Total Maximum Daily Load

Shoreline Segments in Chicago, Cook County, Illinois
29 Segments from Juneway Terrace Park Beach to Calumet 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

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List of Acronyms

BAV	Beach Action Value
BEACH Act	Beaches Environmental Assessment and Coastal Health Act
BMP	best management practice
BPA	Beach Protection Area
BSS	Beach Sanitary Survey
CART	Classification and Regression Tree
cfu	colony forming unit
CPD	Chicago Park District
CRCW	Chicago River Controlling Works
CSO	combined sewer overflow
CWA	Clean Water Act
DNR	Illinois Department of Natural Resources
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
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
LSD	Lake Shore Drive
m	meter
m/s	meters per second

MG	million gallons
mL	Milliliters
MLR	multiple liner regression
MOS	margin of safety
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
STP	sewage treatment plant
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
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UV	ultraviolet
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 29 of the 51 Lake Michigan shoreline segments (10-digit HUC 0404000205) that are located in the Chicago Metropolitan Area within 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 22 segments will be addressed in two companion TMDL documents addressing the Lake Michigan shoreline segments that are in Lake County, IL, and suburban Cook County, IL.

From May through September, the Chicago Park District (CPD) samples Lake Michigan swimming beaches 5 to 7 days a week for bacteria. The Illinois Department of Public Health (IDPH) and CPD use these monitoring data to establish the day-to-day operational status of Lake Michigan beaches for swimming. In Chicago, swim advisories 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 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 three 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 29 segments in Chicago, IL, were not supporting primary contact use and were first included on Illinois’ 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 29 shoreline segments on Illinois’ 303(d) list contain both urban swimming beaches and shoreline segments at which no swimming is allowed.

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 their designated use. For the segments without swimming access, although they are not currently monitored regularly, there were historical data available that indicated the segment was not supporting the designated use.

1.1 Priority Ranking

In accordance with 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:

- **<u>Step 1.</u>** 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.
- **<u>Step 2.</u>** 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 29 segments within Chicago. 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

(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-04	IL087773	Waukegan Beach (North segment)	Waukegan North Beach	LCHD considers the Waukegan Beaches to be a single beach	2219	Lake/ LCHD
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.

(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-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.
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

(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_QN-13	IL586992	Thorndale or George Lane Beach	Thorndale Beach	Considered part of Kathy Osterman Beach by CPD	58	Cook/ CPD
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 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 in 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 an accompanying TMDL document) and the City of Chicago in the south (the focus of this TMDL document). The shoreline within Chicago is highly developed with residential streets dead-ending at the shoreline in the north portion to narrow beaches and shoreline segments bordered by small parks and roadways in the middle and southern portions of Chicago. Several of the impaired segments within Chicago are not swimming beaches, but were sampled for bacteria at times in the past. The descriptions that follow differentiate between swimming beaches and impaired shoreline segments. The TMDLs that are developed as a part of this effort will apply similarly to both types of segments.

The beaches within Chicago are managed by the CPD, which monitors *E. coli* concentrations in the water, collecting samples 5 times per week during beach season from Memorial Day through Labor Day. In 2011, the CPD also collected samples on the weekend after an exceedance (Illinois DPH, 2012). Beach advisories are issued if the water samples are greater than 235 cfu/100 mL of *E. coli*. CPD issues beach closures due to severe or hazardous weather or water conditions (CPD, 2012a).

The CPD and the U.S. Geological Survey (USGS) have developed models to provide information about water quality in real-time. The predictive model uses water quality and weather data collected from real-time stations at each of the modeled beaches to estimate bacteria levels in the waters. When the model predicts that bacteria levels are likely above 235 cfu/100 mL, a beach advisory is issued. CPD currently has 14 models in use at various beaches. One additional model calculated for North Avenue Beach is not in use due to high levels of uncertainty. Data collection and model refinement continued in the 2012 recreation season.

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 “beachsheds,” or watershed areas that contribute surface water flow to the impaired segment area, contain direct drainages area where overland runoff drains directly on to the beach. The direct drainage area was determined through a geographic information systems (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 Chicago, the direct drainage area is limited to a small strip of land along the top of the beach because of the nearby roadways and urban development.

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 drainage to the Chicago Area Waterway System (CAWS), which may discharge to the lake during river reversals. Industrial and other individual potential point sources of bacteria have been identified and are discussed in the following sections. No concentrated animal feeding operations (CAFOs) are located within Chicago. 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) (**Figures 2-1 and 2-2**). 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.

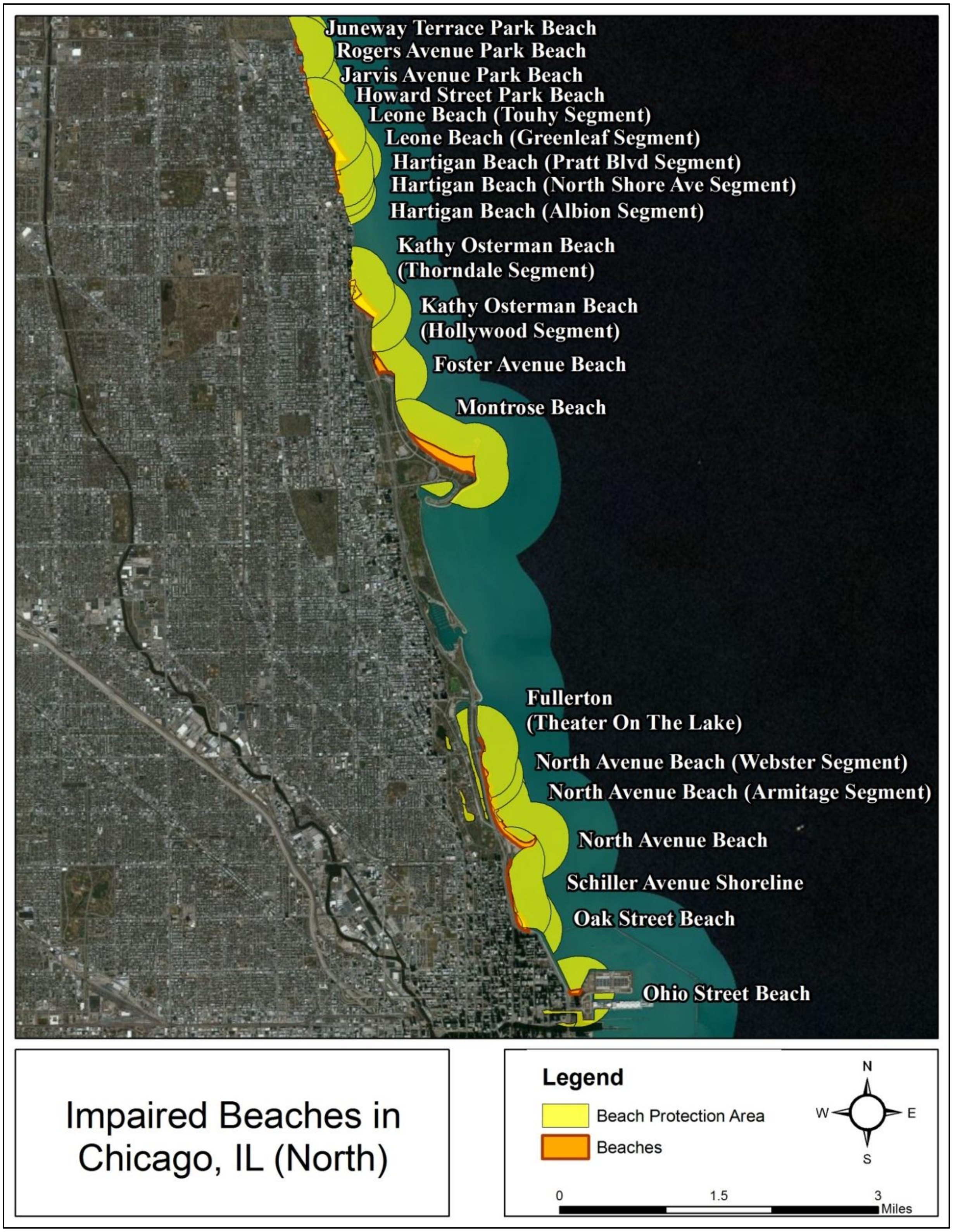

Figure 2-1. Northern Impaired Segments within Chicago, Cook County, Illinois

Figure 2-2. Southern Impaired Segments within Chicago, Cook County, Illinois

According to the CPD, seagull waste is a major source of bacteria to the city's beaches. Other main contributors include combined sewer overflows (CSOs); increasing storm frequency due to climate change; and populations of invasive mussels that facilitate the growth of *cladophora*, an algae that can be a secondary source of *E. coli* bacteria (Lydersen, 2011). All beaches in Chicago are groomed daily with the exception of those in the Rogers Park area.

2.1.1 Rogers Park Beaches

The Rogers Park beaches are a series of small beaches separated from one another by private property in the Rogers Park neighborhood of Chicago. The beaches included in this TMDL are, from north to south, Juneway Terrace Beach, Rogers Beach, Howard Beach, and Jarvis Beach. Fargo Beach is to the immediate south of Jarvis Beach and, although they are considered separate beaches by CPD, they are sampled together. For this stretch of the shoreline, the upland slopes gently to the lakeshore, and bluffs are absent. The shoreline in this area is at or near the predevelopment location (IDNR, 2011b).

Juneway Terrace Beach is a small, northeast-facing beach that is just 0.33 acres in size, with an additional drainage area of 0.5 acres (**Figure 2-3**). The beach is part of Juneway Terrace Park. The area outside of the small park that surrounds the beach is fairly impervious and includes roadways, parking lots, and high-rise buildings.

Rogers Beach is slightly less than half an acre in size and has an additional drainage area of about 0.5 acres (Figure 2-3). Rogers Beach is part of the larger Rogers Avenue Park, and the drainage area for the beach is almost all park land with some impervious surface from walkways and buildings.

Howard Beach is a rectangular, east-facing beach that is roughly 0.5 acres in size. Although the surrounding areas are sewered with storm drain inlets to the combined sewer system, the LIDAR drainage definition identified a 0.75-acre area of land that may directly drain to the beach due to elevation (Figure 2-3). The land identified as directly draining to the beach is mostly park land, rooftops, and roadways. This direct drainage area provides a potential source of runoff, although it is expected that most stormwater is intercepted by the sewer system.

The beach area encompassing both Jarvis and Fargo beaches is 1.5 acres in size. As with Howard Beach, the LIDAR-derived direct drainage area includes 2.5 acres of land where the majority of stormwater is likely intercepted by the storm sewer system (Figure 2-3). The direct drainage area is highly impervious and contains mostly rooftops and roadways with smaller areas of park land and parking lots. Two northeast-facing breakwater structures are present at Jarvis Beach and have created a circular embayment.

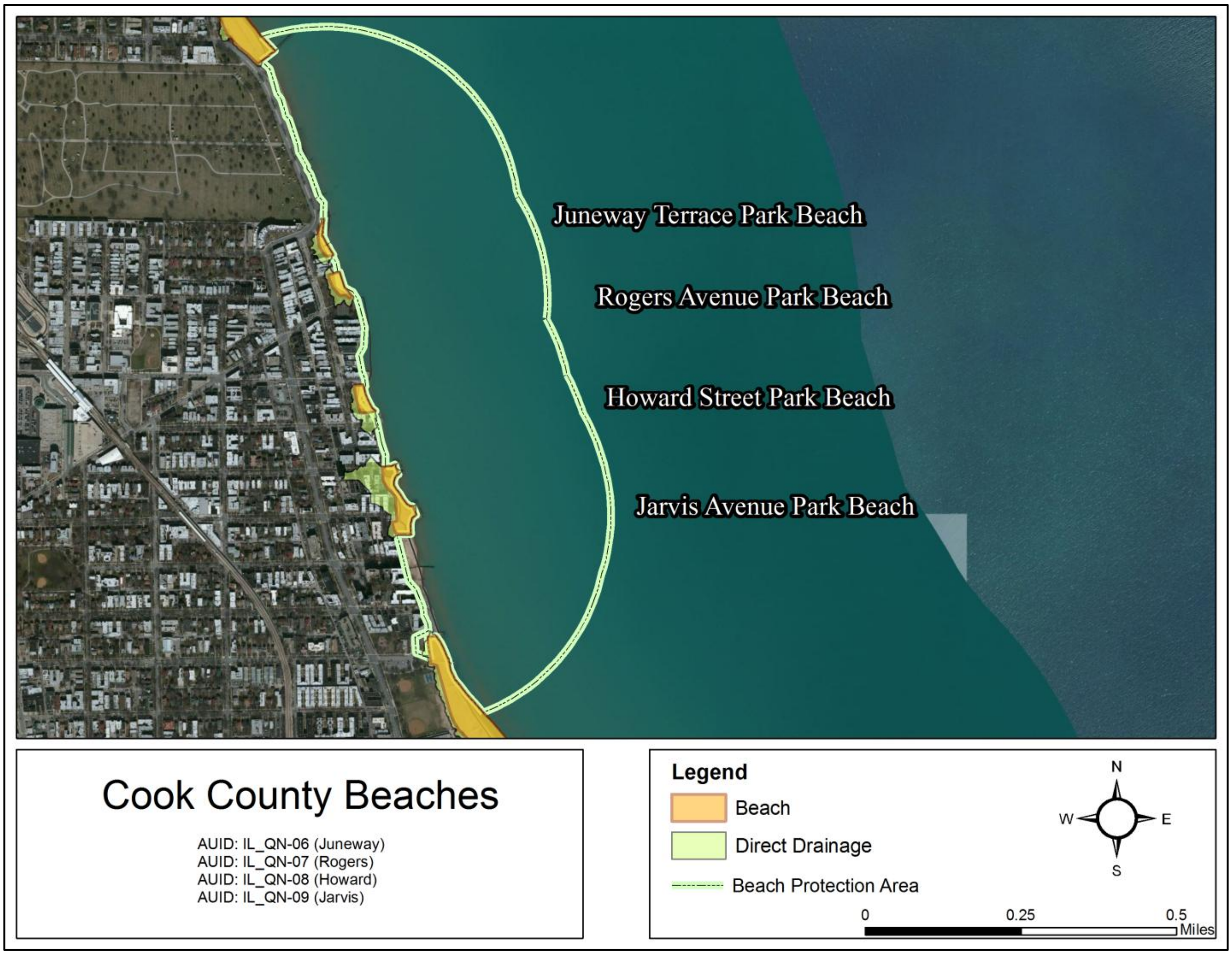

Figure 2-3. Rogers Park Beaches and Drainage Catchments

In this area of the Lake Michigan shoreline, shore-parallel structures are important to protect upland development from wave impact and wave-induced erosion during times of high lake level. Shore-parallel structures consist of a variety of design bulkheads and revetments and provide recreational beaches. Rubble-mound breakwaters protect the beach at Jarvis Avenue Park (IDNR, 2011b).

Table 2-1 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures and advisories were attributed to CSOs and unknown sources at Juneway Terrace, Rogers, Howard, and Jarvis/Fargo beaches (Illinois DPH, 2012). There are no major point-source discharges permitted under the National Pollutant Discharge Elimination System (NPDES) to these beaches; nonpoint sources are primarily responsible for contamination (Whitman and Nevers, 2008). However, occasional releases from the locks in Wilmette Harbor and the Chicago River occur and could contribute combined loadings from point and nonpoint sources from the CAWS to Lake Michigan.

The CPD/USGS-developed predictive models use water quality and weather data collected from real-time stations at Juneway Terrace, Rogers, Howard, and Jarvis/Fargo beaches to estimate bacteria levels in the waters at these beaches.

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

Assessment Units Mapped to Indexed Beaches				BEACH[1] Act Reporting		Monitoring Records				Water Quality Sampling		Hydrometeorologic Monitoring						
ID305B Unit ID	**STORET[2] 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_QN-06	CHJUNEWAY	Juneway Terrace	2007	7	1	5/28/2007	8/31/2007	142	STORET	X	X							
CPD Monitored			2008			5/27/2008	8/29/2008	69	STORET	X	X							
			2009	2	1.5	5/26/2009	9/3/2009	71	STORET	X	X							
			2010	1	3	5/27/2010	9/3/2010	69	STORET	X								
			2011	2	1	5/26/2011	8/31/2011	70	STORET	X								
IL_QN-07	CHROGERS	Rogers Beach	2007	5	1	5/28/2007	8/31/2007	142	STORET	X	X							
CPD Monitored			2008	1	1	5/27/2008	8/29/2008	69	STORET	X	X							
			2009	1	2	5/26/2009	9/3/2009	71	STORET	X	X							
			2010	1	3	5/27/2010	9/3/2010	69	STORET	X								
			2011	1	1	5/26/2011	8/31/2011	72	STORET	X								

[1] BEACH = Beaches Environmental Assessment and Coastal Health

[2] STORET = U.S. EPA's STOrage and RETrieval system

(continued)

Table 2-1. Monitoring and Single Sample Maximum WQS Exceedances for Rogers Park Beaches in the Past 5 Years (continued)

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_QN-08	CHHOWARD	Howard Beach	2007	6	1.2	5/28/2007	8/31/2007	142	STORET	X	X							
CPD Monitored			2008	1	1	5/27/2008	8/29/2008	70	STORET	X	X							
			2009	2	1.5	5/26/2009	9/3/2009	72	STORET	X	X							
			2010	1	3	5/27/2010	9/3/2010	70	STORET	X								
			2011	1	1	5/26/2011	8/31/2011	73	STORET	X								
IL_QN-09	CHJARVIS	Jarvis Beach	2007	7	1.1	5/28/2007	8/31/2007	142	STORET	X	X							
CPD Monitored			2008			5/27/2008	8/29/2008	71	STORET	X	X							
			2009	1	2	5/26/2009	9/3/2009	71	STORET	X	X							
			2010	3	1.7	5/27/2010	9/3/2010	70	STORET	X								
			2011	1	1	5/26/2011	8/31/2011	71	STORET	X								

2.1.2 Leone, Loyola, and Hartigan Beaches

Leone, Loyola, and Hartigan beaches are composed of a series of continuous beach segments located in the Rogers Park neighborhood of Chicago. For this stretch of the shoreline, the upland slopes gently to the lakeshore, and bluffs are absent. The shoreline in this area is at or near the predevelopment location (IDNR, 2011b).

Leone Beach (also known as Touhy Beach) and Loyola Beach (also known as Greenleaf Beach) are located south of Jarvis Beach (**Figure 2-4**). Together, these beaches form one of the largest beaches in Chicago, with a size of about 20 acres and an additional 2.5 acres of direct drainage. These beaches are primarily surrounded by Loyola Park, and most of the land draining directly to the beach is considered park land. A dune restoration site is present along the southeastern edge of the beach.

Hartigan Beach is directly south of Leone Beach. Hartigan Beach goes by many names. Officially, CPD samples this area as one sampling point, labeled Hartigan in the records. Prior to 2010 it was sampled as two or three separate points, labeled by the names of the streets that dead-end at the lake. In the Park District Code, it is recognized as two official beaches, Hartigan North and Hartigan South. Many people in the neighborhood call the beaches by the small parks or streets adjacent to the lake: Pratt, Columbia, North Shore, and Albion. There are three separate segments assessed on the 303(d) list, including Pratt Avenue (Hatrigan North), North Shore Avenue (Hartigan North), and Albion (Hartigan South) (Figure 2-4). A north-facing pier separates Leone Beach from Hartigan Beach, and a second pier divides the beach at about the halfway mark. East-facing Hartigan Beach has an area of 6 acres, with an additional 3 acres of direct drainage. The drainage area contains mostly rooftops, roadways, and park land.

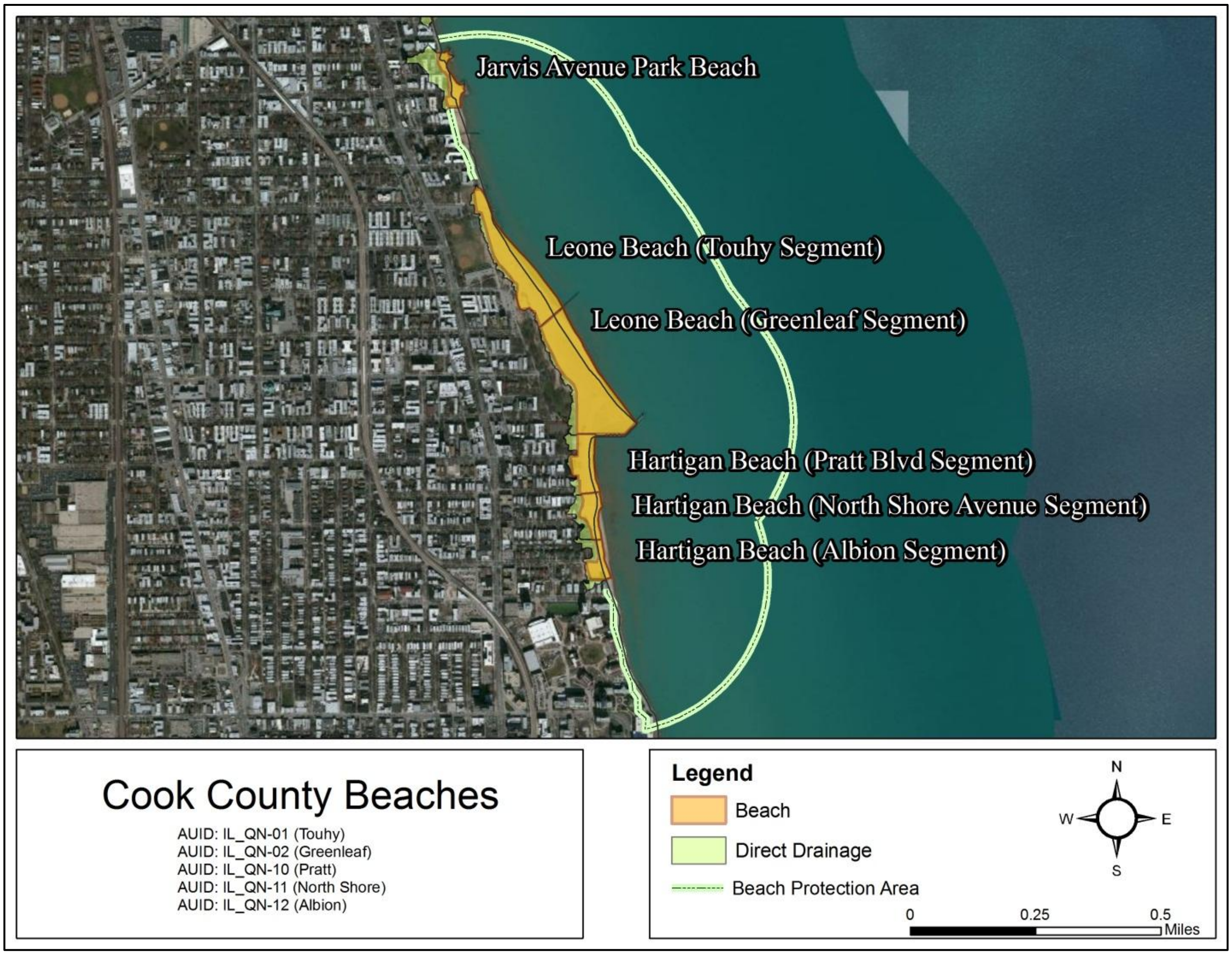

Figure 2-4. Leone, Loyola, and Hartigan Beaches and Drainage Catchments

In this area of the Lake Michigan shoreline, shore-parallel structures are important to protect upland development from wave impact and wave-induced erosion during times of high lake level. Shore-parallel structures consist of a variety of design bulkheads and revetments and provide recreational beaches (IDNR, 2011b). Leone and Loyola beaches contains three hardened groyne structures (one facing southeast and two facing northwest).

Table 2-2 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures and advisories were attributed to CSOs and unknown sources at Hartigan Beach; and CSOs and unknown sources at Leone Beach (Illinois DPH, 2012). There are no NPDES discharges to these beaches; nonpoint sources are primarily responsible for contamination (Whitman and Nevers, 2008). However, occasional releases from the locks in Wilmette Harbor and the Chicago River occur and could contribute combined loadings from point and nonpoint sources from the CAWS to Lake Michigan.

The CPD/USGS-developed predictive models use water quality and weather data collected from real-time stations at Leone and Hartigan beaches to estimate bacteria levels in the waters at these beaches, which includes all of the assessed segments.

Table 2-2. Monitoring and Single Sample Maximum WQS Exceedances for Leone, Loyola, and Hartigan 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_QN-01	CHLOYOLA	Touhy (Leone) Beach	2007	5	1.2	5/28/2007	8/31/2007	142	STORET	X	X							
CPD Monitored			2008	1	1	5/27/2008	8/29/2008	70	STORET	X	X							
			2009	1	2	5/26/2009	9/3/2009	71	STORET	X	X							
			2010	3	1.7	5/27/2010	9/3/2010	71	STORET									
			2011	3	1	5/26/2011	8/31/2011	74	STORET							X	X	X
IL_QN-10	CHPRATT	Pratt Beach	2007	10	1	5/28/2007	8/31/2007	142	STORET	X	X							
CPD Monitored			2008			5/27/2008	8/29/2008	70	STORET	X	X							
			2009	1	2	5/26/2009	9/3/2009	71	STORET	X	X							
			2010	2	2	5/27/2010	9/3/2010	69	STORET	X								
			2011	1	1	5/26/2011	8/31/2011	72	STORET	X								

(continued)

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

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_QN-11	CHNORTHSH	North Shore/Col-umbia	2007	9	1.1	5/28/2007	8/31/2007	141	STORET	X	X							
CPD Monitored			2008			5/27/2008	6/26/2008	23	STORET	X	X							
			2009	2	1.5	5/26/2009	9/3/2009	71	STORET	X	X							
			2010	2	2	5/27/2010	9/3/2010	69	STORET	X								
			2011	1	1	5/26/2011	8/31/2011	72	STORET	X								
IL_QN-12	CHALBION	Albion Beach	2007	7	1.3	5/28/2007	8/31/2007	148	STORET	X	X							
CPD Monitored			2008	1	1	5/27/2008	8/29/2008	70	STORET	X	X							
			2009	2	1.5	5/26/2009	9/3/2009	71	STORET	X	X							
			2010	2	2	5/27/2010	9/3/2010	69	STORET	X								
			2011	1	1	5/26/2011	8/31/2011	72	STORET	X								

2.1.3 Lincoln Park Impaired Segments

Lincoln Park is a 7-mile public park stretching along the Lake Michigan shoreline. The park contains, from north to south, Thorndale Beach (also known as George Lane Beach), Kathy Osterman Beach, Foster Beach, Montrose Beach, and North Avenue Beach. At the north end of North Avenue Beach sits CPD's Theater on the Lake at the end of Fullerton Avenue. Although not a swimming beach, this section of the shoreline was assessed as impaired by IEPA and is therefore included in this assessment. Starting at Kathy Osterman Beach and stretching southward to the Illinois/Indiana state line, the shoreline has been altered due to lake filling. At Montrose Beach, the shoreline has been relocated almost three-quarters of a mile lakeward of its pre-development position (IDNR, 2011b).

Thorndale and Kathy Osterman beaches are located in the northern Chicago neighborhood of Edgewater, about 1 mile down shore from Hartigan Beach (**Figure 2-5**). CPD uses one sample location to account for both beaches. Thorndale Beach, also known as George Land Beach, is approximately 5.6 acres in size, and Kathy Osterman Beach is roughly 13.6 acres in size. Together, the two beaches have an additional 4.4 acres of direct drainage. Thorndale Beach is bordered by Lane Beach Park and developed land. Kathy Osterman Beach is also known as Ardmore Hollywood Beach, Hollywood Avenue Beach, or Hollywood Beach. Kathy Osterman Beach is surrounded by developed land to the east and open park land to the south; the southeastern edge of the beach contains some dune habitat.

Foster Beach is located about a quarter mile south of Kathy Osterman Beach (Figure 2-5). Foster Beach has an area of 8.5 acres, with 3.5 additional acres of direct drainage. Foster Beach is surrounded by Lincoln Park, and nearly all of the drainage area is park land with some impervious areas of roadway or walkway. There is also a small area of dune habitat near the southwestern edge of the beach.

Montrose Beach is a north-facing, crescent-shaped beach that occupies the northern side of a peninsula created by lakefill in the Chicago neighborhood of Uptown (Figure 2-5). It is the largest beach in Chicago with an area of 42.5 acres and a direct drainage area of 4.5 acres. Montrose Beach contains one east-facing, hooked pier at the southern edge of the beach. Lincoln Park surrounds Montrose Beach, and most of the land in the drainage area is open park land with some areas of impervious walkways; there are areas of dune habitat near the southern edge of the beach. Montrose Beach contains a bird sanctuary at its eastern edge.

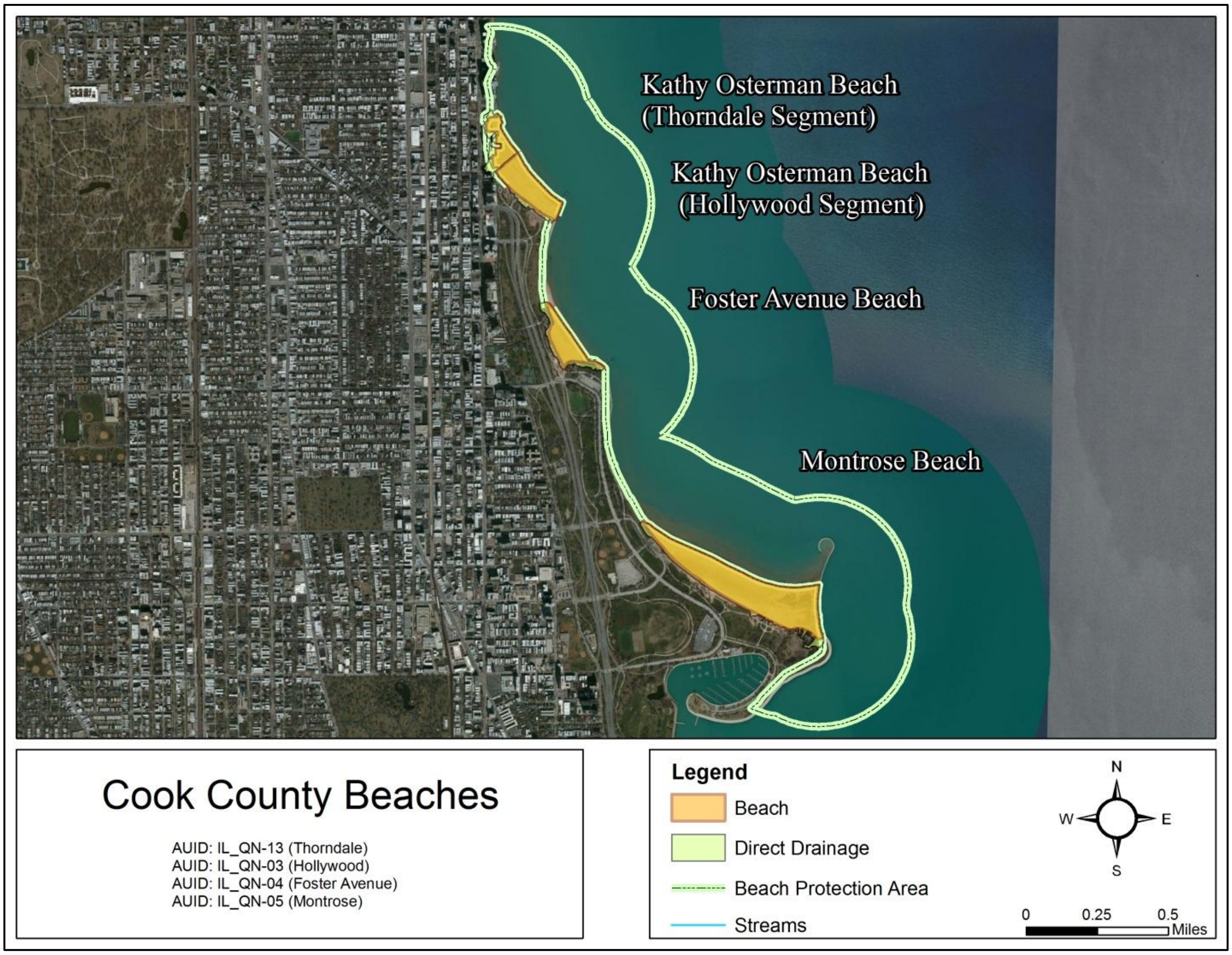

Figure 2-5. Northern Lincoln Park Impaired Segments and Drainage Catchments

The shoreline at the end of Fullerton Avenue is located about 2.5 miles south of Montrose Beach in the Lincoln Park neighborhood of Chicago (**Figure 2-6**). The thin, rounded shoreline segment does not have swimming access and is composed of concrete pier surrounded by breakwaters. The shoreline is 1.5 acres in size, with a direct drainage area of nearly 2 acres. The drainage area contains a small part of Lincoln Park and mostly includes impervious surface from roadways, walkways, and buildings. CPD’s Theater on the Lake is the main attraction at this point of the shoreline.

North Avenue Beach is immediately adjacent to the shoreline segment at Fullerton Avenue and contains the impaired segments assessed as Webster Beach and Armitage Beach in its northern portion (Figure 2-6). Currently, CPD considers all three segments to be North Avenue Beach and takes only one sample for the full length. The thin, crescent-shaped beach contains six southeast-facing piers and one south-facing hooked pier. North Avenue Beach is slightly more than 30 acres in size and has an additional direct drainage area of nine acres. The drainage area contains areas of Lincoln Park, roadways, walkways, and buildings, as well as a small area of dune habitat near the southeastern edge of the beach. The Chicago-Jardin Water Purification Plant has a point-source discharge about 2.5 miles offshore from North Avenue Beach, but has limits only for flow, pH, and chlorine in its NPDES permit. Therefore, between its distance away and its discharge, it is not expected to be a source of impairment to the shoreline.

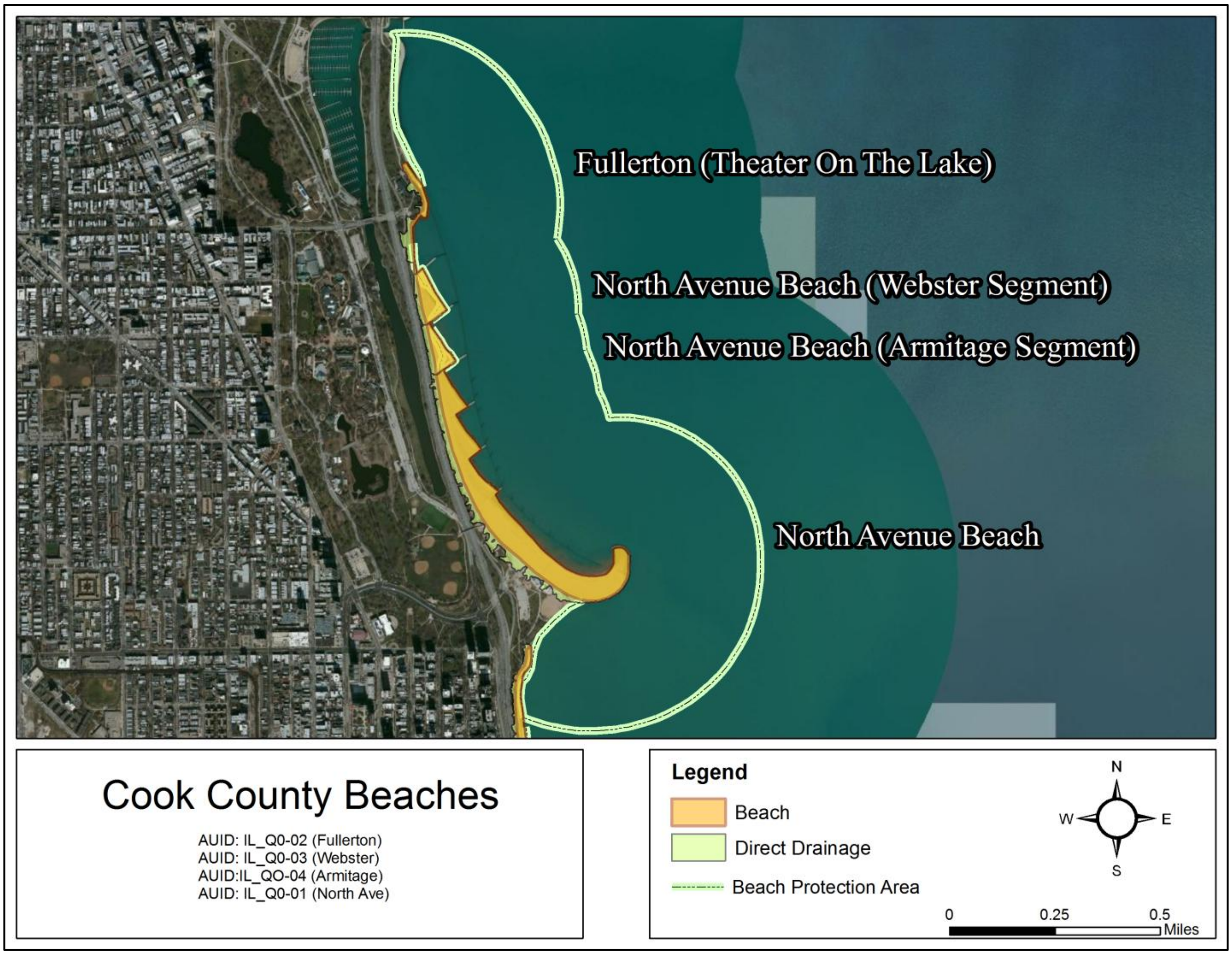

Figure 2-6. Southern Lincoln Park Impaired Segments and Drainage Catchments

Revetments and bulkheads are commonly employed to protect the shoreline along the filled section of the Lake Michigan coast, and all of the beaches in Chicago except for small street-end beaches in Rogers Park are equipped with some type of structure to prevent beach erosion (IDNR, 2011b). There are two hardened structures at Kathy Osterman Beach: a northeast-facing breakwater structure is present at the northern edge of the beach, and a southeast-facing groyne runs along the southern boundary. Rubble-mound breakwaters also protect the beach at the northern portion of Kathy Osterman Beach at Lane Park (IDNR, 2011b). Foster Beach contains one southeast-facing groyne structure at its southern edge. Montrose Beach has a groyne structure and a breakwater system. The prevailing current in this area carries suspended materials southward, where they can become trapped in near beach areas (Whitman and Nevers, 2008). The shoreline at Fullerton Avenue has a hardened breakwater structure. North Avenue Beach has southeast-facing groynes combined with submerged breakwaters that are positioned parallel to the shoreline (IDNR, 2011b).

Table 2-3 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures and advisories were attributed to CSOs and unknown sources at Kathy Osterman Beach, Foster Beach, Montrose Beach, and North Avenue Beach (Illinois DPH, 2012). There are no NPDES discharges to these segments; nonpoint sources are primarily responsible for contamination (Whitman and Nevers, 2008). However, occasional releases from the locks in Wilmette Harbor and the Chicago River occur and could contribute combined loadings from point and nonpoint sources from the CAWS to Lake Michigan.

The extensive breakwaters at Montrose Beach may effectively trap contamination in nearshore waters. In some cases, the contamination may come from points to the north and travel to Montrose Beach with the current, or it may originate from terrestrial sources (e.g., beach sand, runoff) near the beach (Whitman and Nevers, 2008). A small, dog-friendly area is located at the northeastern end of Foster Beach, and a dog beach is located at the northwest end of Montrose Beach. Montrose Harbor is located on the southern side of the peninsula where Montrose Beach is located and a little more than 2 miles north of the Fullerton Avenue shoreline. The harbor is a marina with 630 docking spaces. Belmont Harbor is located south of Montrose Harbor and 730 docking stations. Diversey Harbor offers 714 docks, and the entrance to the harbor is located just north of Fullerton Beach. Waste pump-out equipment is free of charge (Westrec Marinas, 2012). All beaches are groomed daily (Breitenbach, 2011). In 2006 and 2007, dogs were used to harass gulls during a pilot program at Foster Beach (Hartmann et al., 2010).

The CPD/USGS-developed predictive models use water quality and weather data collected from real-time stations at Thorndale (George Lane)/Kathy Osterman beaches, Foster Beach, and Montrose Beach to estimate bacteria levels in the waters at each beach. A model was created for North Avenue Beach, but its use was discontinued due to inaccuracy in the summer of 2012 (Breitenbach, 2012).

Table 2-3. Monitoring and Single Sample Maximum WQS Exceedances for the Lincoln Park Impaired Segments 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_QN-03	CHOSTERMAN	Hollywood/ Osterman Beach	2007	10	1.2	5/30/2007	8/31/2007	69	STORET	X	X							
CPD Monitored			2008	2	1	5/27/2008	8/29/2008	71	STORET	X	X							
			2009	4	1.25	5/26/2009	9/3/2009	73	STORET	X	X							
			2010	3	2	5/27/2010	9/3/2010	70	STORET	X								
			2011	3	1	5/26/2011	8/31/2011	73	STORET	X						X	X	X
IL_QN-04	CHFOSTER	Foster Beach	2007	12	1.1	5/28/2007	8/31/2007	143	STORET	X	X							
CPD Monitored Dispersal of gulls via canine harassment was conducted in 2006 and 2007 for trial purposes (Hartmann et al., 2010).			2008	2	1	5/27/2008	8/29/2008	70	STORET	X	X							
			2009	3	1.3	5/26/2009	9/3/2009	72	STORET	X	X							
			2010	1	3	5/27/2010	9/3/2010	70	STORET	X								
			2011	2	1	5/26/2011	8/31/2011	72	STORET	X						X	X	X

(continued)

Table 2-3. Monitoring and Single Sample Maximum WQS Exceedances for the Lincoln Park Impaired Segments in the Past 5 Years (continued)

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_QN-05	CHMONTROSE	Montrose Beach	2007	15	1.4	5/28/2007	8/31/2007	148	STORET	X	X							
CPD Monitored			2008	7	1.3	5/27/2008	8/29/2008	71	STORET	X	X							
			2009	2	1.5	5/26/2009	9/3/2009	71	STORET	X	X							
			2010	5	1.4	5/27/2010	9/3/2010	70	STORET	X								
			2011	6	1	5/26/2011	8/31/2011	75	STORET	X						X	X	X
IL_QO-02		Fullerton Beach	Not Currently Sampled or Monitored - No swimming access															
IL_QO-01	CHNORTH	North Ave. Beach	2007	12	1.2	5/28/2007	8/31/2007	148	STORET	X	X							
CPD Monitored Indexed Beach (IL666876) covers several Assessment Units (IL_QO-04 - Armitage; IL_QO-03 - Webster). Individual monitoring is not reported for these beaches.			2008			5/27/2008	8/29/2008	68	STORET	X	X							
			2009	2	1.5	5/26/2009	9/3/2009	72	STORET	X	X							
			2010	2	2	5/27/2010	9/3/2010	71	STORET	X								
			2011	1	1	5/26/2011	8/31/2011	75	STORET	X								

2.1.4 Downtown Impaired Segments

The impaired segments considered within this section are those located south of Lincoln Park and north of Navy Pier. These segments include, from north to south, Schiller Avenue Shoreline, Oak Street Beach, and Ohio Street Beach. This portion of the Lake Michigan shoreline has been altered due to lake filling (IDNR, 2011b).

Schiller Avenue Shoreline is just south of North Avenue Beach in the Gold Coast Chicago neighborhood (**Figure 2-7**). This segment does not have swimming access and consists of a concrete shoreline. This thin, 5.75-acre stretch of shoreline has a LIDAR-defined direct drainage area of three acres consisting mostly of roadway with some small areas of park land. It is expected that most of the stormwater runoff in this area is intercepted by the sewer system.

Immediately south of Schiller Avenue Shoreline is Oak Street Beach (Figure 2-7). This small, rounded beach is nearly 7 acres in size, with a direct drainage area of 1 acre. The drainage area includes park land, roadways, and walkways.

Ohio Street Beach is located less than three quarters of a mile down shore from Oak Street Beach (Figure 2-7). This north-facing beach is surrounded by Lake Shore Drive to the west and the Jardine Water Filtration Plant to the east and Navy Pier to the South. The small, 3-acre beach drains an additional 1.75 acres of land. The drainage area includes park land, roadway, walkway, and land in commercial/industrial use. The Chicago River Controlling Works (CRCW) structure that forms the barrier between the Chicago River and Lake Michigan is directly south of Ohio Street Beach and Navy Pier.

Revetments and bulkheads are commonly employed to protect the shoreline along the filled section of the Lake Michigan coast, and all of the beaches in Chicago are equipped with some type of structure to prevent beach erosion (IDNR, 2011b). Schiller Avenue Shoreline consists of a concrete shoreline. One offshore north-facing breakwater structure is located just south of Oak Street Beach. Two breakwater structures (north-facing and northeast-facing) are less than a mile offshore from Ohio Street Beach.

Table 2-4 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures and advisories were attributed to CSOs and unknown sources at Oak Street Beach and Ohio Street Beach (Illinois DPH, 2012). There are no NPDES discharges to these beaches; nonpoint sources are primarily responsible for contamination (Whitman and Nevers, 2008). However, occasional releases from the locks in Wilmette Harbor and the Chicago River occur and could contribute combined loadings from point and nonpoint sources from the CAWS to Lake Michigan. The Chicago River is connected to Lake Michigan through the CRCW lock, located about a third of a mile south of Ohio Street Beach. The Chicago River can carry many point source discharges into Lake Michigan, including discharges and numerous CSOs, during times of river reversals. During extreme rainfall events, the lock is opened and the Chicago River reverses to discharge into Lake Michigan. At other times, the river flows away from the lake into the CAWS (IDNR, 2011c).

The CPD/USGS-developed predictive models use water quality and weather data collected from real-time stations at Oak Street Beach to estimate bacteria levels in the waters at these beaches.

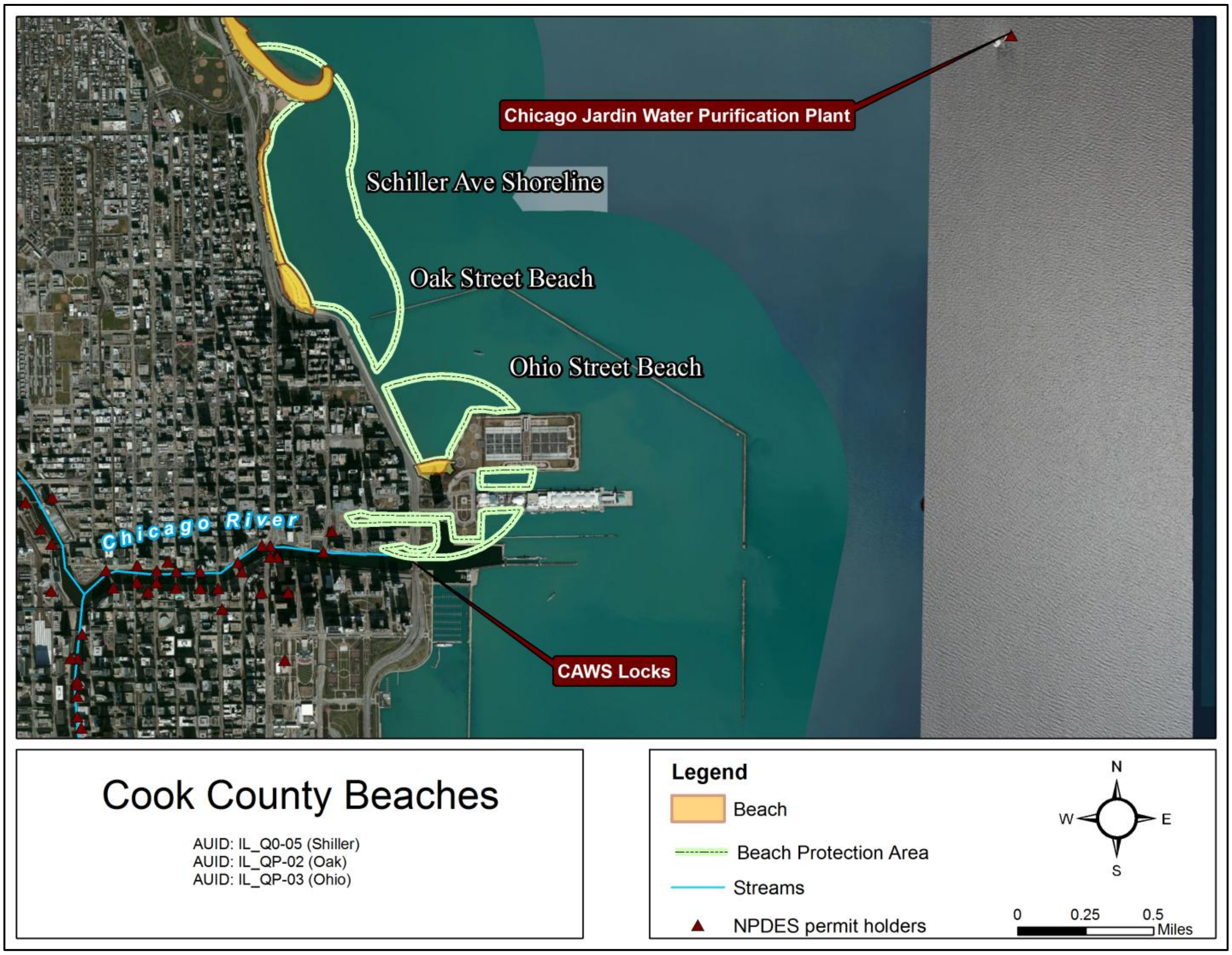

Figure 2-7. Downtown Chicago Impaired Segments and Drainage Catchments

Table 2-4. Monitoring and Single Sample Maximum WQS Exceedances for the Downtown Chicago Impaired Segments 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_QO-05		Schiller Shoreline	Not Currently Sampled or Monitored - No swimming access															
IL_QP-02	CHOAK	Oak St. Beach	2007	13	1.2	5/28/2007	8/31/2007	144	STORET	X	X							
CPD Monitored			2008	2	1	5/27/2008	8/29/2008	68	STORET	X	X							
			2009	1	2	5/26/2009	9/3/2009	72	STORET	X	X							
			2010	2	2	5/27/2010	9/3/2010	72	STORET	X								
			2011	2	1	5/26/2011	8/31/2011	73	STORET	X						X	X	X
IL_QP-03	CHOHIO	Ohio St. Beach	2007	12	1.1	5/28/2007	8/31/2007	144	STORET	X	X							
CPD Monitored			2008	1	1	5/27/2008	8/29/2008	68	STORET	X	X							
			2009	3	1.3	5/26/2009	9/3/2009	72	STORET	X	X							
			2010	1	3	5/27/2010	9/3/2010	69	STORET	X								
			2011	2	1	5/26/2011	8/31/2011	77	STORET	X						X	X	X

2.1.5 Near South Impaired Segments

Burnham Park stretches along 5 miles of Lake Michigan shoreline. 12th Street Beach lies just north of Burnham Park. Within the park the impaired segments include, from north to south, 31st Street Beach, Oakwood Beach, and 49th Street Shoreline. Oakwood Beach is not currently listed as impaired and is therefore not detailed in this assessment. The park is located in the Chicago Lake Plain, an area that is predominately composed of glacial till (Illinois State Geological Survey, 2012). This portion of the Lake Michigan shoreline has been altered due to lake filling (IDNR, 2011b).

12th Street Beach is located about 2 miles south of Ohio Street Beach on Northerly Island, which is man-made (**Figure 2-8**). The small, circular embayment is bounded to the north by an east-facing pier. The beach is 4.25 acres in size and drains an additional 2.25 acres. The surrounding land is mostly open park land, with walkways and a large parking lot. The southern end of Northerly Island has one point source discharge from McCormick Place West Hall, a conference center.

31st Street Beach is 1.5 miles south of 12th Street Beach in Chicago's Prairie Shores neighborhood (Figure 2-8). The beach is roughly 3.75 acres in size, with 1 additional acre of direct drainage. The drainage area includes parts of Burnham Park, as well as roadways and walkways. In 2012, the Park District opened a new harbor with 1,000 boat slips adjacent to the beach to the south.

49th Street Shoreline is located about 2.5 miles down shore from 31st Street Beach in Chicago's East Hyde Park neighborhood (Figure 2-8). This northeast-facing rocky shoreline has no swimming access. The small, thin shoreline is slightly larger than half an acre and has an additional half-acre of direct drainage. The drainage area includes open park land and paved walkway.

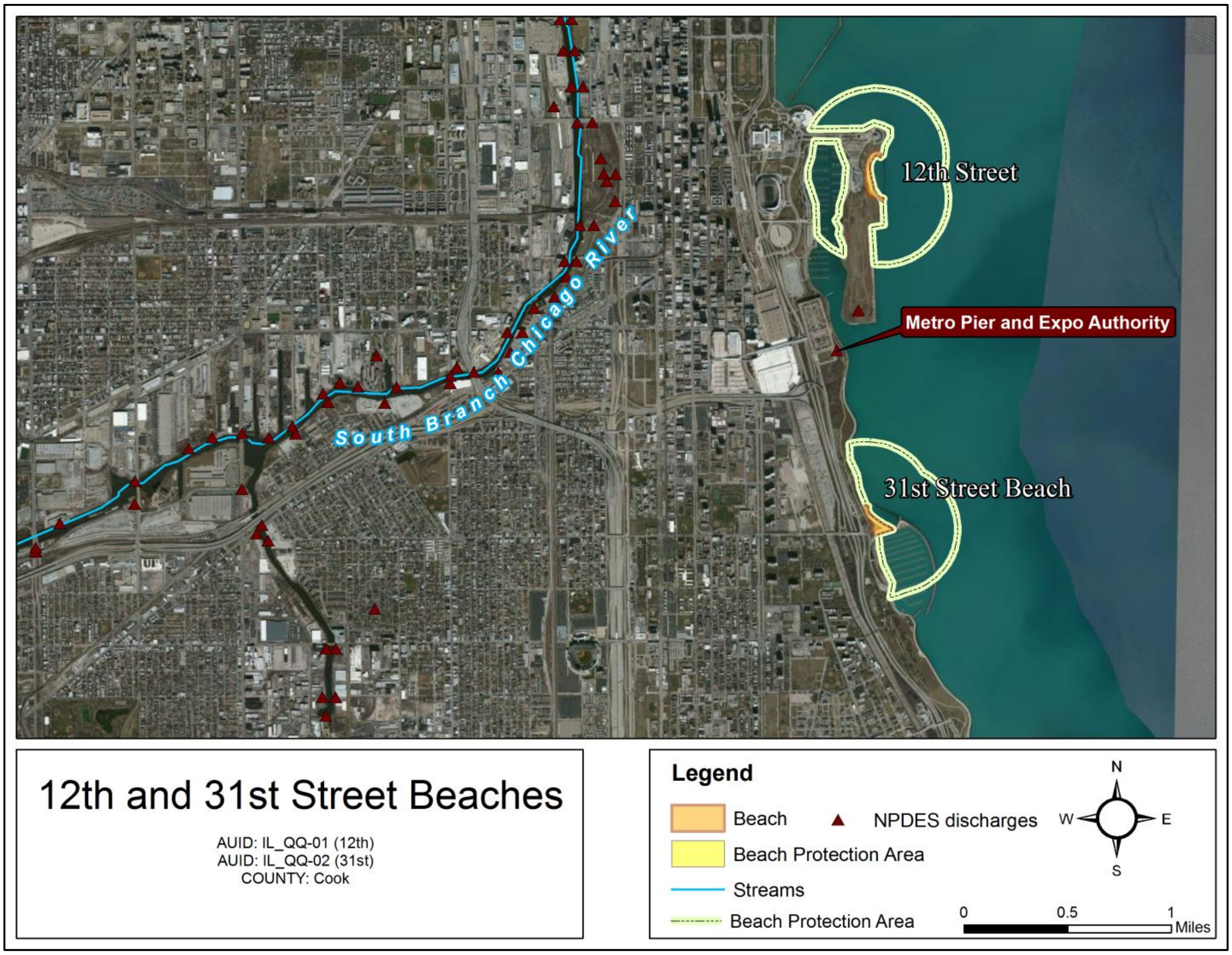

Figure 2-8. Near South Impaired Segments and Drainage Catchments

Revetments and bulkheads are commonly employed to protect the shoreline along the filled section of the Lake Michigan coast, and all of the beaches in Chicago are equipped with some type of structure to prevent beach erosion (IDNR, 2011b). 12th Street Beach has a submerged breakwater that runs parallel to the shore to hold the beach sand in place (IDNR, 2011b; Illinois State Geological Survey, 2012). An offshore breakwater structure is parallel to the beach, and two groynes (one north facing and one southeast facing) have created a circular embayment at 31st Street Beach.

Table 2-5 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures and advisories were attributed to publicly owned treatment works, CSOs, and unknown sources at 12th Street Beach and to publicly owned treatment works, CSOs, and unknown sources at 31st Street Beach (Illinois DPH, 2012). There are two NPDES discharges to these beaches, but they are not considered to be contributors to the impaired bacterial water quality. Neither of the two NPDES-permitted discharges between 12th Street and 31st Street beaches have permit limits for bacteria: Metro Pier and Expo Authority discharges non-contact cooling water and monitors for flow and pH only, while McCormick Place West Hall discharges treated groundwater and monitors for flow, solids, pH, and offensive conditions. Additionally, these discharges are farther than 500 m away from either beach.

Nonpoint sources are primarily responsible for contamination at the Chicago area beaches (Whitman and Nevers, 2008). However, occasional releases from the locks in Wilmette Harbor and the Chicago River occur and could contribute combined loadings from point and nonpoint sources from the CAWS to Lake

Michigan. The CRCW Lock is located approximately 2 miles north of 12th Street Beach (IDNR, 2011c). DuSable Harbor and Monroe Harbor are located between the Chicago Lock and 12th Street Beach. These harbors hold 420 and 1,000 docking stations, respectively. Burnham Harbor is located on the landward side of Northerly Island and has 1,120 docks. 31st Street Harbor is adjacent to 31st Street Beach to the south and houses up to 1,000 boats. Pump-out equipment is available free of charge at all harbors (Westrec Marinas, 2012).

The CPD/USGS-developed predictive models use water quality and weather data collected from real-time stations at 12th Street and 31st Street beaches to estimate bacteria levels in the waters at these beaches.

Table 2-5. Monitoring and Single Sample Maximum WQS Exceedances for the Near South Beaches in the Past 5 Years[1]

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_QQ-01	CH12	12th St. Beach	2007	3	1.3	5/30/2007	8/31/2007	52	STORET	X	X							
CPD Monitored			2008	1	1	5/27/2008	8/29/2008	69	STORET	X	X							
			2009	4	1.25	5/26/2009	9/3/2009	73	STORET	X	X							
			2010	2	2	5/27/2010	9/3/2010	71	STORET	X								
			2011	3	1	5/26/2011	8/31/2011	73	STORET	X						X	X	X
IL_QQ-02	CH31	31st St. Beach	2007	16	2	7/12/2007	8/31/2007	80	STORET	X	X							
CPD Monitored			2008	5	1	5/27/2008	8/29/2008	70	STORET	X	X							
			2009	2	1.5	5/26/2009	9/3/2009	72	STORET	X	X							
			2010	7	1.3	5/27/2010	9/3/2010	72	STORET	X								
			2011	3	1	5/26/2011	8/31/2011	72	STORET	X						X	X	X
IL_QR-01		49th St. Beach	2003			late May	early Sept		USGS	X		X	X	X	X		X	
Not monitored other than during USGS study No beach swimming access			2004			late May	early Sept		USGS	X		X	X	X	X		X	
			2005			late May	early Sept		USGS	X		X	X	X	X		X	

[1] Years prior to 2007 are listed for 49th Street Shoreline because they are the only known data available for the location.

2.1.6 Jackson Park Beaches

57th Street Beach and 63rd Street Beach are located within Jackson Park. This portion of the Lake Michigan shoreline has been altered due to lake filling (IDNR, 2011b).

57th Street Beach is located less than 1 mile south of 49th Street Shoreline in Chicago's East Hyde Park neighborhood. The small, east-facing beach is about 5 acres in size and drains 1.25 acres of land (**Figure 2-9**). The beach is surrounded by Jackson Park and the Museum of Science and Industry. The drainage area includes park land, roadways, and walkways. There is a stormwater outfall to the lake located north of the beach as identified by CPD.

63rd Street Beach is located less than half a mile south of 57th Street Beach in the Chicago neighborhood of Woodlawn (Figure 2-9). This northeast-facing beach is flanked to the south by an east-facing pier that has created a circular embayment. 63rd Street Beach is 15.5 acres in size, with 1 additional acre of direct drainage. The land surrounding the beach is open park land, with some areas of impervious surface. The southern edge of the beach contains some areas of dune habitat. The Chicago South Water Treatment Plant has a point-source discharge for backwater flow and zebra mussel control about 2 miles offshore from 63rd Street Beach, a distance that is assumed to attenuate any impacts to the beach from this discharge. Additionally, this discharge is not expected to be a source of bacterial impairment due to its source water and permit limits for only flow, pH, and chlorine.

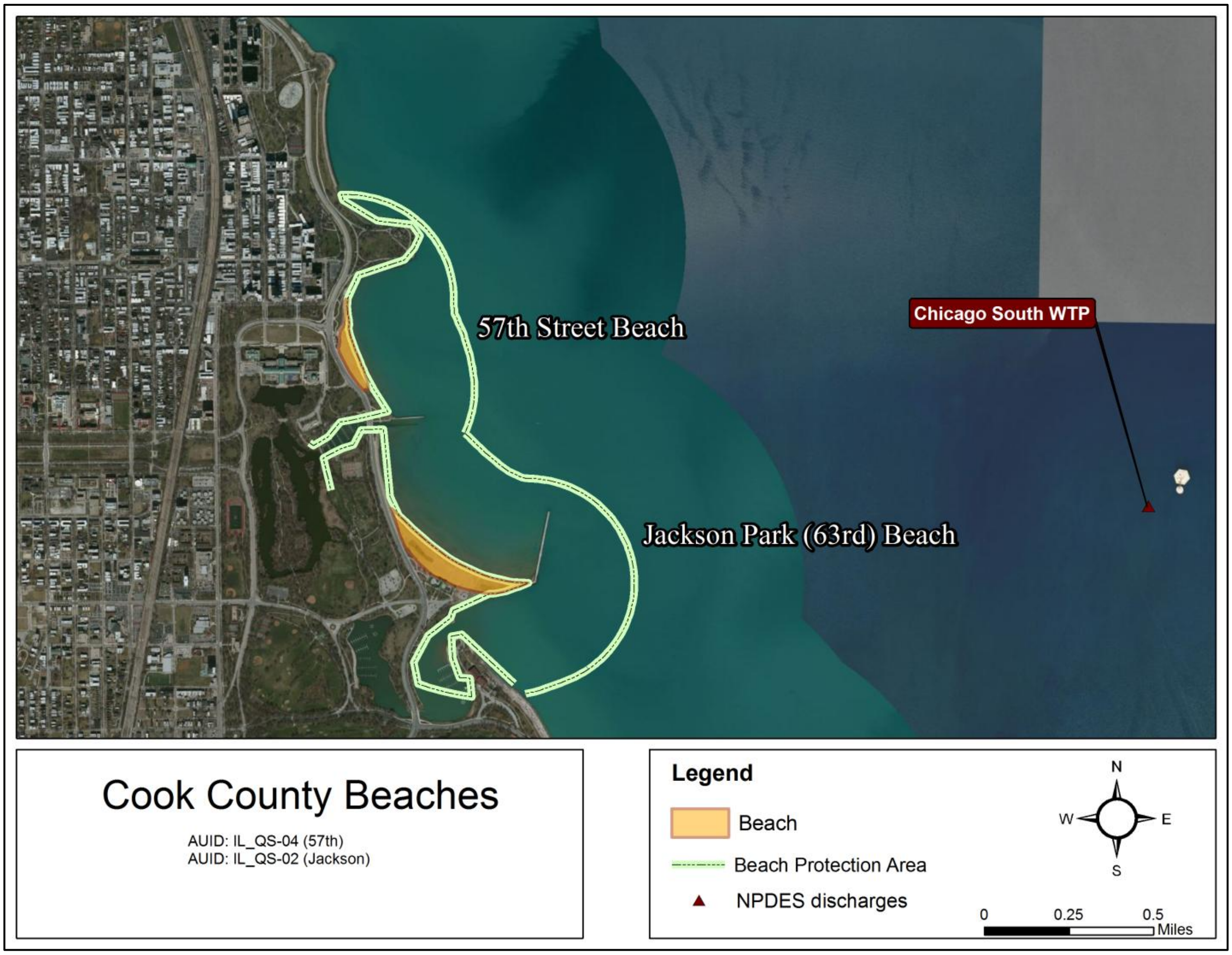

Figure 2-9. Jackson Park Beaches and Drainage Catchments

Revetments and bulkheads are commonly employed to protect the shoreline along the filled section of the Lake Michigan coast, and all of the beaches in Chicago are equipped with some type of structure to prevent beach erosion (IDNR, 2011b). 63rd Street Beach has two breakwaters, a 450-meter revetment followed by a 150-meter breakwater to the north, and a 700-meter breakwater to the south. The two breakwaters intercept the long current from the north (Whitman and Nevers, 2004) and reduce the flushing rate of the resulting embayment (Ge et al., 2012). In 2011, the CPD received a grant from the U.S. EPA to install a culvert in the southern revetment at 63rd Street Beach to improve circulation at water quality at the beach (GLRI, 2011).

Table 2-6 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures and advisories were attributed to publicly owned treatment works, CSOs, and unknown sources at 57th Street Beach and to CSOs and unknown sources at 63rd Street Beach (Illinois DPH, 2012). There are no NPDES discharges to these beaches or with the BPA; nonpoint sources are primarily responsible for contamination (Whitman and Nevers, 2008). However, occasional releases from the locks in Wilmette Harbor and the Chicago River occur and could contribute combined loadings from point and nonpoint sources from the CAWS to Lake Michigan. 59th Street Harbor has 125 docks and is located south of 57th Street Beach and north of 63rd Street Beach. The entrance to Jackson Inner and Outer harbors is located directly south of 63rd Street Beach. Pump-out equipment is available free of charge at all harbors (Westrec Marinas, 2012). Canine harassment of gulls has occurred at 57th Street and 63rd Street Beach on and off since 2007. In 2008, the program was proven to significantly reduce or eliminate the need for swim advisories and bans (Hartmann et al., 2010). The dispersal of gulls by canines will continue in 2012 (CPD, 2012b).

63rd Street Beach has been the subject of several studies to identify the source of contaminants at this beach. A 2001 study indicated that gulls were a significant source of *E. coli* contamination at the beach. In addition, *E. coli* colonies are likely entering Lake Michigan from stormwater, wastewater, and other sources to the north of the beach and are carried south toward the embayment by the current (Whitman et al., 2001). Modeling indicates that the embayment's reduced flushing rate may be causing *E. coli* colonies to settle and accumulate in sediments. The colonies are then reintroduced to the water column in greater densities during resuspension events (Ge et al., 2012). The 2001 study indicated that neighboring 59th Street Harbor was not a significant source of *E. coli* to the beach (Whitman et al., 2001).

The CPD/USGS-developed predictive models use water quality and weather data collected from real-time stations at 63rd Street Beach to estimate bacteria levels in the waters at this beach.

Table 2-6. Monitoring and Single Sample Maximum WQS Exceedances for the Jackson Park Beaches in the Past Five 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_QS-02	CHJACKSON	Jackson Park/63rd Beach	2007	18	2.5	5/28/2007	8/31/2007	160	STORET	X	X							
CPD Monitored Dispersal of gulls via canine harassment was conducted in 2007 for trial purposes and in 2008 full time (Hartmann et al., 2010).			2008			5/27/2008	8/29/2008	69	STORET	X	X							
			2009	13	1.6	5/26/2009	9/3/2009	76	STORET	X	X							
			2010	6	1.3	5/27/2010	9/3/2010	70	STORET	X								
			2011	3	1	5/26/2011	8/31/2011	71	STORET	X						X	X	X
IL_QS-04	CH57	57th St. Beach	2007	12	1.5	5/28/2007	8/31/2007	148	STORET	X	X							
CPD Monitored Dispersal of gulls via canine harassment was conducted in 2008 full time (Hartmann et al., 2010).			2008			5/27/2008	8/29/2008	68	STORET	X	X							
			2009	8	1.4	5/26/2009	9/3/2009	73	STORET	X	X							
			2010	2	2	5/27/2010	9/3/2010	71	STORET	X								
			2011	2	1	5/26/2011	8/31/2011	72	STORET	X						X	X	X

2.1.7 South Chicago Impaired Segments

The 67th Street Shoreline, South Shore Beach, and Rainbow Beach are located in southern Chicago. The 67th Street Shoreline and South Shore Beach are part of the South Shore Cultural Center, a city park that was formerly a country club. Rainbow Beach is located in the 60-acre Rainbow Beach Park. This portion of the Lake Michigan shoreline has been altered due to lake filling (IDNR, 2011b).

The 67th Street Shoreline is located half a mile south of 63rd Street Beach in Chicago's South Shore neighborhood. This rocky shoreline does not have swimming access. The thin segment of shoreline is less than 1 acre in size and has a direct drainage area of about 0.75 acres (**Figure 2-10**). This segment is surrounded by a golf course that makes up all of the land use in the drainage area.

South Shore Beach is a northeast-facing beach located just south of the 67th Street Shoreline near the South Shore Cultural Center. The 5.25-acre beach has a direct drainage area of 1.5 acres (Figure 2-10). The drainage area consists of a golf course and a paved walkway. The southeastern edge of the beach supports a dune habitat.

Crescent-shaped Rainbow Beach is located a half mile south of South Shore Beach in Chicago's South Shore neighborhood. This north-facing beach is roughly 24 acres in size, with an additional 4-acre direct drainage area (Figure 2-10). The drainage area includes park land, parking lot, and walkways; the southeastern edge of the beach contains a dune habitat.

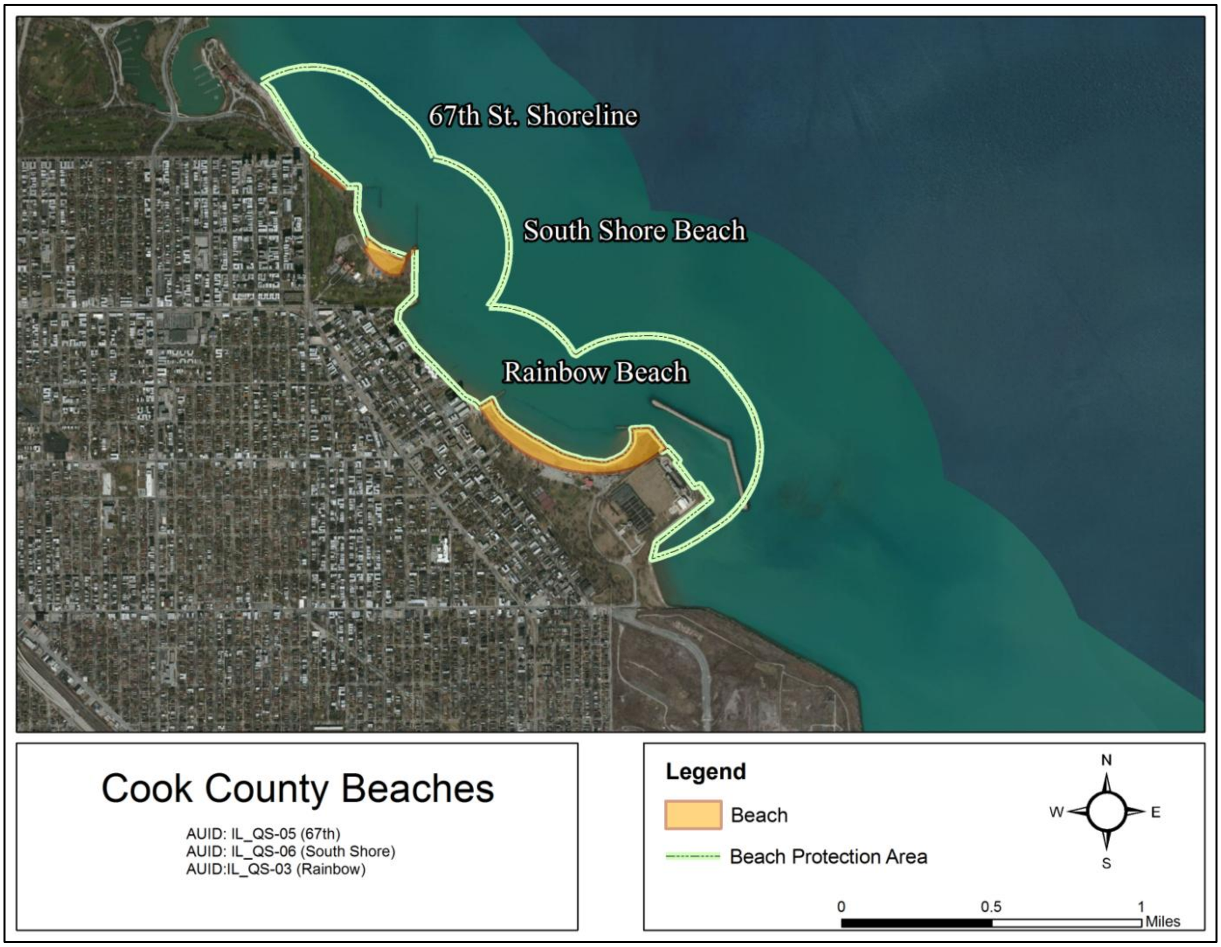

Figure 2-10. South Chicago Impaired Segments and Drainage Catchments

Revetments and bulkheads are commonly employed to protect the shoreline along the filled section of the Lake Michigan coast, and all of the beaches in Chicago are equipped with some type of structure to prevent beach erosion (IDNR, 2011b). South Shore Beach is bordered by two groyne structures (one faces north, and the other faces east), which have created a circular embayment. Rainbow Beach is flanked by two groyne structures (one faces northwest, and the other faces north); one breakwater structure is parallel to the beachfront and faces north.

Table 2-7 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures and advisories were attributed to CSOs and unknown sources at South Shore Beach and to CSOs and unknown sources at Rainbow Beach (Illinois DPH, 2012). There are no NPDES discharges to these beaches; nonpoint sources are primarily responsible for contamination (Whitman and Nevers, 2008). However, occasional releases from the locks in Wilmette Harbor and the Chicago River occur and could contribute combined loadings from point and nonpoint sources from the CAWS to Lake Michigan.

Table 2-7. Monitoring and Single Sample Maximum WQS Exceedances for the South Chicago Impaired Segments 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_QS-05		67th St. Shoreline	Not Currently Sampled or Monitored - No swimming access															
IL_QS-06	CHSOUTH SHORE	South Shore Beach	2007	13	1.5	5/28/2007	8/31/2007	146	STORET	X	X							
CPD Monitored			2008	2	1	5/27/2008	8/29/2008	71	STORET	X	X							
			2009	2	1.5	5/26/2009	9/3/2009	73	STORET	X	X							
			2010	7	1.3	5/27/2010	9/3/2010	73	STORET	X								
			2011	7	1.1	5/26/2011	8/31/2011	73	STORET	X						X	X	X
IL_QS-03	CHRAINBOW	Rainbow	2007	16	1.8	5/28/2007	8/31/2007	146	STORET	X	X							
CPD Monitored			2008	4	1	5/27/2008	8/29/2008	72	STORET	X	X							
			2009	8	1.1	5/26/2009	9/3/2009	74	STORET	X	X							
			2010	6	1.3	5/27/2010	9/3/2010	71	STORET	X								
			2011	4	1	5/26/2011	8/31/2011	74	STORET	X						X	X	X

2.1.8 Calumet South Beach

Calumet South Beach is the southernmost beach in the City of Chicago and is located in Calumet Park. This portion of the Lake Michigan shoreline has been altered due to lake filling (IDNR, 2011b).

The beach is located about three miles south of Rainbow Beach in Chicago's East Side neighborhood. The small, 4-acre beach has a direct drainage area of about 1.75 acres (**Figure 2-11**). The beach is part of Calumet Park, and most of the drainage area consists of open park land with some impervious structures and walkways. Additional drainage from the park enters the storm sewer system that runs along the small road within the park. This storm sewer has an outfall near the beach, which may be a source of impairment to the beach.

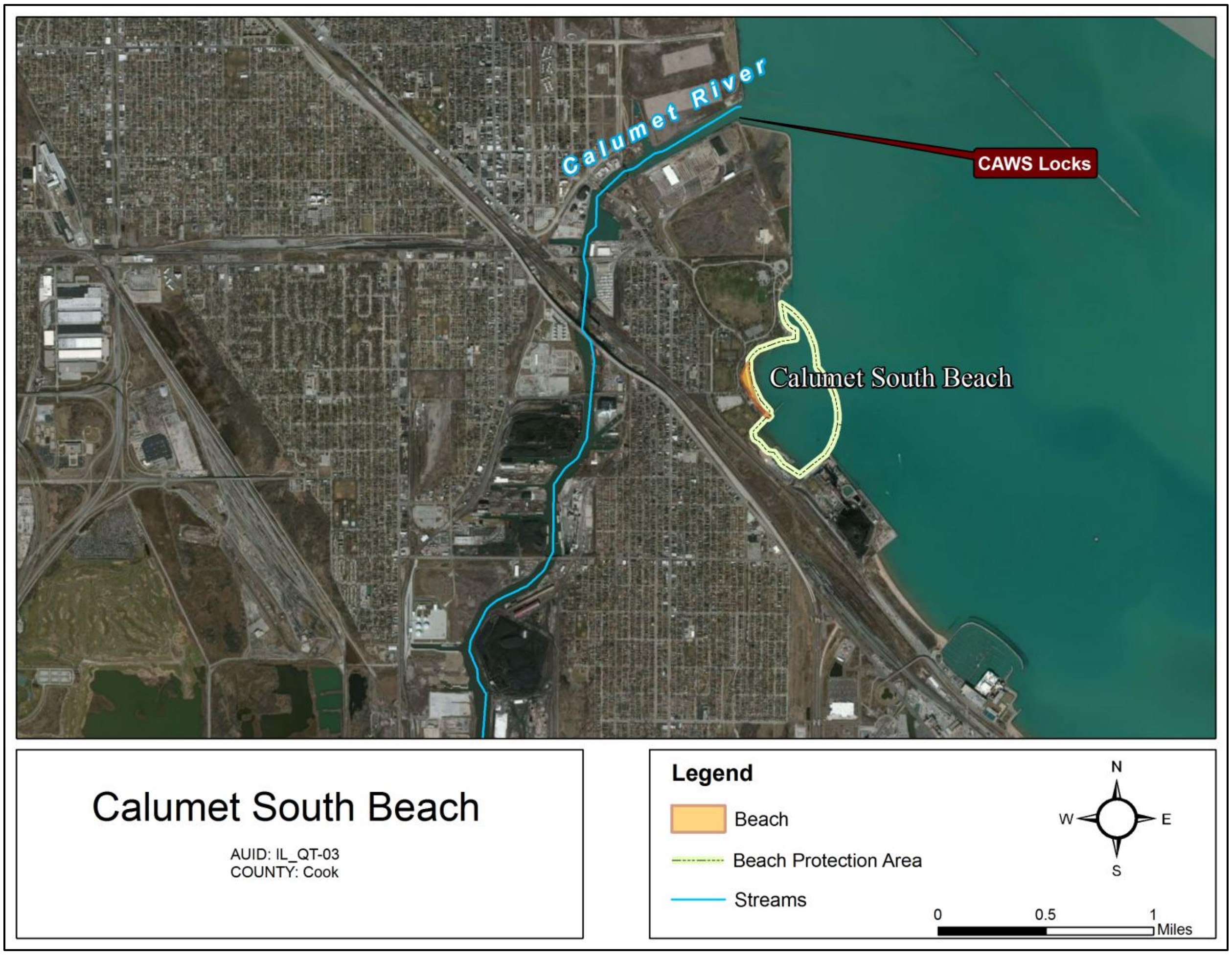

Figure 2-11. Calumet South Beach and Drainage Catchment

Revetments and bulkheads are commonly employed to protect the shoreline along the filled section of the Lake Michigan coast, and all of the beaches in Chicago are equipped with some type of structure to prevent beach erosion (IDNR, 2011b). One southeast-facing groyne structure has created a circular east-facing embayment at Calumet South Beach.

Table 2-8 shows information about beach monitoring and closures for the past 5 years. In 2010 and 2011, closures and advisories were attributed to publicly owned treatment works, CSOs, and unknown sources (Illinois DPH, 2012). There are no major point-source discharges to these beaches; nonpoint sources are primarily responsible for contamination (Whitman and Nevers, 2008). During extreme rainfall events, the lock separating the CAWS from the Calumet River is opened. The Calumet River, connected to Lake Michigan north of Calumet South Beach, runs approximately 8 miles from upstream of the O’Brien Lock and Dam to the Calumet Harbor on Lake Michigan. The highly altered river predominately flows to Lake Michigan, whereas the Little Calumet River and the Calumet-Sag Channel—modifications of the original Calumet River—flow to the Illinois River drainage system as part of the CAWS on the other side of the O’Brien Dam (IDNR, 2011a). The CAWS receives stormwater runoff and numerous NPDES discharges from industrial and municipal wastewater sources.

The CPD/USGS-developed predictive models use water quality and weather data collected from real-time stations at Calumet South Beach to estimate bacteria levels in the waters at this beach.

Table 2-8. Monitoring and Single Sample Maximum WQS Exceedances for the Calumet South Beach in the Past Five 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_QT-03	CHCALUMET	Calumet Beach	2007	14	2.1	5/28/2007	8/30/2007	71	STORET	X	X							
CPD Monitored			2008	3	1	5/27/2008	8/29/2008	70	STORET	X	X							
			2009	7	1.1	5/26/2009	9/3/2009	73	STORET	X	X							
			2010	3	1.7	5/27/2010	9/3/2010	72	STORET	X								
			2011	3	1.3	5/26/2011	8/31/2011	74	STORET	X						X	X	X

2.2 Current E. coli Conditions

All 29 impaired beaches within Chicago are monitored on weekdays (at least 4 days) by CPD from Memorial Day through Labor Day (i.e., no monitoring is conducted along segments without swimming access). The daily *E. coli* concentration measures are compared with the single sample maximum (SSM) and geometric mean (GM) WQS in **Table 2-9**. **Figures 2-12 and 2-13** provide 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 2-8 in terms of number of closures and average duration of the closures.

All shoreline segments addressed in this TMDL have experienced exeedances 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, Chicago beaches were monitored for hydrometeorologic conditions and presence of gulls during Beach Sanitary Surveys (BSSs) in the summer of 2011. Several of these surveys corresponded to days with water quality monitoring.

In terms of the number of SSM exceedances, there are mixed findings on the trends in recent years. There are no clearly improving beaches in terms of water quality. 2010 and 2011 exhibited increased exceedances in several of the beaches, particularly those at the southern end of the shoreline (e.g., Calumet South, South Shore, and Rainbow). 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 that 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, whereas the SSM measures public health risk on a daily increment. This distinguishes water quality targets needed for TMDL development and restoring designated uses from targets needed for daily beach management focused on the public. With the exception of some sporadic years at a few beaches (e.g., 2010 at 31st Street, 2008–2009 at Hartigan, 2011 at Rainbow), there appears to be no sustained source of impairment at the Chicago impaired beach segments.

Table 2-9. 5-year Monitored Exceedances of the WQSs

Beach	Year	Count of Single Samples	SSM Exceedances	Count of 30-day GM Calculations	GM Exceedances
12th Street Beach	2007	50	15	21	2
	2008	38	4	11	0
	2009	47	9	21	0
	2010	72	9	41	4
	2011	73	9	41	0
31st Street Beach	2007	53	11	20	0
	2008	48	6	19	0
	2009	44	6	15	0
	2010	70	12	37	10
	2011	71	11	39	0

(continued)

Table 2-9. 5-year Monitored Exceedances of the WQSs (continued)

Beach	Year	Count of Single Samples	SSM Exceedances	Count of 30-day GM Calculations	GM Exceedances
57th Street Beach	2007	42	**12**	12	**0**
	2008	49	**6**	17	**0**
	2009	45	**8**	19	**0**
	2010	72	**9**	41	**0**
	2011	74	**10**	43	**0**
Calumet South Beach	2007	38	**13**	11	**0**
	2008	44	**5**	14	**0**
	2009	53	**6**	21	**0**
	2010	72	**15**	41	**0**
	2011	76	**12**	44	**0**
Foster Beach	2007[1]	N/A	**N/A**	N/A	**N/A**
	2008	41	**5**	13	**0**
	2009	43	**8**	12	**0**
	2010	69	**7**	37	**0**
	2011	73	**3**	42	**0**
Hartigan Beach	2007[1]	N/A	**N/A**	N/A	**N/A**
	2008	66	**14**	38	**12**
	2009	75	**21**	42	**33**
	2010	67	**5**	35	**0**
	2011	70	**2**	38	**0**
Kathy Osterman Beach	2007[1]	N/A	**N/A**	N/A	**N/A**
	2008	40	**6**	10	**0**
	2009	44	**10**	17	**1**
	2010	71	**13**	40	**0**
	2011	73	**8**	41	**0**
Howard Beach	2007[1]	N/A	**N/A**	N/A	**N/A**
	2008	47	**9**	18	**0**
	2009	43	**7**	19	**0**
	2010	70	**6**	40	**0**
	2011	68	**5**	35	**0**
63rd Street Beach	2007	45	**10**	16	**0**
	2008	49	**9**	18	**0**
	2009	53	**4**	19	**0**
	2010	69	**14**	37	**0**
	2011	74	**9**	43	**0**
Jarvis Beach	2007[1]	N/A	**N/A**	N/A	**N/A**
	2008	37	**6**	13	**0**
	2009	49	**8**	21	**1**
	2010	71	**7**	40	**0**
	2011	68	**4**	35	**0**

(continued)

Table 2-9. 5-year Monitored Exceedances of the WQSs (continued)

Beach	Year	Count of Single Samples	SSM Exceedances	Count of 30-day GM Calculations	GM Exceedances
Juneway Beach	2007[1]	N/A	**N/A**	N/A	**N/A**
	2008	41	**6**	14	**0**
	2009	46	**10**	14	**0**
	2010	67	**3**	36	**0**
	2011	69	**4**	37	**0**
Leone Beach	2007[1]	N/A	**N/A**	N/A	**N/A**
	2008[2]	N/A	**N/A**	N/A	**N/A**
	2009[3]	N/A	**N/A**	N/A	**N/A**
	2010	70	**5**	39	**0**
	2011	75	**5**	43	**0**
Loyola Beach	2007[1]	N/A	**N/A**	N/A	**N/A**
	2008	43	**8**	15	**2**
	2009	46	**12**	17	**4**
	2010[4]	N/A	**N/A**	N/A	**N/A**
	2011[5]	N/A	**N/A**	N/A	**N/A**
Montrose Beach	2007[1]	N/A	**N/A**	N/A	**N/A**
	2008	43	**8**	15	**0**
	2009	42	**8**	14	**1**
	2010	69	**13**	37	**0**
	2011	75	**15**	43	**1**
North Avenue Beach	2007	40	**9**	23	**0**
	2008	52	**5**	26	**0**
	2009	55	**4**	40	**0**
	2010	72	**2**	55	**0**
	2011	77	**6**	59	**0**
Oak Street Beach	2007	41	**13**	16	**1**
	2008	48	**3**	17	**0**
	2009	48	**10**	19	**0**
	2010	72	**8**	40	**0**
	2011	75	**4**	43	**0**
Ohio Street Beach	2007	39	**10**	14	**0**
	2008	49	**8**	20	**0**
	2009	53	**9**	23	**0**
	2010	70	**5**	39	**0**
	2011	78	**12**	46	**2**
Rainbow Beach	2007	36	**10**	9	**0**
	2008	51	**2**	25	**0**
	2009	47	**9**	17	**0**
	2010	69	**14**	37	**2**
	2011	75	**17**	44	**21**

(continued)

Table 2-9. 5-year Monitored Exceedances of the WQSs (continued)

Beach	Year	Count of Single Samples	SSM Exceedances	Count of 30-day GM Calculations	GM Exceedances
Rogers Beach	2007[1]	N/A	N/A	N/A	N/A
	2008	44	9	16	0
	2009	47	5	16	0
	2010	69	3	39	0
	2011	68	4	35	0
South Shore Beach	2007	42	13	12	1
	2008	44	5	17	0
	2009	50	8	18	0
	2010	70	20	40	6
	2011	75	17	43	0
Thorndale Beach	2007[1]	N/A	N/A	N/A	N/A
	2008	35	4	13	0
	2009	45	13	18	4
	2010[4]	N/A	N/A	N/A	N/A
	2011[5]	N/A	N/A	N/A	N/A

[1] No data for 2007 at this beach

[2] No data for 2008 at this beach

[3] No data for 2009 at this beach

[4] No data for 2010 at this beach

[5] No data for 2011 at this beach

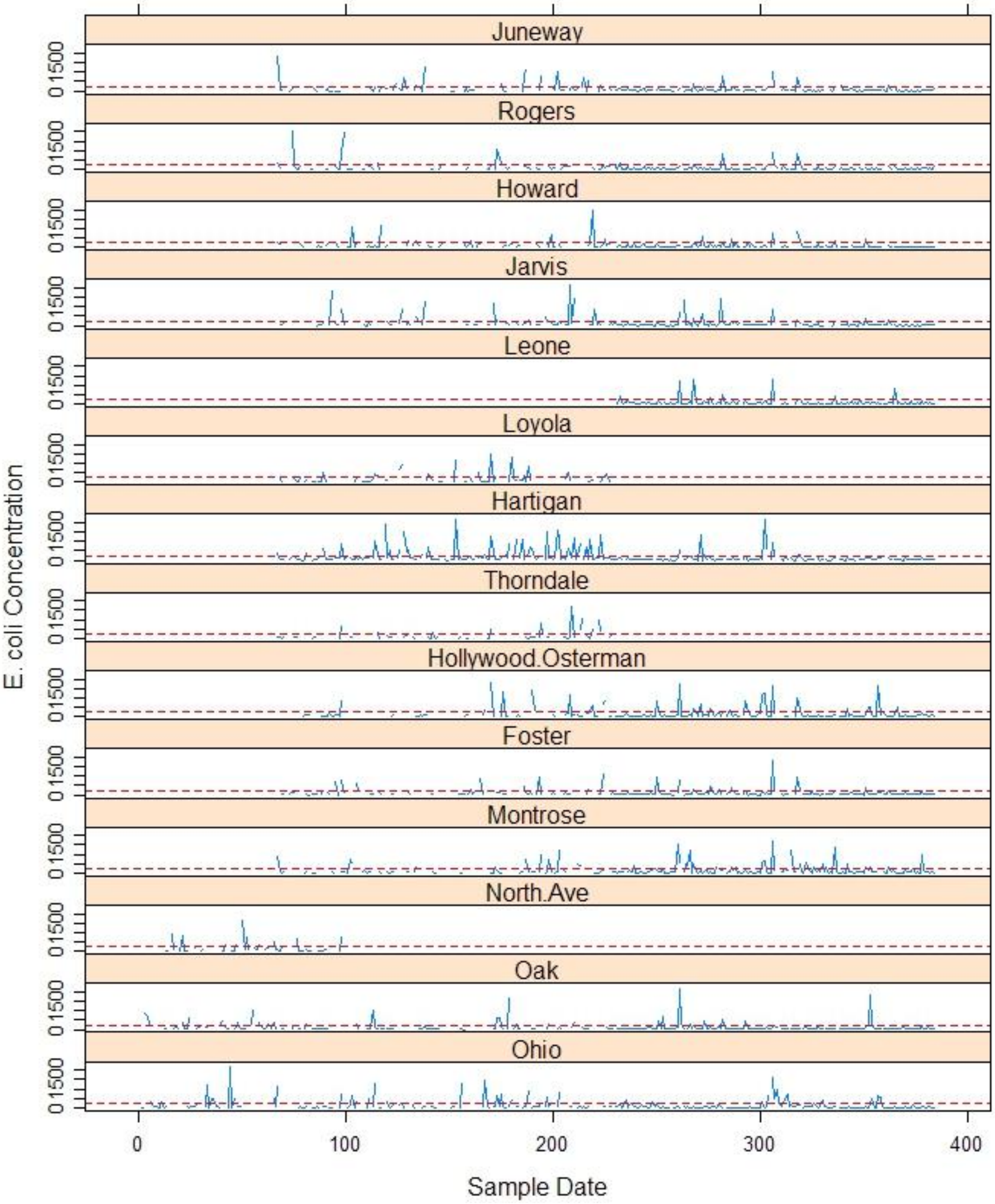

Figure 2-12. Monitored *E. coli* levels at northern Chicago Beaches as Compared with the SSM WQS (red line) for May 2007–September 2011

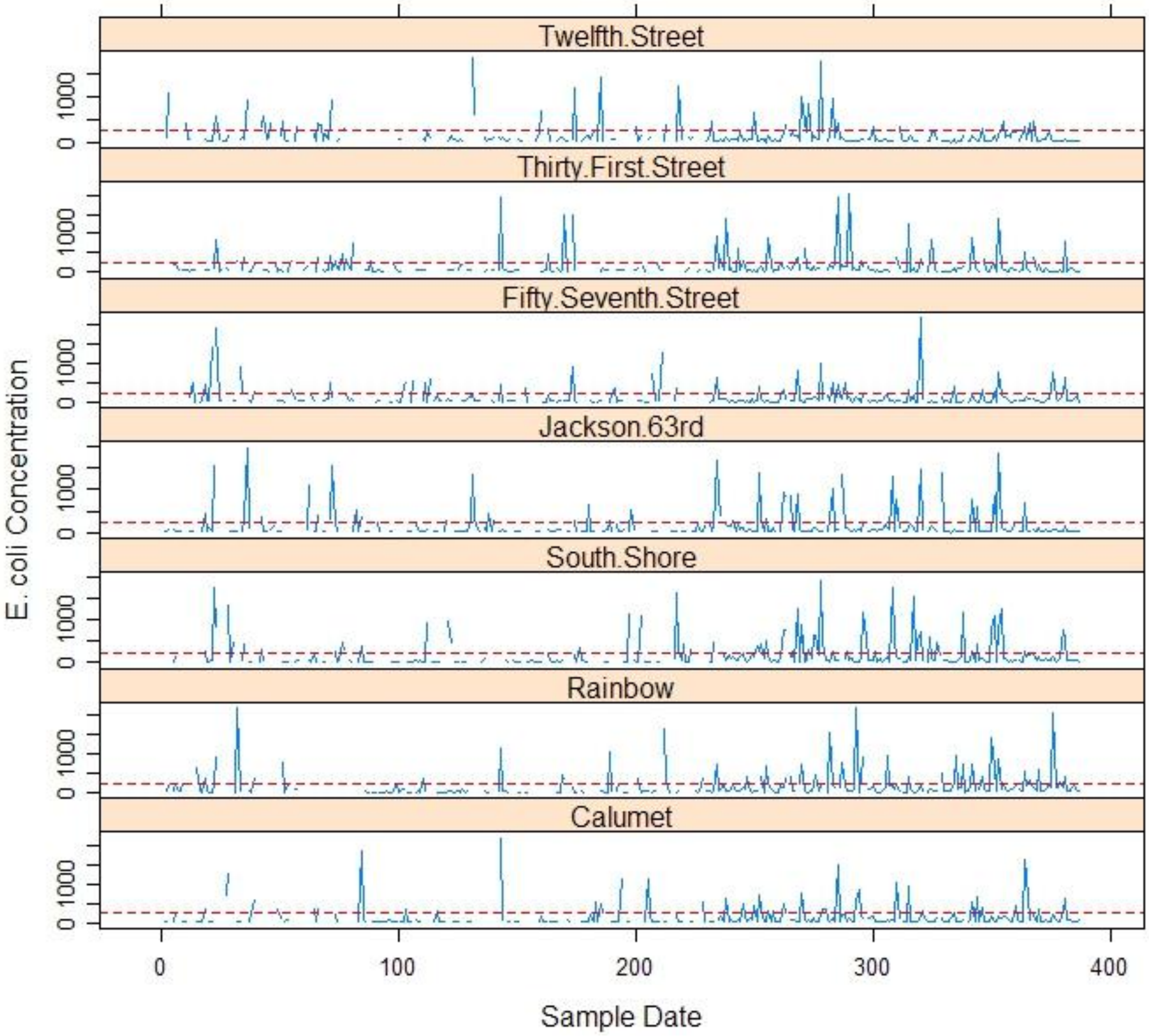

Figure 2-13. Monitored *E. coli* levels at southern Chicago Beaches as Compared to the SSM WQS (red line) for May 2007–September 2011

3. Problem Statement

All 29 of the Chicago 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 water quality standards 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 Chicago 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 2-7, 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**).The Jackson Park and South Chicago beaches experienced the largest number of closures on average and as a maximum with 2007 being a highly affected year. Overall, 2007 was the year with the largest number of closures throughout the Chicago area.

Table 3-2. Swim Ban Statistics for Impaired Segments Based on Reporting to U.S. EPA's PRAWN[1] System

Impaired Segment Name	Metric	Year	Number
Juneway Terrace	5-Year Average	N/A	3[1]
	Minimum	2010	1
	Maximum	2007	7
Rogers Beach	5-Year Average	N/A	1.8
	Minimum	2008–2011	1
	Maximum	2007	5
Howard Beach	5-Year Average	N/A	2.2
	Minimum	2008, 2010 & 2011	1
	Maximum	2007	6
Jarvis and Fargo Beaches	5-Year Average	N/A	3[1]
	Minimum	2009 & 2011	1
	Maximum	2007	7

(continued)

Table 3-2. Swim Ban Statistics for Impaired Segments Based on Reporting to U.S. EPA's PRAWN[1] System (Continued)

Impaired Segment Name	Metric	Year	Number
Leone Beach	5-Year Average	N/A	2.6
	Minimum	2008 & 2009	1
	Maximum	2007	5
Hartigan North (Pratt) Beach	5-Year Average	N/A	3.5[1]
	Minimum	2009 & 2011	1
	Maximum	2007	10
Hartigan North (North Shore/Columbia) Beach	5-Year Average	N/A	3.5[1]
	Minimum	2011	1
	Maximum	2007	9
Hartigan South (Albion) Beach	5-Year Average	N/A	2.6
	Minimum	2008 & 2011	1
	Maximum	2007	7
Kathy Osterman Beach	5-Year Average	N/A	4.4
	Minimum	2008	2
	Maximum	2007	10
Foster Beach	5-Year Average	N/A	4
	Minimum	2010	1
	Maximum	2007	11
Montrose Beach	5-Year Average	N/A	7
	Minimum	2009	2
	Maximum	2007	15
North Avenue Beach	5-Year Average	N/A	4.25[1]
	Minimum	2011	1
	Maximum	2007	12
Oak Street Beach	5-Year Average	N/A	4
	Minimum	2009	1
	Maximum	2007	13
Ohio Street Beach	5-Year Average	N/A	3
	Minimum	2008 & 2010	1
	Maximum	2007	12
12th Street Beach	5-Year Average	N/A	2.6
	Minimum	2008	1
	Maximum	2009	4
31st Street Beach	5-Year Average	N/A	6.6[1]
	Minimum	2009	2
	Maximum	2007	16
57th Street Beach	5-Year Average	N/A	6[1]
	Minimum	2010 & 2011	2
	Maximum	2007	12

(continued)

Table 3-2. Swim Ban Statistics for Impaired Segments Based on Reporting to U.S. EPA's PRAWN[1] System (Continued)

Impaired Segment Name	Metric	Year	Number
63rd Street Beach	5-Year Average	N/A	10
	Minimum	2011	3
	Maximum	2007	18
South Shore Beach	5-Year Average	N/A	6.2
	Minimum	2008 & 2009	2
	Maximum	2007	13
Rainbow Beach	5-Year Average	N/A	7.6
	Minimum	2008 & 2011	4
	Maximum	2007	16
Calumet South Beach	5-Year Average	N/A	6
	Minimum	2008, 2010 & 2011	3
	Maximum	2007	14

[1] PRAWN = PRogram tracking, beach Advisories, Water quality standards, and Nutrients

[2] Average is based on 4 years of data for this 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 geometric mean), and the second is an upper limit (single sample maximum). 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 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 page 67225 of Federal Rule) The SSM may, but need not, also play a role in implementing other Clean Water Act 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

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[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

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.

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 that 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 parameters 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 being 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 beachgoers	Count	Human sources; disturbance of sediments	X	Fees
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		Green infrastructure such as porous pavement and rain gardens. Stormwater BMPs
Hours since rain event	Temporal	Build-up		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 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 two-kilometer 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 Chicago beaches, the influence of wave period on *E. coli* concentrations is clear: increasing wave period can be correlated with higher *E. coli* concentrations along the shoreline. The impacts of wave action are somewhat attenuated when the beach is embayed (right panel of Figure 3-1 versus open beaches in left panel of Figure 3-1). 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.

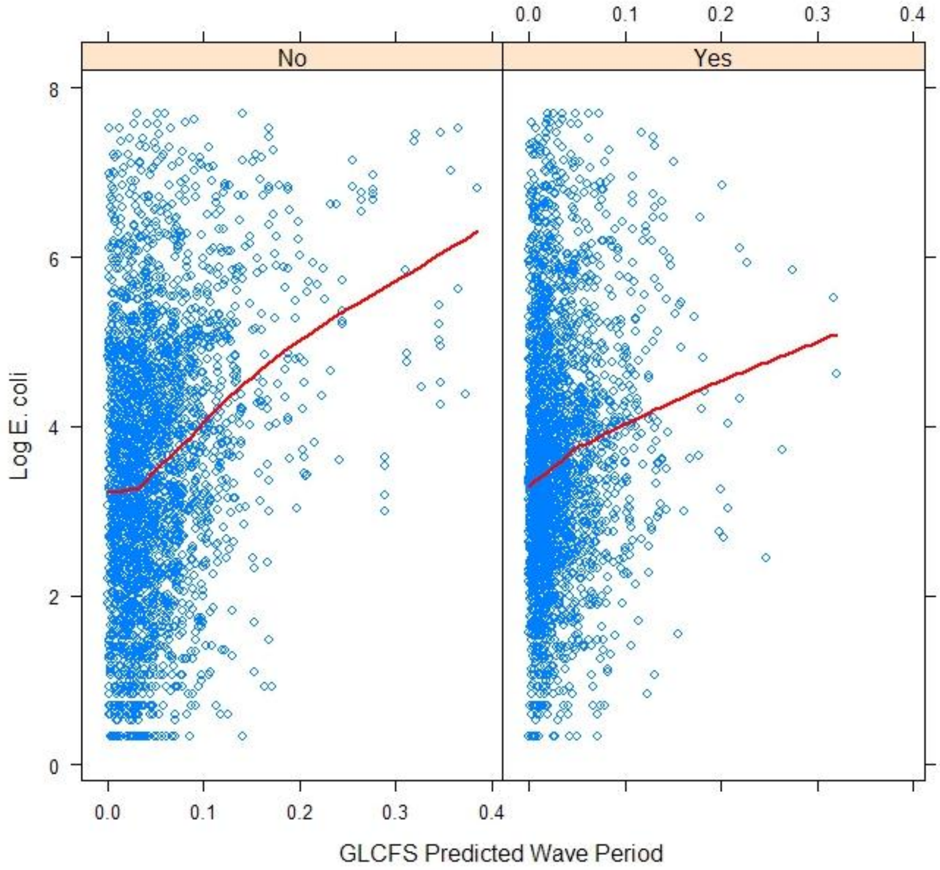

Figure 3-1. Impact on *E. coli* Concentrations (all CPD beaches) by Wave Period and Embayment

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 Chicago beaches, there is a slight trend for increasing *E. coli* concentrations with increasing amounts of precipitation (**Figure 3-2**). 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.

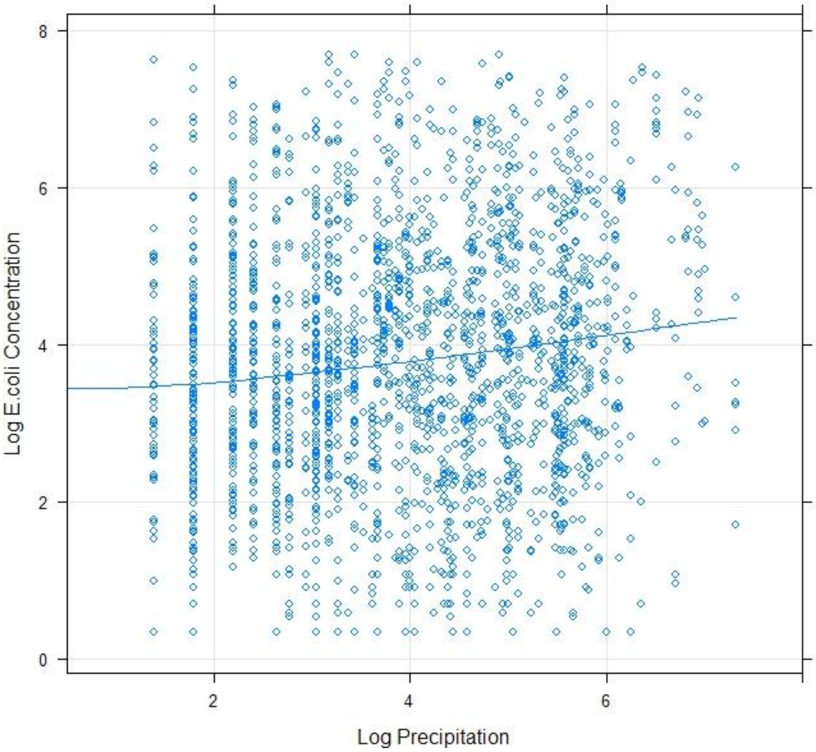

Figure 3-2. Influence of Precipitation on *E. Coli* Concentrations at all CPD beaches

3.2.3 Land Use/Cover

The land cover layer for Cook County, including Chicago, 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 (**Figures 3-3 and 3-4**). **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

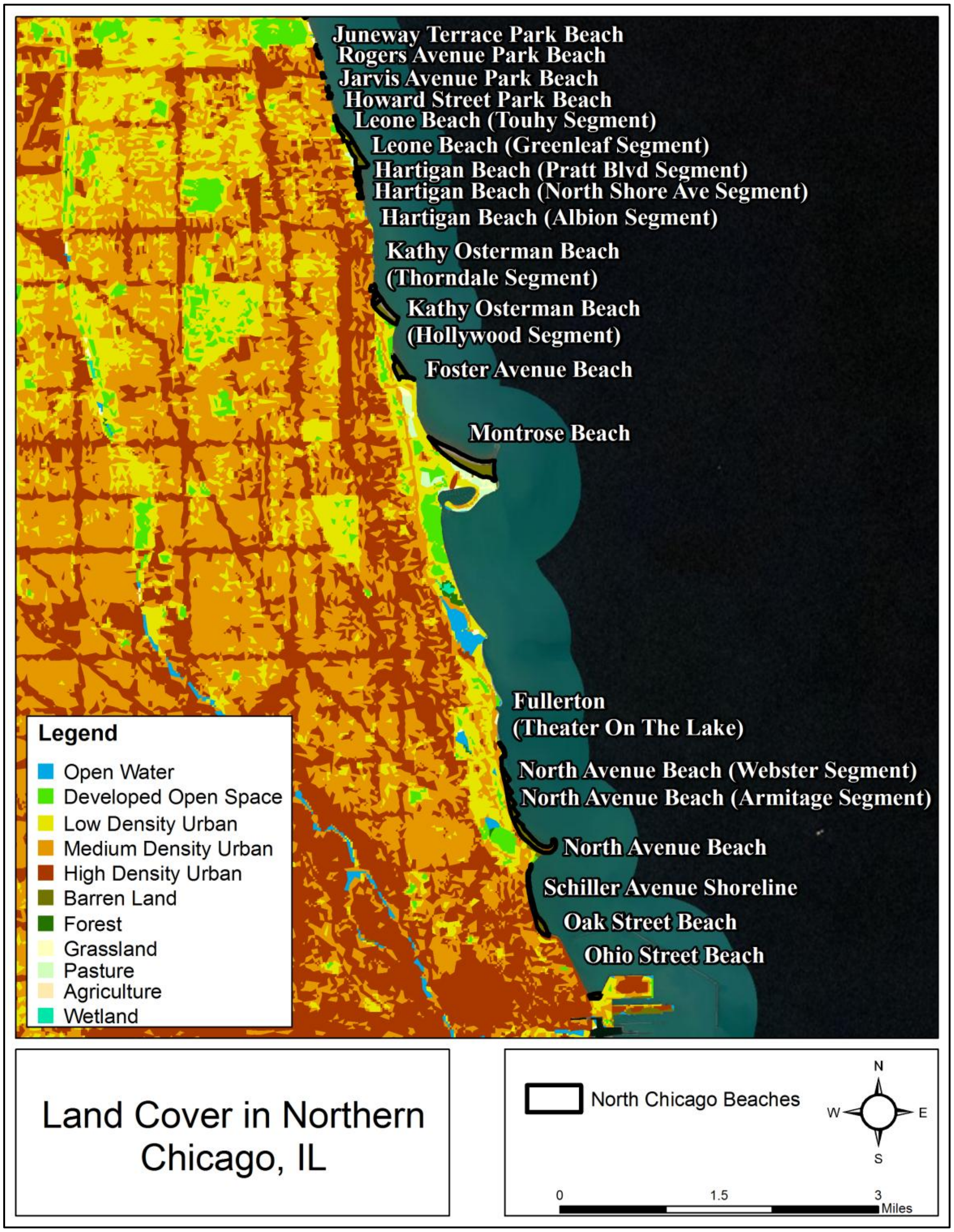

Figure 3-3. Land Use along the Northern Chicago Shoreline

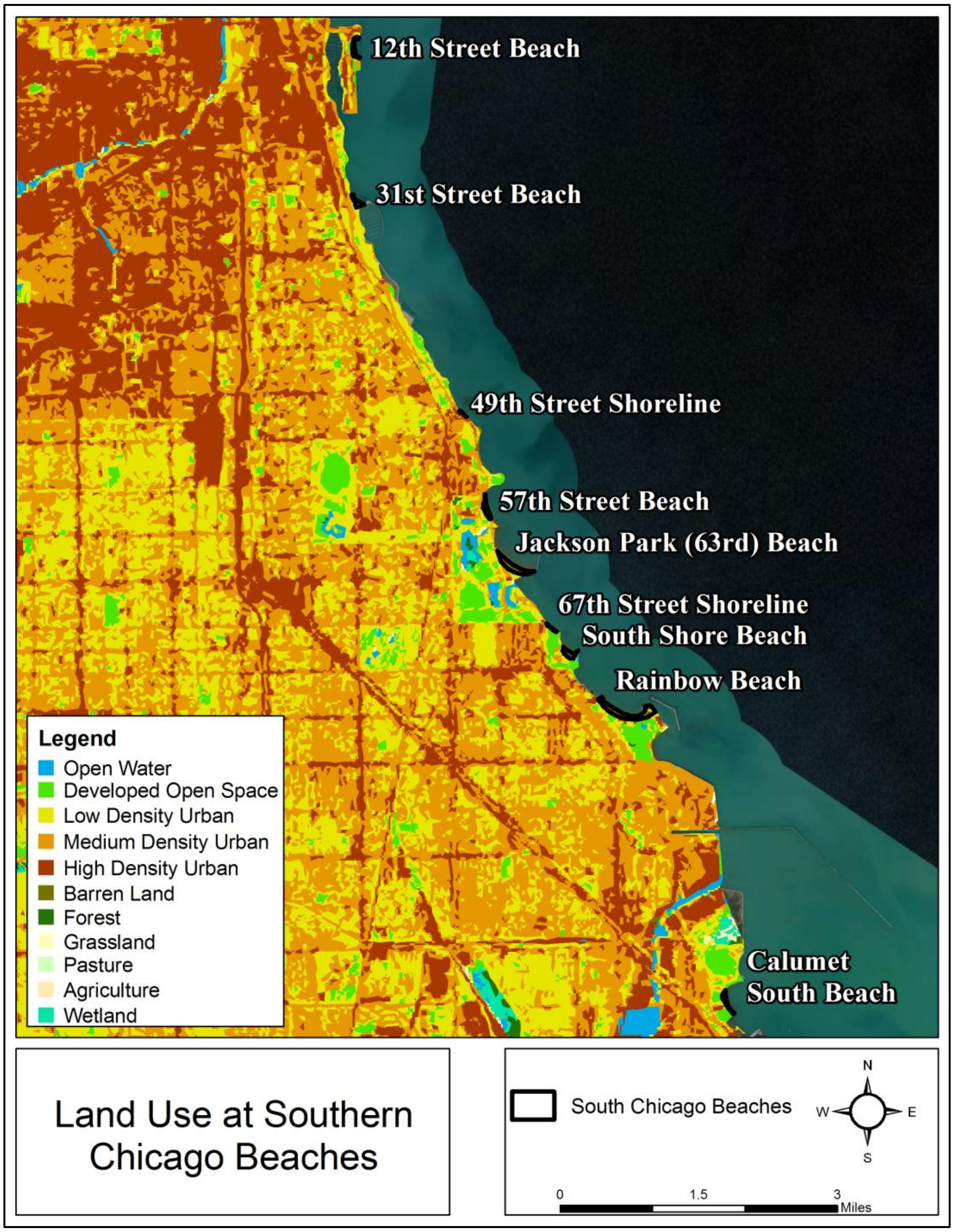

Figure 3-4. Land Use along the Southern Chicago Shoreline

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.

Figures 3-5 and 3-6 display 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 Chicago support findings in peer-reviewed research that finer substrates are more likely to harbor and allow build-up of bacteria than coarser, looser substrates.

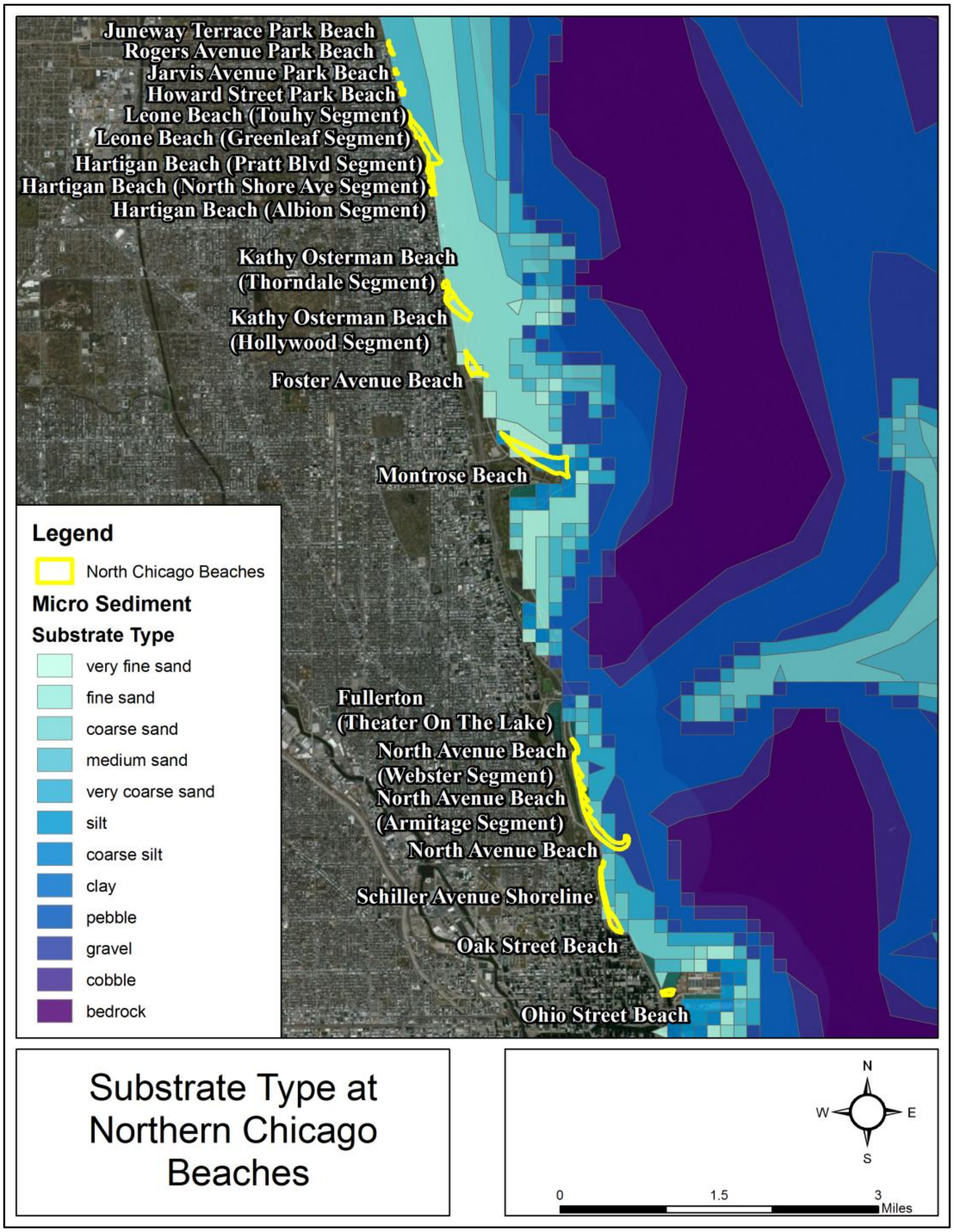

Figure 3-5. Substrate along the Northern Chicago Shoreline

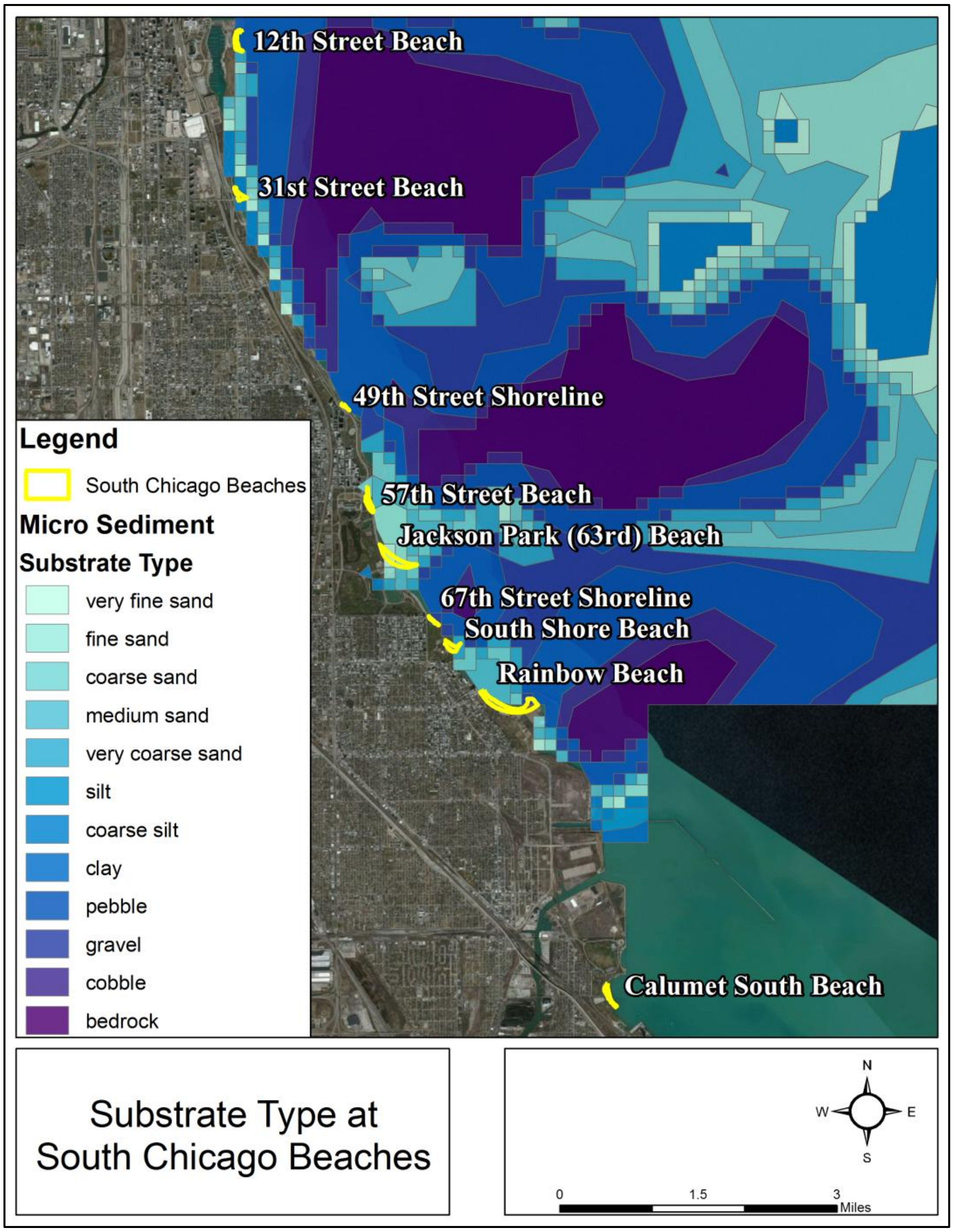

Figure 3-6. Substrate along the Southern Chicago Shoreline

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 3-7** 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 3-7. 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 Chicago Area Waterway System

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 stormwater, 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 3 lock structures through which reversals may occur include the Wilmette Pumping Station, the CRCW, and the O'Brien Lock and Dam. Authority to control the lock structures resides with the USACE. The CRCW lock is located about a third of a mile south of Ohio Street Beach (see Figure 2-7), whereas the Calumet River, through which the O'Brien Lock and Dam may reverse flows from the CAWS, empties into Lack Michigan approximately one mile north of Calumet South Beach (see Figure 2-11).

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-dimensional 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 water bodies 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 Chicago (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 resuspended 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 septic systems in the urban environments of Chicago 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 (STPs) expected to contribute *E. coli* directly to impaired segments under typical conditions. Because STPs are permitted to discharge to the CAWS and there are river reversals into the CAWS under high precipitation conditions, there is the potential for STP impact at some local impaired segments. River reversals are considered in the load allocation of this TMDL, but they are not given a specific WLA and therefore no STPs are given a WLA under this TMDL.

4.1.2 Stormwater

Stormwater may impact 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, relic 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.

Stormwater from the surrounding area is captured by three 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 Chicago impaired 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).

Various Lake Shore Drive (LSD) reconstruction projects have resulted in strategies to manage surface runoff. In general, reconstruction efforts focused on moving stormwater away from Lake Michigan (Breitenbach, 2012). However, some projects allow stormwater to be discharged into the lake during high precipitation events (ILDOT, 2007). Researchers have also observed stormwater flowing into nearshore waters at Chicago beaches (Whitman and Nevers, 2008). Thus, despite the LSD reconstruction efforts and the use of the Calumet and Chicago Rivers as discharge points for stormwater (both of which flow away from Lake Michigan), it is likely that the Chicago beaches and impaired shoreline segments are highly impacted by nonpoint source surface runoff (Whitman and Nevers, 2008).

Table 4-1. MS4 Permitted Discharges Surrounding Impaired Chicago Shoreline Segments

Facility Name	Permit Number	Receiving Water
Chicago, City of	ILR400173	Calumet River
Cook County Highway Department	ILR400485	Not listed
Union Drainage District No. 1 Middle Fork	ILR400518	Chicago River

In addition, the region contains three industrial facilities with NPDES permits as shown in **Table 4-2**. However, discharge from these facilities is not expected to contribute *E. coli* because of the origin of their discharge waters (i.e., cooling water or backflow), their permitted effluent characteristics, and the distance between the point discharge and the impaired segments.

Table 4-2. Permitted Industrial Stormwater Discharges to Lake Michigan

Facility Name	Outfall[1]	Description	Receiving Water	Type of Permit	Permit No.	Beachshed
Metro Pier and Expo Authority	0010	Non-contact cooling water	Lake Michigan	Individual	ILG250114	31st Street Beach
Chicago South WTP	0010	Backflow Waters/Zebra Mussel Control	Lake Michigan	Individual	IL0002429	Offshore
Chicago-Jardin Water Purification Plant	0010, 0020	Backflow Waters/Zebra Mussel Control	Lake Michigan	Individual	IL0001996	Offshore

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

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 4-3**). Observed *E. coli* concentrations in discharged water can be high (**Table 4-4**). For Chicago impaired segments, reversals from the CRCW and O'Brien Lock are expected to impact water quality at the surrounding beaches (i.e., Fullerton Shoreline to Oak Street Beach at the CRCW and Calumet South Beach below the Calumet River and O'Brien Lock). 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 example, on July 23 and 24, 2010, the Chicago-land area experienced one of the most severe storms in recent history. As a result of this heavy rainfall, there was a reversal from the Chicago River to Lake Michigan at the CRCW, which allowed the Chicago River to flow into the lake for a total of 16 hours and 45 minutes during which 5,784.6 million gallons (MG) of flow from the river passed into the lake. Following this reversal, MWRDGC sampled the surrounding beaches (Oak Street, North Avenue, 12th Street, and 31st Street) on the morning of July 26, 2010, and found no detectable *E. coli* concentrations (MWRDGC, 2011). However, sampling by CPD on the same day showed exceedances of the WQS at Oak Street Beach and elevated concentrations at 12th Street and 31st Street Beaches.

Table 4-3. 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 4-4. 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, both due to the intermittent nature of the event and the fact that 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.

In order to meet newly revised and approved recreation bacteria criteria for the CAWs disinfection is expected to occur at two of the four MWRDGC facilities in the CAWS. 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 reversals 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 resuspension of resident; *E. coli* populations (Alm et al., 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 municipal 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, resuspended sand in the swash zone, and *E. coli* transported from outside the beachshed by lake currents.

4.2.1 Wasteload Allocations

Municipal stormwater permittees with discharges to Lake Michigan were given a WLA of 126 *E. coli* cfu/100 mL as a geometric mean (**Table 4-5**).An exception to this allocation is for the MS4 permit for Cook County Highway Department, which received a WLA of 0 cfu/100 mL. This allocation is a result of the stormwater management from roadways, which was designed to be intercepted fully by the CAWS.

Table 4-5. WLAs for Chicago Impaired Segments

NPDES Permittee	Permit No.	WLA (cfu/100 mL)
Municipal Stormwater		
Chicago City	ILR400164	126
Union Drainage District No. 1 Middle Fork	ILR400518	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 non-point 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 geometric mean of 126 cfu/100 mL. This covers discharges from unregulated sources, including direct deposition from gulls, dogs, and wildlife; resuspended 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).

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 the resultant allocations in the TMDL will result in attaining WQSs. 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 to 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 to 2011. These timeframes help ensure that the TMDL incorporates variability due to seasonal and annual effects. For instance, average precipitation data from the Chicago 5.5 weather station, as reported by the National Climatic Data Center, indicate that both wetter years (2010) and drier years (2007) occurred during the assessment period (**Table 4-6**).

Table 4-6. May–September Weather Station "Chicago 5.5" Precipitation

Year	Precipitation (in)
2007	25.3
2008	32.5
2009	24.6
2010	35.2
2011	32.5

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 4-7**). Variables representing critical conditions include high gull counts (nonpoint source); wave intensity, height, and eastward direction (resuspension of resident *E. coli* populations in swash zone); and 48-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 4-7. Examples of Critical Conditions in 2011 CPD BSS Dataset

Beach	East Water Velocity (mph)	Precip-itation (in)	Previous 48-Hour Precipitation (in)	Turbidity	Wave Intensity	Wave Height (in)	Gull Count	*E. coli* (cfu/ 100 mL)
31st	-0.0227	0.3	0.48	turbid	rough	36	0	2,420
Montrose	-0.0099	0.38	0.38	clear	calm	4	67	2,420
63rd Street	-0.0094	0	0	opaque	normal	5	25	1,406
Calumet	0.0118	0.59	0.59	slightly turbid	normal	10	0	1,641
Kathy Osterman	-0.0129	1.03	1.03	clear	calm	2	30	1,641
South Shore	-0.0044	13	13	turbid	normal	4	15	1,091
Rainbow	0.0087	0	0	turbid	normal	6	60	2,420

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., new dischargers, 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 4-8** 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 4-8. 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 CPD jurisdiction, 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 in the different parameters used in the model that are needed to meet the WQS. 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 CPD 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.

In addition, BSS data were obtained for 2011 for a subset of CPD beaches.

Information that might predict *E. coli* concentrations at CPD 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 BSS dataset contained information not obtainable from other sources, such as animal counts, water clarity, etc. However, no *E. coli* data were included in the BSS dataset. The 2011 BSS data were therefore linked by date and beach location to the 2006–2011 *E. coli* data. Two distinct datasets were analyzed for CPD beaches: *E. coli* data from 2006–2011, along with predictor variables derived from public information; and the 2011 BSS dataset linked both to measured *E. coli* concentrations and to the additional derived predictor variables.

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 CPD 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. Three final models were chosen; one model for the 2011 BSS data; one model using the 2006–2011 data for beach sites located south of the Navy Pier area; and one model using the 2006–2011 data for beach sites located north of the Navy Pier area (**Table 4-9**). Splitting the 2006–2011 dataset beach sites into these groups greatly improved model fit, and most likely reflects changes in hydrologic response due to the impact of the Navy Pier complex on long shore currents and offshore wind and storm activity (Whitman and Nevers, 2008).

Table 4-9. Beaches with Similar Distributions of *E. coli*, by Model

Model	Beach Groups
2011 BSS Data	12th, 31st, Rainbow, Calumet South
	South Shore, Montrose, Kathy Osterman, Oak, Ohio, Leone, 63rd, 57th, Foster
2006–2011 CPD North Group	Montrose, Hartigan, Kathy Osterman, Loyola, Thorndale/George Lane, North Avenue
	Foster, Howard, Leone, Rogers, Jarvis, Juneway, Oak, Ohio
2006–2011 CPD South Group	12th, 31st
	57th, 63rd, South Shore, Rainbow, Calumet South

4.8.3 Step 3: Simulation

Both manageable and non-manageable variables were included in the final models (**Tables 4-10 through 4-12**). Manageable variables are those that can be influenced by beach managers (i.e., birds), 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 gulls 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**.

4.9 Final Reductions

The predictor variables in the final CPD models were chosen for explanatory value, physical interpretation, and management value (Tables 4-10 to 4-12). 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 local conditions—wave energy, near shore surface runoff, physical structures, and gull presence. Because surface runoff in the city of Chicago is generally directed to the CAWS, beach drainage areas, or "beachsheds," were based on fine scale topographic data (i.e., LIDAR); no information was available to confirm the existence of larger drainage units. With the exception of impervious surface area within the CPD South beach group (**Table 4-12**), beachshed characteristics such as land cover or area were not found to be significantly related to measured *E. coli* concentrations. Apparent correlations in *E. coli* concentrations across beach sites often co-occurred with precipitation events that were likely to affect multiple sites. The impact of precipitation-driven surface runoff is therefore dependent on the availability of *E. coli* in near shore environments. Precipitation may increase water column concentrations either by washing source loads (e.g., gull 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 within beach direct drainages 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).

The negative correlation between average beach area slope and *E. coli* concentration is likely due to reduced area exposed to wave energy, reductions in standing water, and reductions in surface runoff reaching the swash zone (Kinzelman et al., 2003; Pittner and Kleinheinz, 2009).

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

There was some modeling support for the idea that hardened structures and embayed morphologies can both increase and decrease *E. coli* concentrations depending on lake and weather conditions (Tables 4-10 through 4-12). Beaches sheltered by hardened structures or embayed conditions may prevent flushing, which may increase water column concentrations of *E. coli*. However, these same factors may protect the beach from wave and current energy, which lessens the risk of wave-generated resuspension of resident colonies in the swash zone.

Table 4-10. CPD BSS Predictor Variables

Variable	Statistically Significant	Correlation with *E. coli* Concentration	Physical Interpretation	Manageable Parameter
Turbidity	Depends on level	Positive	Proxy for storm and wave activity; may shade suspended colonies	No
Bird Count	Yes	Positive	Fecal source	Yes
Embayment	Yes	Positive	Prevents flushing of near-shore loading	No
Wave Height	Yes	Positive	Direct measure of wave energy	No
Water Level	No	Positive	Storm proxy	No
East Surface Water Velocity	Yes	Negative	Eastward currents assist with flushing near beach water column	No
Sample Month	Yes	Positive	Slight rise in concentrations as summer progresses. Increased temperatures may encourage bacterial growth	No
Precipitation	Yes	Positive	Near shore transport mechanism	Yes
Interaction: Embayment and Wave Height	Yes	Negative	Sheltered beaches protected from wave-induced resuspension	No

Table 4-11. CPD North Group Predictor Variables

Variable	Statistically Significant	Correlation with *E. coli* Concentration	Physical Interpretation	Manageable Parameter
Average Slope	Yes	Negative	Mitigates surface runoff; impact of wave energy in swash zone	Yes
Water Level	Yes	Positive	Storm proxy	No
48 Hour Precipitation Total	Yes	Positive	Transport mechanism via runoff and sand infiltration	Yes
East Surface Water Velocity	Yes	Negative	Eastward currents assist with flushing near beach water column	No
Sample Month	Yes	Positive	Increased temperatures may encourage bacterial growth	No
Wave Height	Yes	Positive	Direct measure of wave energy	No

Table 4-12. CPD South Group 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
24 Hour Precipitation	Yes	Positive	Transport mechanism via runoff and sand infiltration	Yes
Sample Month	Yes	Positive	Increased temperatures may encourage bacterial growth	No
Wave Period	Yes	Positive	Frequency of waves; proxy for wind and storm activity	No
Groyne Presence	Yes	Positive	Hardened structures may limit near shore flushing	No
Impervious Area	Yes	Positive	Increases near shore runoff; possible source	Yes

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 2006–2011 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 two broad distributional beach groups within each modeling framework (BSS, CPD North group, CPD South group) as shown in **Figures 4-1** through **4-3**. These groups share commonalities in the overall probabilities of observed *E. coli* concentrations. As such, for predictive purposes these groups were considered individually for the simulation process described in **Section 4.8.3**. The reason that distributional groups must be examined is that making predictions for beaches that have statistically different *E. coli* concentrations can lead to underestimation or overestimation for beaches that have higher or lower *E. coli* distributions, respectively.

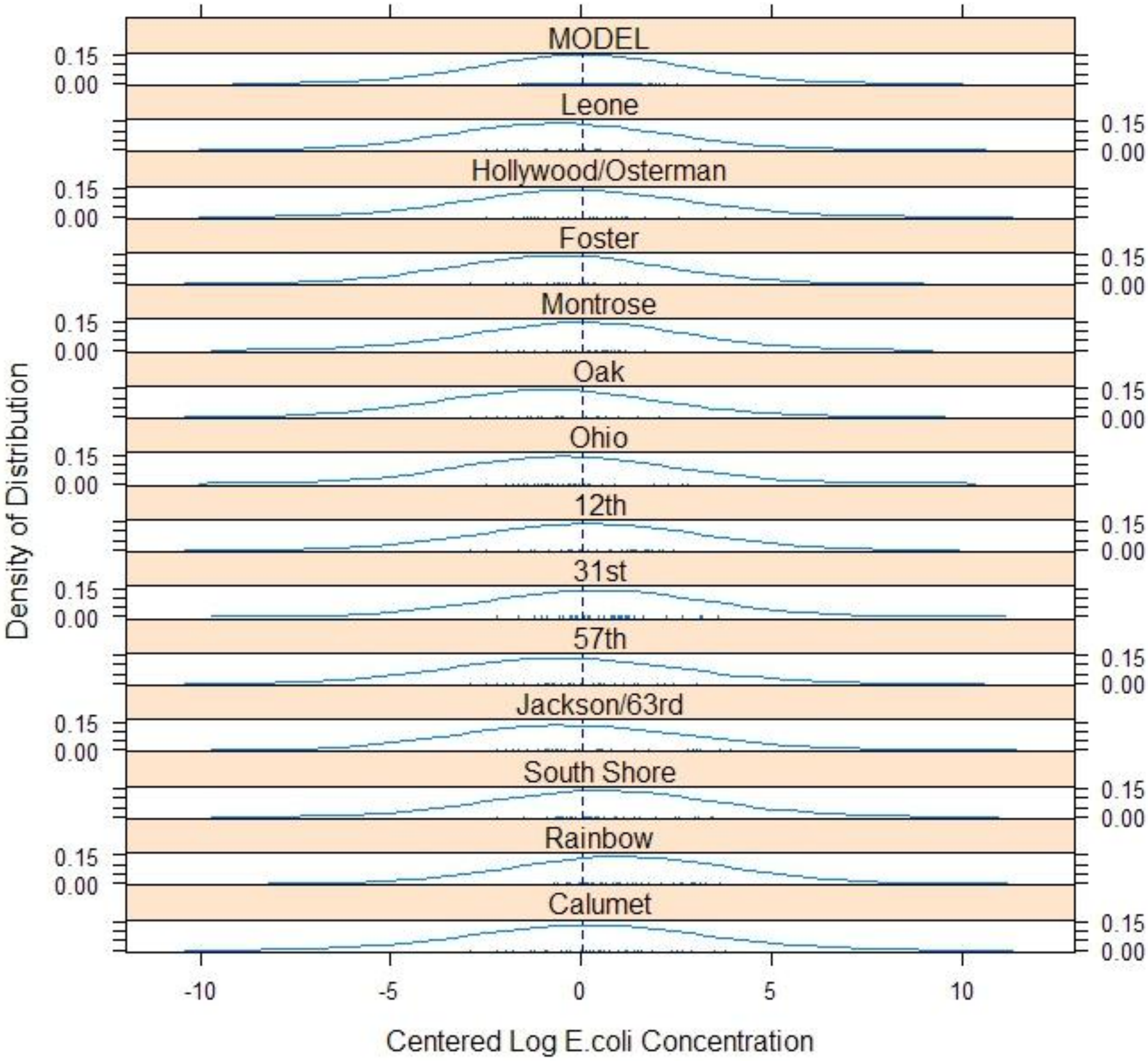

Figure 4-1. Predicted Distributions of *E. coli* at all BSS Beaches (top panel) versus Monitored Distributions at Individual Beaches for 2011

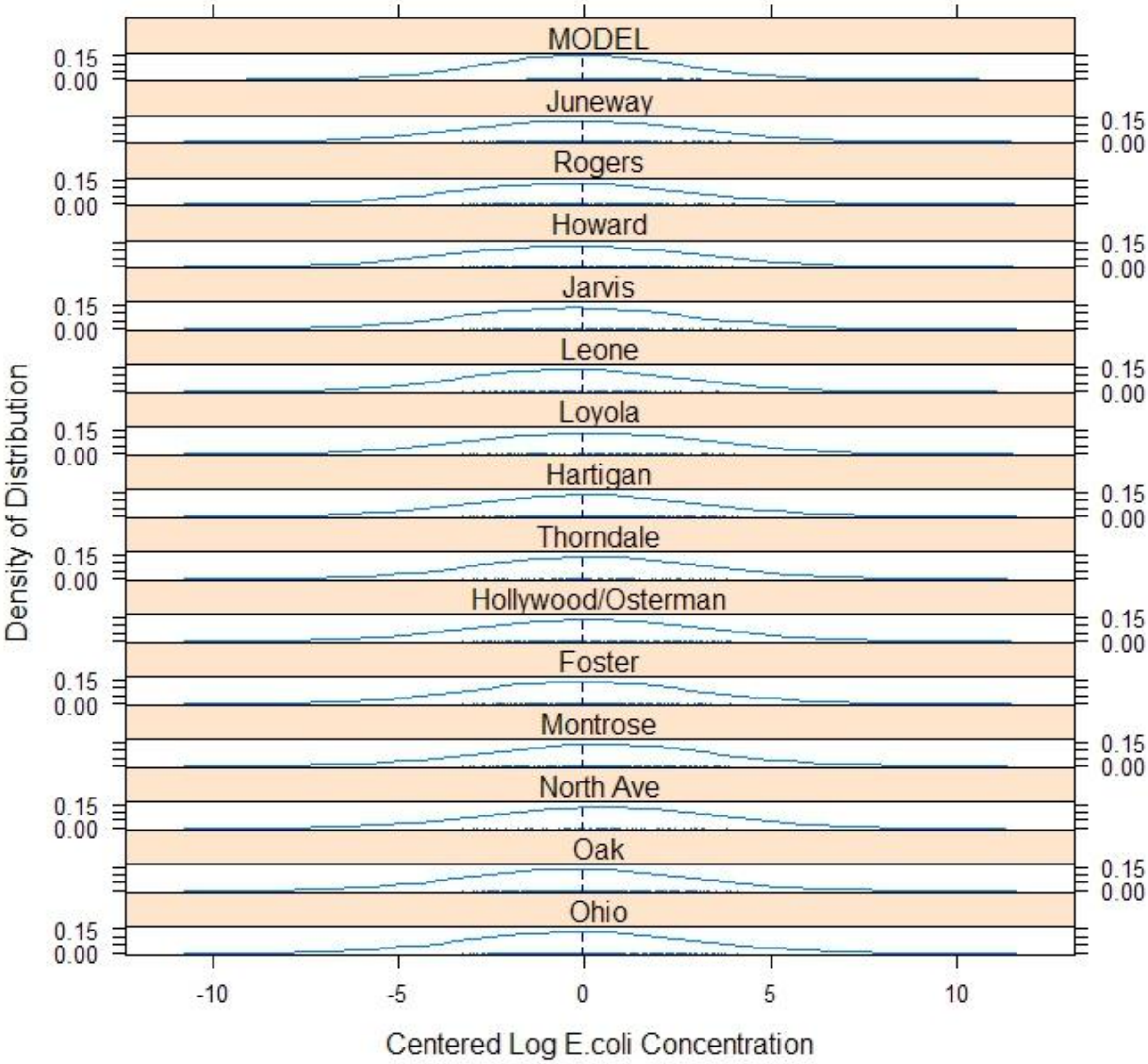

Figure 4-2. Predicted Distributions of *E. coli* at CPD North Beaches (top panel) versus Monitored Distributions at Individual Beaches for 2006–2011 Dataset

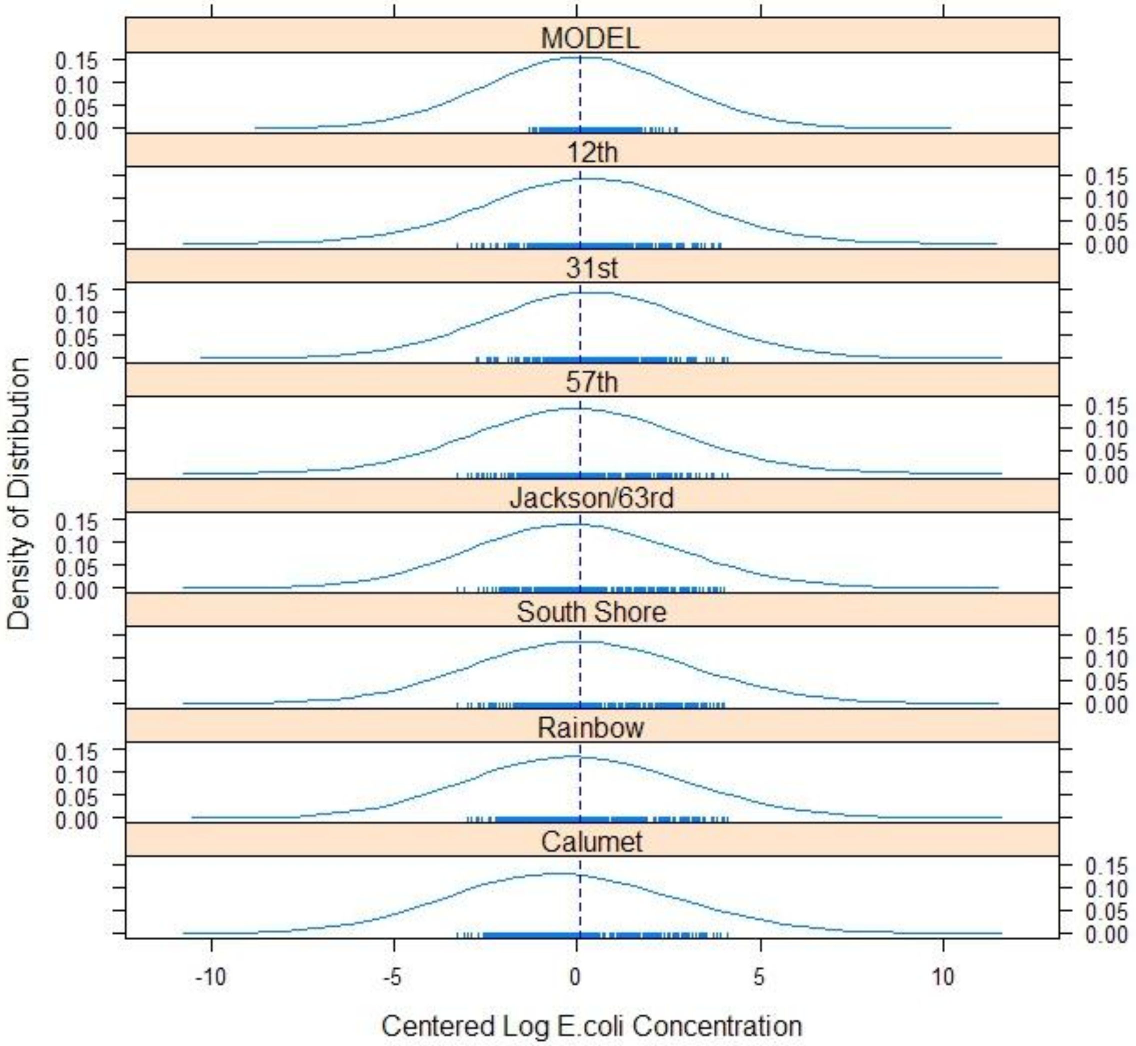

Figure 4-3. Predicted Distributions of *E. coli* at CPD South Beaches (top panel) versus Monitored Distributions at Individual Beaches for 2006–2011 Dataset

4.9.2 Analysis

Of the predictor variables included in the final models (Tables 4-10 through 4-12), 5 were considered to be readily manageable: bird count, 24-hour precipitation, 48-hour precipitation, average slope, and impervious surface area. As described in **Section 4.8.3**, these variables were subset in iterative statistical simulations to achieve 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 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 4-13 through 4-15** present the thresholds of the 5 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.

Table 4-13. Manageable Variable Thresholds Required to Meet the Load Allocation for the 2011 BSS Dataset Model

Beaches/Distributional Group	SSM Informational Target[1]		GM TMDL Target		
	Reduce Daily Bird Count Below	Reduce 24-hour Rainfall Below[2] (in)	Reduce Daily Bird Count Below	Reduce 24-hour Rainfall Below[2] (in)	Predicted Percent of SSM Exceedances when GM Is Attained
Group 1: 12th, 31st, Rainbow, Calumet South	10	0.3	40	0.75	9%
Group 2: South Shore, Montrose, Kathy Osterman, Oak, Ohio, Leone, 63rd, 57th, Foster	40	0.5	60	0.85	8%

[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 4-14. Manageable Variable Thresholds Required to Meet the Load Allocation for the 2006–2011 CPD North Group Model

Beach/Distributional Group	SSM Informational Target		GM TMDL Target		
	Reduce 48-hour Rainfall Below (in)	Increase in Slope Required (%)	Reduce 48-hour Rainfall Below (in)	Increase in Slope Required (%)	Predicted Percent of SSM Exceedances when GM Is Attained
Group 1: Montrose, Hartigan, Kathy Osterman, Loyola, Thorndale, North Avenue	0.7	3	0.9	3	7%
Group 2: Foster, Howard, Leone, Rogers, Jarvis, Juneway, Oak, Ohio	0.5	2	0.7	2	9%

Table 4-15. Manageable Variable Thresholds Required to Meet the Load Allocation for the 2006–2011 CPD South Group Model

Beach/Distributional Group	SSM Informational Target		GM TMDL Target		
	Reduce 24-hour Rainfall Below (in)	Reduce Impervious Area (%)	Reduce 24-hour Rainfall Below (in)	Reduce Impervious Area (%)	Predicted Percent of SSM Exceedances when GM Is Attained
Group 1: 12th, 31st	0.4	30	0.6	30	7%
Group 2: 57th, 63rd, South Shore, Rainbow, Calumet South	0.6	30	0.7	30	8%

Within CPD's jurisdiction, there are several impaired shoreline segments listed on the 303(d) list that have no current *E. coli* data, monitoring programs, or swimming access (**Table 4-16**). Due the lack of current assessment data, these segments were not available to be included in modeling efforts. However, since the primary drivers of *E. coli* concentrations at CPD beaches are precipitation and lake condition, and since these drivers are likely to be locally consistent along the shoreline, each of the shoreline segments in Table 4-16 was paired with a modeled beach based on geographic location and orientation. The assigned management targets at the respective paired beaches that apply to the impaired shoreline segments in Table 4-16 can therefore be adopted as the management targets for these sites. Note that since there are no beaches at these shoreline segments, the management variable for average beach slope will not apply, but parties responsible for the management of these segments of shoreline may work to reduce stormwater runoff, increase pervious areas, and reduce the number of birds frequenting the segment.

Table 4-16. Listed Impaired Segments with No Swimming Access or Current Data

Shoreline Segment	ID 305B	Jurisdiction	Paired Beach
49th St.	IL_QR-01	CPD (no access)	31st Street
67th St.	IL_QS-05	CPD (no access)	South Shore
Fullerton Avenue	IL_QO-02	CPD (no access)	Webster (North Avenue)
Schiller Avenue	IL_QO-05	CPD (no access)	Oak Street

A second issue with the assignment of management targets is the limited coverage of bird data. Although birds are known to be a source of *E. coli* (**Section 4.1.4**), the only bird data for CPD beaches is for 2011 at a subset of impaired beaches. Without a longer period of record, it is not possible to determine whether the numbers of birds observed in 2011 represent average conditions. However, since birds are a recognized nonpoint source for the TMDL, a determination was made to assign bird management targets at all beaches. 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, groups labeled "Group 1" in the CPD North Group and CPD South Group models will be assigned the bird management targets assigned to "Group 1" in the BSS dataset model (Table 4-13); in general, the "Group 1" designation refers to sites with *E. coli* concentrations above the average concentration observed in all beaches over the relevant timeframe. Groups labeled as "Group 2" in the CPD North Group and CPD South Group models will be assigned the bird management targets assigned to "Group 2" in the BSS dataset model (Table 4-13); in general, the "Group 2" designation refers to sites with *E. coli* concentrations at or slightly below the average concentration observed in all beaches over the relevant timeframe.

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 CPD South Group 1 beaches, the SSM requires managers to arrange for stormwater management when the 24-hour precipitation total is at 0.4 of one inch. If they manage precipitation at these sites to achieve the GM, they will experience approximately 8% SSM exceedances; however, they need to manage stormwater only when 24-hour precipitation is above 0.7 inches. An 8% chance of exceeding the SSM equals approximately 8 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 4-17 through 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 4-17. Observed Bird Count and 24-hour Rainfall by Predictive Group, BSS Dataset

Beach/Distributional Group	Birds			Previous 24-hour Rainfall (in)		
	Median	Mean	Max	Median	Mean	Max
Group 1: 12th, 31st, Rainbow, Calumet South	18	28	140	0	0.2	3.2
Group 2: South Shore, Montrose, Kathy Osterman, Oak, Ohio, Leone, 63rd, 57th, Foster	7	19	160	0	0.17	3.2

Table 4-18. Observed 24-hour Rainfall and Average Slope by Predictive Group, 2006–2011 Dataset, CPD North Beaches

Beach/Distributional Group	Previous 24-hour Rainfall (in)			Average Slope (%)
	Median	Mean	Max	
Group 1: Montrose, Hartigan, Kathy Osterman, Loyola, Thorndale/ George Lane, North Avenue	0	0.17	5.9	1.9–3.3
Group 2: Foster, Howard, Leone, Rogers, Jarvis, Juneway, Oak, Ohio	0	0.18	5.9	2–10

Table 4-19. Observed 24-hour Rainfall and Percent Impervious Area by Predictive Group, 2006–2011 dataset, CPD South Beaches

Beach/Distributional Group	Previous 24-hour Rainfall (in)			Impervious Area (%)
	Median	Mean	Max	
Group 1: 12th, 31st	0	0.2	4.18	5.2–5.5
Group 2: 57th, 63rd, South Shore, Rainbow, Calumet South	0	0.19	4.05	3.2–13.7

In order to provide a point of reference for the 24- and 48-hour rainfall thresholds presented as load reduction scenarios, recreation season rainfall events of varying depths from 2007–2011 were examined from the four rainfall monitoring stations used in the analysis: CHICAGO 4.7, CHICAGO 5.5, CHICAGO 6.8, and EVANSTON 1.2. As indicated in Table 4-6, this timeframe includes both relatively dry years (2007) and wet years (2010). **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 24-hour Rainfall (in)	Percent of Rainfall Events	Percent of All Recreation Season Days
0.3	41	15
0.5	27	10
0.7	23	8.5
0.8	19	7.5
0.9	19	7

[1] Percentages based on recreation season rainfall averages (May-September) 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 the 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 (bird count, rainfall, and beach slope) and (2) those variables that could not be modeled due to lack of information. These unmodeled variables include potential impacts from opening the Chicago River locks, public education efforts, and ordinances aimed at personal habitats. Although these variables were not modeled, they may be influencing Chicago beach water quality and therefore are included in this discussion.

There is a lock located at the mouth of the Chicago River that separates the river from Lake Michigan. Although the lock is opened very infrequently during large rain events to prevent flooding in Chicago, it does cycle 12,000 times a year to accommodate boat traffic. This allows approximately 40,000 government, passenger, and recreational vessels to transit each year (GLMRIS, 2011). There have been no formal studies to determine if and how these frequent openings impact the water quality along the Lake Michigan shoreline.

Several beach managers have implemented 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 showing 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 BSSs 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	Birds
Create natural areas to discourage gulls	Birds
Conduct egg oiling to reduce hatchlings	Gulls
Conduct goose nest destruction	Geese
Apply goose repellent	Geese
Beach Management	
Employ deep beach grooming measures	Birds, 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	Birds

(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	Birds
Support/prepare print ads, handouts, websites, signage regarding littering	Birds
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	Birds
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 includes 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 stormwater 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–$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 five-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–$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 to 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–$5/square foot or 15%–25% higher than standard asphalt (SEMCOG, 2008).
Pervious Concrete without infiltration bed: $4–$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, 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 being purchased.

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

5.1.1.3 Bird Management

Bird Harassment. Multiple techniques are available to reduce beach water quality impacts caused by excessive gull or geese 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 birds 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, R., 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 bird exclusion measure. Gulls and geese 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.

Goose Repellents. There are several commercially available non-toxic spray repellents that can be used to deter Canada geese. Each use methyl anthranilate, which is a substance found in concord grapes and used as flavoring in grape bubblegum. Birds, including Canada geese, dislike the taste and will avoid eating material that has been treated with it. The product is used to spray turf grass that serves as a food source to the geese. A study was conducted in Rockland County, New York determined that methyl anthranilate was effective in repelling Canada geese when applied at the proper time of year and with the appropriate application rate and technique (Curtis and Jirka, 1994).

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 in viable 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 (GLRI) grant

Goose Nest Destruction. Canada goose populations can be controlled by destroying nests and eggs. Eggs are made non-productive by shaking them vigorously as soon as possible after a full clutch is laid and incubation begins. After the eggs are shaken, they are returned to the nest and the geese are allowed to unsuccessfully incubate them. Because the eggs are returned to the nest seemingly unharmed, the geese are tricked into thinking nothing is different (if the eggs were removed entirely, the female would promptly lay more eggs). After 3 weeks of incubating their eggs, geese will usually not try to renest. Removal and disposal of the nest and eggs can then be done. This discourages continuation of nesting effort and defense of the nest territory.

Egg shaking and nest destruction requires a permit from the IDNR. It is important to note that if the eggs have begun to hatch they may not be disturbed, even if you have a permit for egg shaking. Detailed guidelines are available from the U.S. Department of Agricultural (USDA) and the U.S. Fish and Wildlife Service (IEPA, 1996).

Each year the Wheaton Park District receives a permit from IDNR to render Canada goose eggs non-productive, which prevents renesting. Each potentially nesting site within the park district is monitored, and when nests are found they are taken care of properly. Rendering the eggs non-productive was their most effective goose management effort. In the spring of 2007, they prevented the hatching of 202 eggs (Wheaton Park District, 2012).

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 near shore 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, Wisconsin" (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.

5.1.1.1 Public Education

Source: The Watershed Center of Grand Traverse Bay

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.

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 (e.g., public works, maintenance staff) at least on an annual basis so they can understand their role in keeping the beaches open.

The CPD conducted a detailed survey in 2000, in coordination with other city departments, to identify any illicit discharges that could potentially be tributary to the beach areas. All potential illicit discharge sources were taken care of at that time. It is recommended that a map of storm sewers draining to Lake Michigan be developed, field verified by MWRDGC, and shared to verify CPD's findings. Storm sewer discharges should be reexamined if there are unexplained increases in *E. coli* counts at the beaches.

Gull management efforts should be conducted (or continued when currently implemented) at most of the City of Chicago beaches. The walls at the Ohio Street Beach are one known nesting site, but locating other nesting areas has been a challenge. The CPD should continue their coordination with the USDA and/or the IDNR to conduct population control measures, such as locating additional nesting sites and oiling eggs to reduce the number of gull hatchlings. CPD has been conducting harassment measures based upon need and budget at different beaches to determine which locations benefit the most from gull harassment measures. Harassment measures should continue as much as possible to reduce the number of gulls loafing on the beaches.

Goose management efforts are important in the open space areas tributary to the beach. CPD has been applying goose repellent to their golf courses and turf grass sections within the beachshed areas. These measures, as well as nest destruction, harassment, and the conversion of turf to naturalized areas should continue in order to reduce the population and the number of geese loafing in these tributary areas.

The CPD has had highly publicized public education efforts to promote beach health and safety, but the funding for their additional efforts over the past few years expires in December 2012. The efforts included the painting of a large scale mural on Oak Street Beach that discourages feeding wildlife and provides education about beach health. This campaign should be continued and improved to limit littering, promote the use of swim diapers on infants in the water, keep dogs in designated areas, clean up pet waste and dispose of it properly, and limit the feeding of gulls, geese and other wildlife at all of the City of Chicago beaches. This could include 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. The CPD has also made great strides to implement an *E. coli* predictive model for the beaches and informs the public of beach status through social media and e-mail blasts. This line of communication could be utilized to help promote education about beach health.

In addition, a study should be performed to determine if the frequent opening of the Chicago Locks for boat passage is a potential source of bacteria to the Chicago area beaches. This could help to provide answers for CPD as to why the beaches located south of the Chicago River have more water quality issues than those beaches north of the Chicago River.

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.

Rogers Park Beaches (Juneway, Rogers, Jarvis, Fargo, and Howard)

Known (k) or suspected (s) issues:

- Remote location and limited accessibility results in less frequent grooming. (k)

Suggested solutions:

- Implement more frequent grooming.

Leone and Loyola Beaches

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater runoff from turf areas adjacent to the beach. (s)
- Excessive gull populations. (k)

Suggested solutions:

- Mitigate stormwater flow from turf areas adjacent to the beach by using GI measures.
- Research the use of stormwater filtration devices.
- Conduct gull harassment or population reduction measures.
- Improve “Don’t Feed the Birds” signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, and pet waste clean-up.

Hartigan Beach

Known (k) or suspected (s) issues:

- None known at this time.

Lane and Osterman Beaches

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater runoff from turf areas adjacent to the beach. (s)
- Excessive gull populations. (k)

Suggested solutions:

- Mitigate stormwater flow from turf areas adjacent to the beach (by the bike path) by using GI measures.
- Conduct gull harassment or population reduction measures.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, and pet waste clean-up.

Foster Avenue Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater runoff from impervious parking area adjacent to the beach. (s)
- Excessive gull populations. (k)
- Drainage from neighboring dog beach. (s)

Suggested solutions:

- Consider the use of pervious pavement for the parking area.
- Mitigate stormwater flow from adjacent impervious parking area by using GI measures.
- Research the use of stormwater filtration devices.
- Conduct gull harassment while investigating population control measures.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at littering, pet waste clean-up, and illicit discharge elimination.
- Supply and maintain pet waste stations.
- Enforce pet waste clean-up and access rules at the beach.

Montrose Beach

Known (k) or suspected (s) issues:

- Excessive gull populations. (k)
- Drainage from neighboring dog beach. (s)
- *E. coli* impacted stormwater runoff from urbanized areas adjacent to the beach. (s)

Suggested solutions:

- Conduct full-time gull harassment while investigating population control measures.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.

- Improve local ordinances aimed at littering, pet waste clean-up, and illicit discharge elimination.
- Supply and maintain pet waste stations.
- Enforce pet waste clean-up and access rules at the beach.
- Conduct source tracking investigations to determine if the dog beach is impacting the water quality at this beach.
- Mitigate stormwater flow from adjacent urbanized areas adjacent to the beach by using GI measures.
- Research the use of stormwater filtration devices.

Fullerton

Fullerton is a rocky rubble shoreline area that is not considered swimmable per the CPD and therefore is not maintained by the city as a beach.

North Avenue Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from pervious and impervious surface areas to lagoon that outlets to the lake adjacent to the beach area. (s)
- Excessive goose populations. (k)

Suggested solutions:

- Mitigate stormwater flow to nearby tributary lagoon by using GI measures.
- Research the use of stormwater filtration devices.
- Conduct goose management while investigating population control measures.
- Improve “Don’t Feed the Birds” signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at littering, pet waste clean-up, and illicit discharge elimination.

Schiller Avenue Shoreline

Schiller Avenue Shoreline is a solid concrete shoreline area that is not considered swimmable per the CPD and therefore is not maintained by the city as a beach.

Oak Street Beach

Known (k) or suspected (s) issues:

- None known at this time.

Ohio Street Beach

Known (k) or suspected (s) issues:

- Improper disposal of septic waste from boats. (s)

Suggested solutions:

- Continue to enforce ordinance regulating proper disposal of boater septic waste and ensure ease of access to and proper use of pump-out stations.

12th Street Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater runoff from turf areas northwest of the beach. (s)
- Excessive gull populations. (k)
- Excessive geese populations. (k)

Suggested solutions:

- Mitigate stormwater flow from adjacent turf areas adjacent to the beach (northwest side) by using GI measures.
- Consider the use of pervious pavement for the parking area.
- Research the use of stormwater filtration devices.
- Continue to conduct gull harassment or population reduction measures.
- Conduct goose management while investigating population control measures.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, and pet waste clean-up

31st Street Beach

The CPD and IDNR are working in cooperation to promote a "Green Harbor" for the recently constructed harbor adjacent to the beach.

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater runoff from turf areas adjacent to the beach. (s)
- Excessive gull populations. (k)

Suggested solutions:

- Mitigate stormwater flow from adjacent turf areas adjacent to the beach (along Lake Shore Drive) by using GI measures.
- Research the use of stormwater filtration devices.
- Continue to conduct gull harassment or population reduction measures.
- Improve "Don't Feed the Birds" signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, and pet waste clean-up.

49th Street Shoreline

49th Street Shoreline is a rocky rubble shoreline area that is not considered swimmable per the CPD and therefore is not maintained by the city as a beach.

57th Street (Jackson Park)

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from stormwater outfall located north of the beach. (s)
- *E. coli* impacted stormwater runoff from turf areas adjacent to the beach. (s)
- Excessive gull populations. (k)
- Excessive geese populations. (k)
- *E. coli* impacted stormwater flow from pervious and impervious surface areas to lagoon that outlets to the lake adjacent to the beach area. (s)

Suggested solutions:

- Continue to conduct illicit discharge investigations for the stormwater outfall located near the beach.
- Mitigate stormwater flow in area tributary to the stormwater outfall north of the beach by using GI measures.
- Mitigate stormwater flow from adjacent turf areas adjacent to the beach (along Lake Shore Drive) by using GI measures.
- Research the use of stormwater filtration devices.
- Continue to conduct gull harassment or population reduction measures.
- Conduct goose management while investigating population control measures.
- Improve “Don’t Feed the Birds” signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, and pet waste clean-up.
- Mitigate stormwater flow to nearby tributary lagoon by using GI measures.

63rd Street

The beach area is embayed and very shallow, so the CPD is punching a hole in the eastern breaker wall to help promote circulation in the winter of 2012/2013.

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater runoff from turf areas adjacent to the beach. (s)
- Excessive gull populations. (k)

Suggested solutions:

- Mitigate stormwater flow from adjacent turf areas adjacent to the beach (along Lake Shore Drive) by using GI measures.
- Research the use of stormwater filtration devices.
- Continue to conduct gull harassment or population reduction measures.
- Improve “Don’t Feed the Birds” signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at wildlife feeding, littering, and pet waste clean-up.

67th Street Shoreline

67th Street Shoreline is a rocky rubble shoreline area that is not considered swimmable per the CPD and therefore is not maintained by the city as a beach.

South Shore

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from the golf course turf areas and parking area adjacent to the beach area. (s)
- Excessive goose populations. (k)

Suggested solutions:

- Consider the use of pervious pavement for the parking area.
- Mitigate stormwater flow from adjacent golf course turf areas and parking area by using GI measures.

- Research the use of stormwater filtration devices.
- Conduct goose management while investigating population control measures.
- Improve “Don’t Feed the Birds” signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at littering, pet waste clean-up, and illicit discharge elimination.

Rainbow Beach

The CPD has obtained a GLRI grant to install an underground filtration system for stormwater runoff drains from the parking lot towards the beach area.

Known (k) or suspected (s) issues:

- Excessive goose populations. (k)

Suggested solutions:

- Conduct goose management while investigating population control measures.
- Improve “Don’t Feed the Birds” signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at littering, pet waste clean-up, and illicit discharge elimination.

Calumet South Beach

Known (k) or suspected (s) issues:

- *E. coli* impacted stormwater flow from Calumet River and stormwater outfalls located near the beach. (s)
- *E. coli* impacted stormwater flow from a parking lot north of the beach area. (s)
- Excessive goose populations. (k)

Suggested solutions:

- Continue to work with the U.S. Geological Survey (USGS) to determine if the discharge from the Calumet River is contributing to water quality issues at the beach.
- Conduct illicit discharge investigations for sewage sources in the Calumet River.
- Continue to conduct illicit discharge investigations for the stormwater outfalls located near the beach.
- Mitigate stormwater flow to the Calumet River and stormwater outfalls by using GI measures.
- Consider the use of pervious pavement for the parking area.
- Mitigate stormwater flow from adjacent impervious parking area by using GI measures.
- Research the use of stormwater filtration devices.
- Conduct goose management while investigating population control measures.
- Improve “Don’t Feed the Birds” signage.
- Improve public education campaign aimed at wildlife feeding and littering.
- Improve local ordinances aimed at littering, pet waste clean-up, and illicit discharge elimination.

5.1.3 Implementation

A schedule for implementation of the suggested measures is not appropriate in this document. There are practical, political, and financial limitations that potential need to be considered and overcome before some of the BMPs are undertaken. Nonetheless, it is recommended that the city prioritize their beaches and the recommended strategies to determine the most feasible options at the most impacted beaches.

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 stormwater 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 were favorable, able, or planning to be 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 datasets 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 will 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/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, Metropolitan Water Reclamation District of Greater Chicago [MWRDGC], local municipalities, and nonprofit groups). Regular participating members of 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 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, PhD, NRCM	Metropolitan Water Reclamation District of Greater Chicago
Justin Dewitt, PE, 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, Illinois. 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 e-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

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. 2012. 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).

Breitenbach, C. 2011. *Implementing the Great Lakes Restoration Initiative: A Beach Manager's View*. Presentation. Presented at the 2011 National Beach Conference, Miami, FL, March 15-17, 2011.

Breitenbach, C. 2012. "Predictive modeling for Chicago beaches." Personal communication: C. Breitenbach (Chicago Park District) with M. Cutrofello (RTI) and M. Kamerath (U.S. EPA). March 15.

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 & Technology 46*(18):10206–13.

CPD (Chicago Park District). 2012a. *Beach Report*. Online information. Chicago Park District, Chicago, IL. Available at: http://www.cfmstage.com/beach-report/beach-report-list.cfm (Accessed May 2012).

CPD (Chicago Park District). 2012b. *Chicago Park District Improves Beach Monitoring for 2012 Season*. Press Release. Chicago Park District, Chicago, IL. May 22.

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.

Curtis, P.D., and A.S. Jirka. 1994. *Assessment of Methyl Anthranilate (ReJeX-IT AG-36™) for Reducing Canada Goose Use of Turf Grass Areas*. Department of Natural Resources, Cornell University, Ithaca, NY.

Dorfman, M., and K.S. Rosselot. 2011. *Testing the Waters: A Guide to Water Quality at Vacation Beaches. Twenty-First Annual Report.* Natural Resources Defense Council, New York, NY.

ECT (Environmental Consulting & Technology, Inc.). 2008. *Delisting Targets for the Waukegan Harbor Area of Concern: Final Report.* Prepared by Environmental Consulting & Technology, Ann Arbor, MI, for the Illinois Environmental Protection Agency, Springfield, IL.

Elmir, S.M., M.E. Wright, A. Abdelzaher, H.M. Solo-Gabriele, L.E. Fleming, G. Miller, M. Rybolowik, M.T. Peter Shih, S.P. Pillai, J.A. Cooper, and E.A. Quaye. 2007. Quantitative evaluation of bacteria released by bathers in a marine water. *Water Res 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.

Fawcett, A. 2009. When one beach closes, why do others stay open? *GazeboNews.com.* August 18.

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.

GLMRIS (Great Lakes Mississippi River Interbasin Study). 2011. *Baseline Assessment of Non-Cargo CAWS Traffic*. GLMRIS, Chicago District, U.S. Army Corps of Engineer, Chicago, IL. November.

GLRI (Great Lakes Restoration Initiative). 2011. *EPA 2011 Grants.* Online information. Great Lakes Restoration Initiative, Chicago, IL. Available at: http://www.glri.us/2011epagrants.html (Accessed June 2012).

Hartmann, J.W., S.F. Beckerman, T.W. Seamans, R.M. Engeman, and S. Abu-Absi. 2010. *Report to the City of Chicago on Conflicts with Ring-Billed Gulls and the 2009 Integrated Ring-Billed Gull Damage Management Project.* Prepared for Chicago Department of Environment, Chicago, IL.

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.

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.

IDOT (Illinois Department of Transportation). 2007. *South Lake Shore Drive Reconstruction.* Illinois Department of Transportation, Springfield, IL. Available at: http://www.itre.ncsu.edu/ADC10/PDFs/2007_Summer_Conference/EnvAnalysisTour/South_Lake_Shore_Drive_Reconstruction.pdf (accessed July 2012)

IEPA (Illinois Environmental Protection Agency). 1996. *Lake Notes: Canada Geese and Your Lake*. Available at: http://www.epa.state.il.us/water/conservation/lake-notes/canada-geese.pdf (accessed November 20, 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 State Geological Survey. 2012. *A Walking Guide to the History & features of Burnham Park, Chicago, Illinois.* Illinois State Geological Survey, Champaign, IL.

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., M. Colleen, S.H. McDermott, and A. Brown. 2009. Effects of rainfall on *E. coli* concentrations at Door County, Wisconsin Beaches. *International Journal of Microbiology 2009*:1.

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.

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*(4):1089–1096.

Lydersen, K. 2011. Humans not to blame for beach bacteria. Online information. *Chicago.org June 29, 2011*.

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*(11):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.

MWRDGC (Metropolitan Water Reclamation District of Greater Chicago). 2011. *Microbiological Report of Backflow Samples in 2010*. Report No. 11-19. Monitoring and Research Department. Chicago, IL.

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.

Scopel, O., Harris, J., McLellan, S. 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.

Soucie, W.J., and M.A. Pfister. 2003. E. coli *Source Identification on Lake Michigan Beaches in Lake County, Illinois*. Presented at: 2003 Great Lakes Beach Association Annual Meeting, Muskegon, MI.

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.

Westrec Marinas. 2012. *The Chicago Harbors*. Online information. Westrec Marinas, Encino, CA. Available at: http://www.chicagoharbors.info/ (Accessed May 2012).

Wheaton Park District. Canada Geese Management Practices. Downloaded on November 20, 2012: http://www.wheatonparkdistrict.com/pgs/parks/geese_management.html

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

Whitman, R.L., and M.B. Nevers. 2004. *Escherichia coli* sampling reliability at a frequently closed Chicago Beach: Monitoring and management implications. *Environmental Science & Technology 38*(16): 4241-4246.

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.

Whitman, R.L., T.G. Horvath, M.L. Goodrich, M.B Nevers, M.J. Wolcott, and S.K. Haack. 2001. *Characterization of E. coli Levels at 63rd Street Beach.* Prepared for the City of Chicago, Chicago, IL.

Whitman, R.L., D.A. Shively, H. Pawlik, M.B. Nevers, and M.N. Byappanahalli. 2003. Occurrence of *Escherichia coli* and enterococci in *Cladophora* (Chlorophyta) in nearshore water and beach sand of Lake Michigan. *Applied and Environmental Microbiology 69*(8): 4714-4719.

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):1649–1656.

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 CPD within 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 CPD beaches. *E. coli* data, including sample location, date and time, were obtained for all available impaired segments for the years 2006–2011. BSS data for select CPD beaches were obtained for the year 2011; this dataset contains information on animal and human usage, beach and water conditions, and additional meteorological data. However, the BSS data does not contain *E. coli* data.

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

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

Measured *E. coli* concentrations for CPD 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. CPD 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 2% 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. 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 CPD 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 and stakeholder input. 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 2011 BSS data were then linked to the *E. coli* dataset by survey location, date, and time. Once assembled, the BSS dataset underwent the same battery of exploratory analyses described in this section to identify trends and likely predictor variables for *E. coli* concentrations in the year 2011.

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 are 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; Qian, 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 variables 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 2011 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 2011 BSS to be incorporated into the TMDL process.

In multilevel modeling, variable selection is largely based on physical interpretation (i.e., 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 CPD 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 the model fitting process, it was discovered that dividing beach sites into two groups based on geographic position north or south of the Chicago River intake produced models with higher explanatory power. Similar geographic groupings have been documented in the literature (Whitman and Nevers, 2008). Thus, two models—one composed of beaches north of the Chicago River, and the other composed of beaches south of the Chicago River—were fit for the 2007–2011 *E. coli* concentration data. A similar split for the 2011 BSS data did not produce large improvements in explanatory power, so a single model was fit to this dataset.

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 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 five 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 five 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 WQS exceedances will differ from the distribution of observed concentrations at a beach with no WQS 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 2011 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 bird count is less than 60. Refitting the model and recreating 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. 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.

Helsel, D.R., and T.A. Cohn. 1988. Estimation of descriptive statistics for multiply censored water-quality data. *Water Resources Research* 24(12): 1997-2004.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 and A.II-2 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 CPD north group multilevel-model, while Table A.II-2 contains the parameters estimates for the CPD south group 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-3 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 CPD North Group Multilevel-Model

Variable	Estimate	Std. Error	t value
Intercept	-0.798	0.152	-5.261
Average slope	-0.067	0.015	-4.351
Water level*	3.645	1.240	2.940
48 hour precipitation	0.001	0.000	5.514
Sample Month - June	0.388	0.115	3.385
Sample Month - July	0.580	0.115	5.048
Sample Month - August	0.491	0.114	4.323
Sample Month - September	0.607	0.186	3.266
Wave Height*	1.248	0.124	10.069

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

Variable	Estimate	Std. Error	t value
Intercept	-1.584	0.346	-4.576
Water level*	5.634	1.848	3.049
East water velocity	-1.700	1.089	-1.561
Precipitation	0.001	0.000	6.410
Wave Period	0.219	0.028	7.858
Percent Impervious Cover	0.286	0.135	2.127
Sample Month - June	0.212	0.130	1.635
Sample Month - July	0.308	0.129	2.381
Sample Month - August	0.384	0.129	2.976
Sample Month - September	0.128	0.214	0.599
Groyne presence - Yes	0.477	0.138	3.458

Table A.II-3. 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.

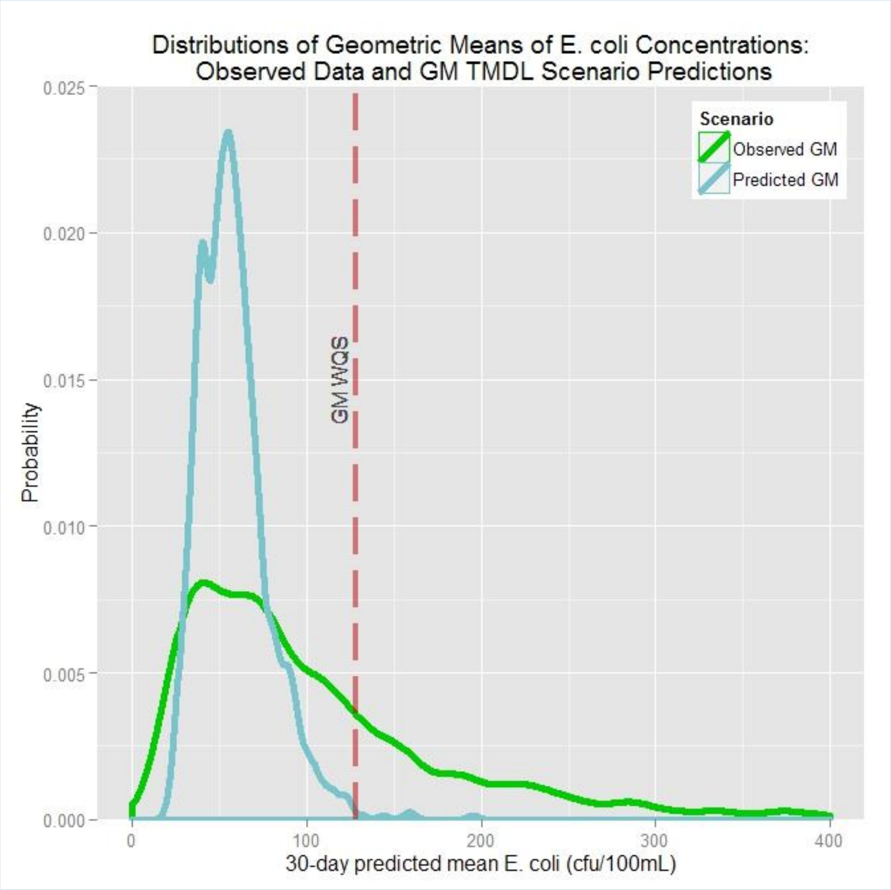

Figure A.III-1. Comparison of 30-day GM Distributions at Waukegan North Beach

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.

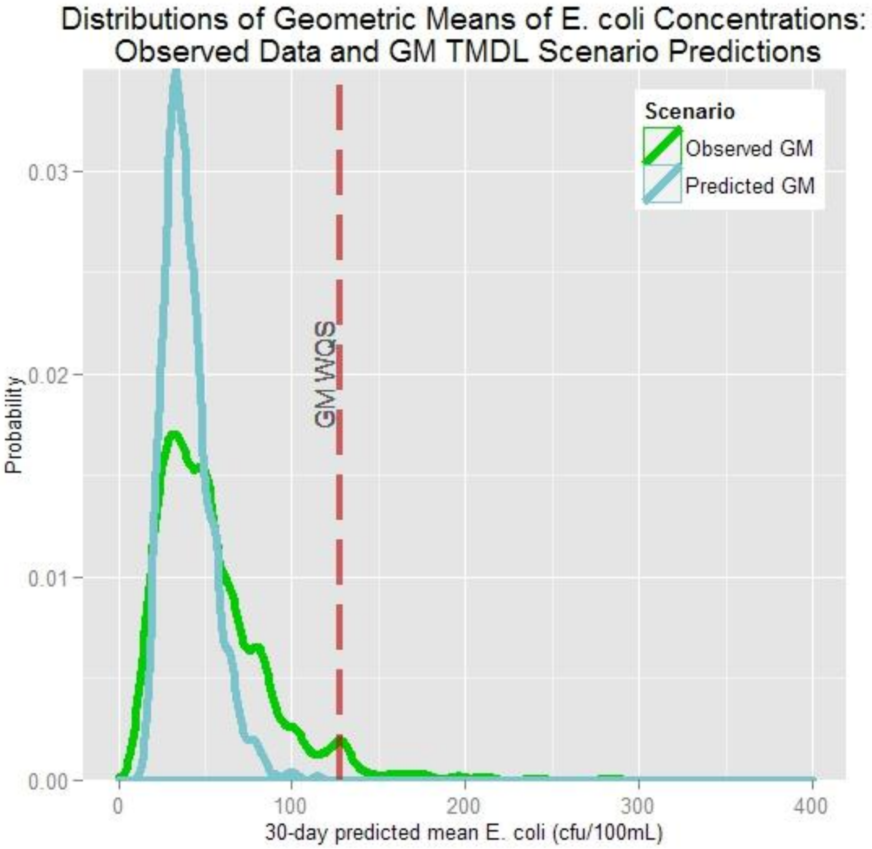

Figure A.III-2. Comparison of 30-day GM Distributions at Evanston Lee Beach

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 the large area under the green curve to the right of the GM WQS.

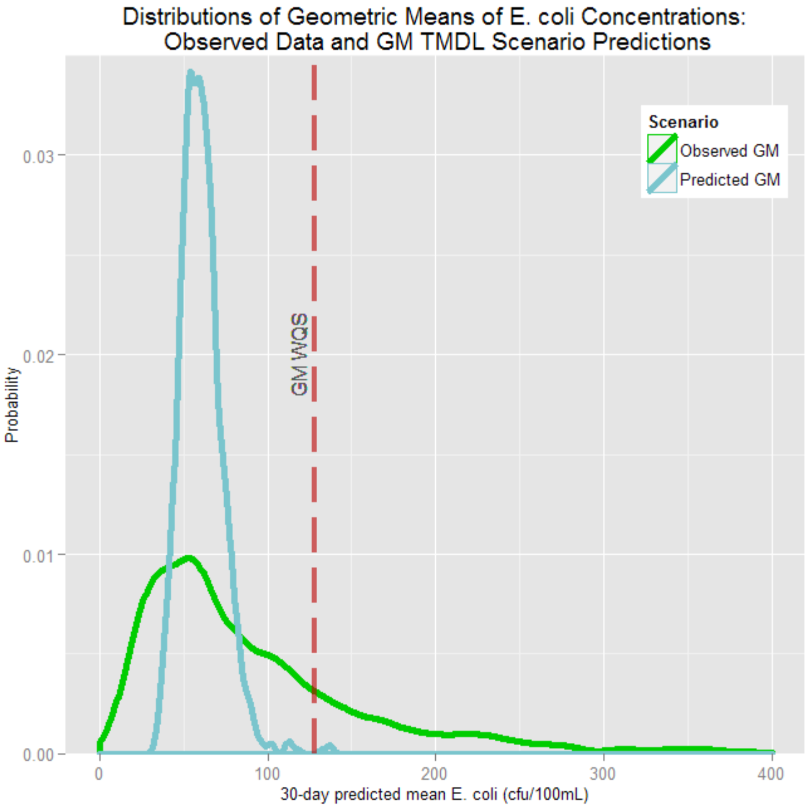

Figure A.III-3. Comparison of 30-day GM Distributions at Rainbow Beach

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 and 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. Although these data characterize the historical condition, the data represent conditions that would be much different from the conditions that 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 TMDLs and **Appendix II** for Suburban Cook County and Chicago TMDLs, which contains the metadata for each variable used in the model domain including where those data can be 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.