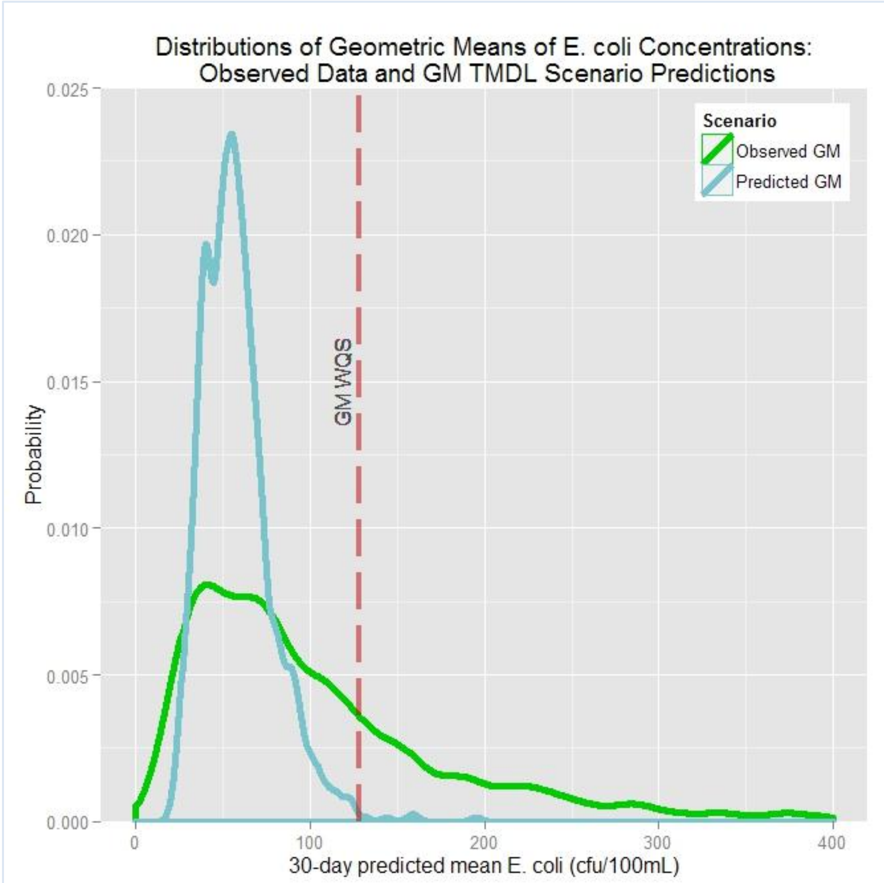


Figure A.III-1. Comparison of 30-day GM Distributions at Waukegan North Beach

Table A.III-1 provides a summary of observed and predicted concentrations for Waukegan North Beach. Observed data represent 30-day GMs of all reported *E. coli* values obtained for the beach from 2007 to 2011. Predicted values are simulated from the distribution expected after implementation of recommended GM management targets. The GM exceedance rate for the observed data is 26 %; the predicted GM exceedance rate after implementation of the recommended GM management targets prescribed by the IL Beaches TMDL study is <1%. Although these management recommendations target the GM WQS, implementation also greatly reduces the predicted SSM exceedance rate, which declines from 30 % in the observed data to a predicted 9 % under the GM management target scenario.

Table A.III-1. Summary Values of Observed and Predicted *E. coli* Concentrations at Waukegan North Beach

	30-day GM of Observed Waukegan North Beach *E. coli* Data (2007-2011)	Predicted Values under GM TMDL Management Targets
Mean GM Value	108	90
Median GM Value	82	88
% SSM exceeded	30	9
% GM exceeded	26	<1

Figure A.III-2 provides a visualization of the distribution of the 30-day GMs calculated from observed *E. coli* concentrations at Evanston Lee Beach, from 2008–2011 (green curve) as compared to the 30-day GMs of predicted *E. coli* concentrations when achieving the recommended GM management targets prescribed by the IL Beaches TMDL study (blue curve). This beach is characterized by a very low number of observed GM exceedances.

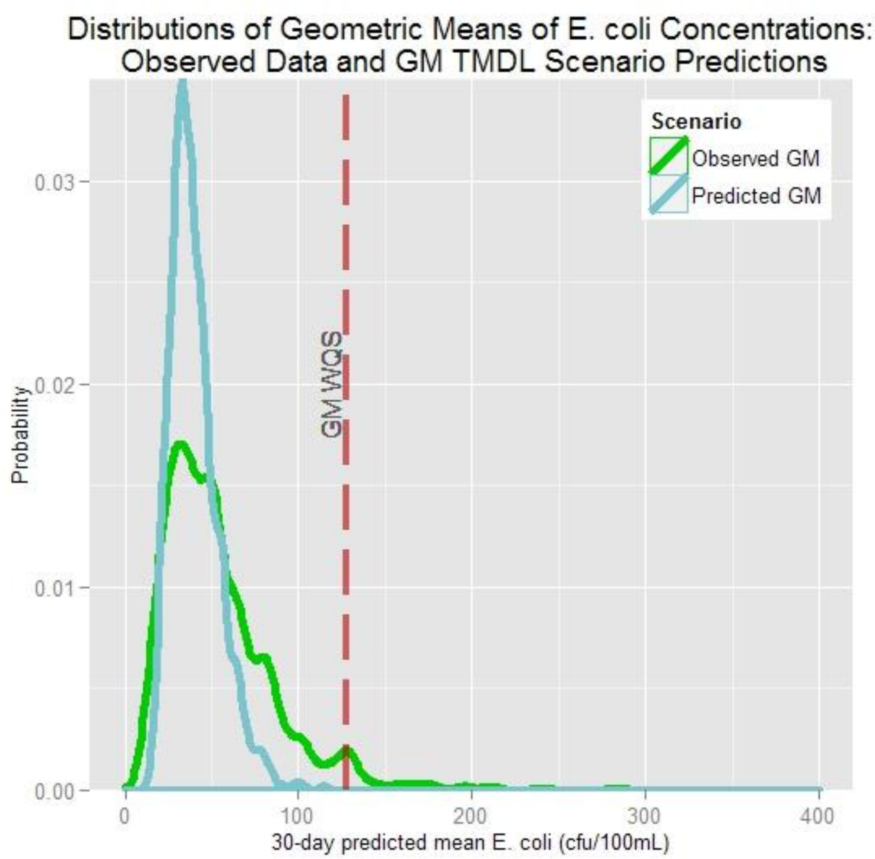


Figure A.III-2. Comparison of 30-day GM Distributions at Evanston Lee Beach

Table A.III-2 provides a summary of observed and predicted concentrations for Evanston Lee Beach. Observed data represent 30-day GMs of all reported *E. coli* values obtained for the beach from 2008 to 2011. Predicted values are simulated from the distribution expected after implementation of targets prescribed by the TMDL. The GM exceedance rate for the observed data is 1%; the predicted GM exceedance rate after implementation of the recommended GM management targets prescribed by the IL Beaches TMDL study is <1%. Although these management recommendations target the GM WQS, implementation also reduces the predicted SSM exceedance rate, which declines from 12% in the observed data to a predicted 8% under the GM management target scenario.

Table A.III-2. Summary Values of Observed and Predicted *E. coli* Concentrations at Evanston Lee Beach

	30-day GM of Observed Evanston Lee Beach *E. coli* Data (2008–2011)	Predicted Values under GM TMDL Management Targets
Mean GM Value	54	40
Median GM Value	47	37
% SSM exceeded	12	7–8
% GM exceeded	1–2	<1

Figure A.III-3 provides a visualization of the distribution of the 30-day GMs calculated from observed *E. coli* concentrations at Rainbow Beach, from 2007–2011 (green curve) as compared to the 30-day GMs of predicted *E. coli* concentrations when achieving the recommended GM management targets prescribed by the IL Beaches TMDL study (blue curve). This beach is characterized by a high number of observed GM exceedances as displayed by the large area under the green curve to the right of the GM WQS.

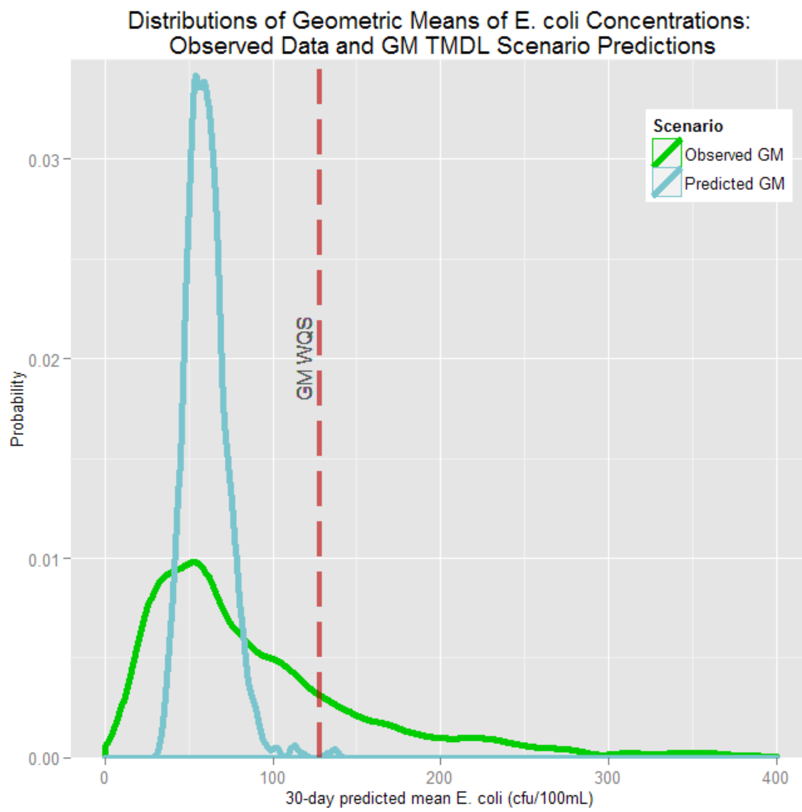


Figure A.III-3. Comparison of 30-day GM Distributions at Rainbow Beach

Table A.III-3 provides a summary of observed and predicted concentrations for Rainbow Beach. Observed data represent 30-day GMs of all reported *E. coli* values obtained for the beach from 2007 to 2011. Predicted values are simulated from the distribution expected after implementation of targets prescribed by the TMDL. The GM exceedance rate for the observed data is 17%; the predicted GM exceedance rate after implementation of the recommended GM management targets prescribed by the IL Beaches TMDL is <1%. Although these management recommendations target the GM WQS, implementation also reduces the predicted SSM exceedance rate, which declines from 18% in the observed data to a predicted 8% under the GM management target scenario.

Table A.III-3. Summary Values of Observed and Predicted *E. coli* Concentrations at Rainbow Beach

	30-day GM of Observed Evanston Lee Beach *E. coli* Data (2008–2011)	Predicted Values under GM TMDL Management Targets
Mean GM Value	91	62
Median GM Value	57	59
% SSM exceeded	18	8
% GM exceeded	17	<1

B. No part of the design incorporates the SSM or STV components from the state or federal standards

Response: The design explicitly considers the rate at which the SSM criterion would be exceeded when the GM criterion is met through implementation of the TMDL. This value is reported for each beach group and is found in **Section 4.9.2** of the TMDL document (**Table 4-11** of Lake County, **Tables 4-15 through 4-17** of Suburban Cook County, and **Tables 4-13 through 4-15** of Chicago TMDL documents). For more detail see the response in 2A of this appendix as well as **Section 4.9.2** of the TMDLs.

C. The data reported by IEPA in the draft final TMDL seems to indicate that the actual historic SSM exceedance rate is substantially higher than 10% at many beaches

Response: This is correct and identifies part of the reason the beaches were classified as Not Supporting recreational use. Beaches on the Illinois shoreline have exceeded the SSM by more than 10% and the corresponding attainment of the GM WQS varied during the period of 2007 through 2011. The observed data characterize the historical condition, while the expected data are predicted based on the validated statistical model representing the conditions which would exist when a TMDL is achieved. When the TMDL was set, the sources of bacteria were adjusted in the statistically verified model until the distribution of *E. coli* at a beach would be at or below the GM. Based on the statistically valid and verified relationships built using historical data, the TMDL study predicted that the amount of reduction required to achieve the GM would result in *E. Coli* concentrations exceeding the SSM by no more than 4–10% depending on the beach.

D. At the very least, the TMDL draft should disclose all of the underlying data and should include a comprehensive analysis supporting these assertions

Response: All of the data are publicly available. The raw data used are too extensive to include in print format (e.g., the *E. coli* data alone comprise approximately 18,000 rows of data), but a table has been added in **Appendix III** for Lake County and **Appendix II** for Suburban Cook County and Chicago TMDL documents, which contains the metadata for each variable used in the model domain including where those data were accessed.

E. Possible concerns about the practicality and cost of a combined GM and SSM (or STV) appear misguided.

Response: The TMDL considers both the GM and SSM and provides allocations that will result in being at or below the GM as a rolling 30-day value. The modeling also predicts that when meeting the TMDL the SSM will not be exceeded more than 4–10% of the time over the long-term as presented in **Section 4.9.2** in the TMDL document. However, concerns were raised about the practicality of meeting a TMDL designed to never exceed the SSM.

IEPA selected the management actions designed to consistently achieve the GM, while allowing for some exceedance of SSM, on the basis that the level of protection intended by the promulgated federal criteria could be met with some SSM exceedances. The 2004 Federal *E. coli* criteria illustrate this point with an example calculation (Water Quality Standards for Coastal and Great Lakes Recreation Waters. EPA, Federal Register, Vol. 69, No. 220, November 16, 2004, Page 67225). Meeting the level of protection for primary contact use that the bacteria criteria were designed to provide does not require that the SSM never be exceeded.

As noted in written comments, the Lake St. Clair (MDEQ, 2007) and Indiana beach (Tetra Tech, 2004) TMDLs include targets that both the GM and SSM are not to be exceeded, while IEPA's TMDL allows for some SSM exceedances. IEPA notes that EPA's 2004 *E. coli* criteria do not specify upper limit values as never to be exceeded. By contrast Michigan WQSs (Michigan Public Health Code and Rule 323.1062(1) of the Part 4. Water Quality Standards [Promulgated pursuant to Part 31 of the Natural Resources and Environmental Protection Act, 1997 PA 451, as amended]) do specify that upper limit values cannot be exceeded. Indiana WQSs (327 IAC 2-1.5-8 (e)) specify that, with some exceptions described at 327 IAC 2-1.5-8(e)(3)(B), upper limit values cannot be exceeded. The SSM can be exceeded in 10% of samples where there are at least 10 samples in a 30-day period, the exceedances are incidental and attributed to a discharge of treated wastewater, and the GM criterion is still met.

For informational purposes, the IL Beaches TMDL study identifies actions necessary to manage beaches such that the SSM is never exceeded (**Section 4.9.2** of the TMDL documents). These actions, compared to those designed to meet the TMDL (i.e., consistently meet a GM with some limited SSM exceedance) would be expected to require additional costs and maintenance whereas the TMDL targets already provide the level of protection required to meet the criteria. These management actions are compared in **Table A.III-4** and in the TMDL documents (See **Table 4-11** in Lake County, **Tables 4-15 through 4-17** in Suburban Cook County, and **Tables 4-13 through 4-15** in Chicago TMDL documents).

For example (**Table A.III-4**), in Lake County the group of beaches comprising Forest Park, Rosewood, IBSP South, and Waukegan North would be subjected to thresholds of reducing rainfall below 0.4 inches, keeping gulls below 30, and increasing the slope of the beaches by 3% if the SSM were never to be exceeded. While to achieve the GM rainfall above 1 inch would need to be captured, gulls could reach a count of approximately 50, and the slope of the beaches would only need to be increased by 1%. Examining rainfall for the last 10 years, only 8% of rainfall events reached 1 inch in depth, whereas closer to 25% of events were at least 0.4 inches in depth. Considering that at these beaches the mean count of gulls experienced during the study period was 35, keeping the gull counts below 50 would be a feasible goal. Finally, the slopes of the beaches in this group range from 4.4 to 6.8%. Requiring an increase of 3% would require maintenance of beach slopes near the maximum slope observed at all Lake County beaches (9.4%), whereas an increase of 1% would keep the beaches within the mid-range of slopes that have been observed.

Table A.III-4. Example Manageable Variable Thresholds[1]

Beach/Distributional Group	SSM Informational Target			GM TMDL Target			
	Reduce 24-hour Rainfall Below (inches)	Reduce Daily Gull Count Below	Increase in Slope Required (%)	Reduce 24-hour Rainfall Below (inches)[1]	Reduce Daily Gull Count Below	Increase in Slope Required (%)	Predicted Percent of SSM Exceedance when GM Is Attained
Group 1: Forest Park, Rosewood, IBSP South, Waukegan North	0.4	30	3	1	50	1	8%

[1] SSM informational targets are designed so that a SSM is not exceeded. GM TMDL targets are designed to consistently achieve the GM with some predicted percent of SSM exceedance.

F. In addition, the draft final TMDL does not on its face ensure compliance with the applicable Illinois WQC for fecal coliform […] As such, we ask that the TMDL explain the relationship between *E. coli* and fecal coliform in more depth and explain how achieving the *E. coli* target will also achieve compliance with Illinois WQC for fecal coliform.

Response: The fecal coliform criteria were first proposed by the National Technical Advisory Committee (NTAC) to the Federal Water Pollution Control Administration in 1968. The NTAC used epidemiological data collected by the United States Public Health Service (USPHS) from 1948–1950 to develop criteria for recreational bathing waters. In 1986, new bacteria criteria were promulgated for *E. coli* due, in part, from a need to improve the certainty in the relationship between indicator bacteria levels and illness rate. Studies used to develop the criteria examined illness rates in swimmers (and non-swimmers as a control) as it related to three bacteria criteria indicators: fecal coliform, *E. coli*, and Enterococci. The study found *E. coli* and Enterococci were most closely related to illness rates (Dufour, A.P. 1984. Health effects criteria for fresh recreational waters, EPA-600/1-84-004).

The TMDL allocations to reduce *E. coli* are reasonably expected to reduce fecal coliform loads to a level where water quality is associated with an illness rate that supports primary recreational use. Both *E. coli* and fecal coliform are used as bacteria indicators, yet *E. coli* is part of the parent fecal coliform group. Where *E. coli* is reduced, fecal coliform concentrations that are comprised of *E. coli* will consequently decrease. Due to the widespread and consistent availability of *E. coli* data across beaches and years, but the absence of fecal coliform data, the TMDL considered *E. coli* data and relied on the reasonable assumptions that reduced *E. coli* would consequently reduce fecal coliforms, and that reduced bacteria levels would protect water quality at a level that supports primary contact recreational use.

3. Implementation for new sources, such as planned additional MS4 outfalls, must be clarified.

Response: The TMDL will be incorporated into the Illinois MS4 General Permit (Permit No. ILR40) by reference once the TMDL is approved. The MS4 General Permit's current expiration date is March 31, 2014. The existing wastewater treatment plants must continue to comply with their permits to be consistent with the WLA provided in the TMDL. All existing and new MS4 Permittees are expected to meet the requirements of the Storm Water General Permit ILR40 and the TMDL WLA, i.e., 126 cfu/100 mL as the 30-day GM of *E. coli* as discussed in this report. The current General Permit Part III- Special Conditions (C) requires the MS4 Permittee to review their storm water management plan and determine whether the Permittee is meeting the TMDL allocation or approved watershed management plan. If they are not meeting the TMDL allocations, they must modify their storm water management program to implement the TMDL or watershed management plan within eighteen months of notification by the Agency of the TMDL or watershed management approval.

4. The draft final TMDL insufficiently considers designated uses.

Response: The TMDLs sufficiently consider designated uses and were designed to provide protection at a level equivalent to the applicable criteria. The bacteria criteria are designed to protect the public from illness related to primary contact use (e.g., swimming). The *E. coli* GM of 126 cfu/100 mL is associated with the accepted illness rate of 8 out of 1000 recreators. When the criteria were set, the SSM was determined as the upper 75th confidence interval of the GM of 126 cfu/100 mL. A confidence interval describes a range that is expected to contain the true population parameter (in this case, the mean) over repeated observations; the upper 75th confidence interval of the GM denotes a value that is expected to be at or above the true GM 75 percent of the time. The promulgation of *E. coli* criteria in 2004 clarified that the SSM was not intended for use as a never to exceed value for other CWA purposes, and doing so would result in a level that is more stringent than the level of protection provided by the criteria. That is, the GM is the basis for the illness rate and the SSM is an upper boundary, determined from the GM, which is used when making an immediate beach closure decision. Regardless, both of these criteria are considered in the TMDL. While the allocations were designed to consistently meet the GM, the corresponding rate that the SSM would be exceeded was also predicted. This provides a measure for how often a beach could exceed the SSM within a season and be expected to meet the GM and thus the level of protection that supports primary contact use. Reductions were assigned to the sources of bacteria (i.e., allocations) at a level that achieves these conditions.

5. The draft final TMDL is inconsistent with Illinois impairment listing standards

Response: A TMDL must be written to meet applicable WQSs. Illinois' impairment listing methodology is a process used to assess impairment status, rather than a codified and EPA-approved standard. The TMDLs were designed to be protective of the designated primary contact use and meet the applicable water quality criteria that were designed to protect this use. Furthermore, obtaining the TMDL is expected to reduce the frequency that SSM is exceeded and thereby expected to reduce the number of beach closures (See **Tables A.III-1 through A.III-3** in this appendix).

The Illinois EPA impairment listing methodology is based on the number of closures a particular beach experiences in a given time frame. These closures are based on the Beach Management Authority obtaining a sample on a daily basis during the swimming season and comparing the results of the sample to the Federal criteria for beaches.

6. Implementation schedules for TMDL measures should be included.

Response: NPDES permits must be consistent with the WLA and the assumptions used to derive them. Existing Wastewater Treatment Plants that discharge to Lake Michigan are expected to meet effluent limits that are outlined in their respective NPDES permits.

Current NPDES Permits will remain in effect until the permits are reissued; provided that IEPA receives the NPDES permit renewal application prior to the expiration date of the existing NPDES permit. The WLAs will be incorporated into the permits upon reissuance. The following is a list of permitted facilities along with their current permit expiration dates:

- North Shore Sanitary District – Waukegan WWTP (NPDES Permit No. IL0030244) renewal request received Nov. 2011. Current expiration 4/30/2012.
- North Shore Sanitary District – Gurnee WWTP (NPDES Permit No. IL0035092). Renewal request received June 2011. Current expiration 11/30/2011
- Abbot Labs (NPDES Permit No. IL0001881). Expiration date is 9/30/2016
- Outboard Marine (NPDES Permit No. IL0002267). Permit expired 6/1/1992. Permit will not be renewed. Awaiting No Further Remediation letter.
- Winnetka Water and Electric (NPDES Permit NO. IL0002364). Permit expired on 1/31/09. Permit renewal is in progress.

The MS4 communities are covered under the General NPDES Permit No. ILR40 that expires on March 31, 2014. The TMDL will be incorporated into the MS4 General Permit by reference. The General Permit will remain in effect until a new General Permit is reissued (pending new Storm Water Regulations). The current General Permit Part III- Special Condition (C) requires the MS4 Permittee to comply with the WLA when a TMDL is developed for that particular watershed within eighteen months of notification by IEPA of the TMDL.

Implementation of the LA is voluntary. However, IEPA has demonstrated reasonable assurance that the TMDL target will be met.

References

MDEQ (Michigan Department of Environmental Quality). 2007. Total Maximum Daily Load for *E. coli* for Lake St. Clair Metropolitan and Memorial Beaches Macomb County.

Tetra Tech. 2004. Lake Michigan Shoreline TMDL for E. coli Bacteria. Submitted to Indiana Department of Environmental Management. Indianapolis, IN.