Lake Superior South and St. Louis River Watersheds

May 2022

Duluth Area Beaches Total Maximum Daily Load Report

Restoring and Protecting Beaches in the Duluth Urban Area.

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Acronyms

1W1P	One Watershed, One Plan
AOC	area of concern
AOX	adsorbable organic halides
BEACH	Beaches Environmental Assessment and Coastal Health
BEACON	Beach Advisory and Closing Online Notification
BMP	best management practice
BUI	beneficial use impairment
BWSR	Board of Water and Soil Resources
CAFO	Confined Animal Feeding Operation
CWA	Clean Water Act
DUWAC	Duluth Urban Watershed Advisory Committee
DNA	deoxyribonucleic acid
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
FDC	flow duration curve
GLRI	Great Lakes Restoration Initiative
HUC	hydrologic unit code
HSPF	Hydrological Simulation Program Fortran
I&I	inflow and infiltration
LA	load allocation
org/100 mL	organisms per 100 milliliters
MDH	Minnesota Department of Health
MnDOT	Minnesota Department of Transportation
MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
MST	microbial source tracking
n	number
NOAA	National Oceanic and Atmospheric Administration

NPDES	National Pollutant Discharge Elimination System
RAP	Remedial Action Plan
SDS	state disposal system
SSLSWCD	South St. Louis Soil and Water Conservation District
SWPPP	stormwater pollution prevention plan
TMDL	total maximum daily load
WLA	wasteload allocation
WRAPS	Watershed Restoration and Protection Strategy

Executive summary

The Clean Water Act (CWA), Section 303(d) requires total maximum daily loads (TMDLs) to be developed for surface waters that do not meet applicable water quality standards necessary to support their designated uses. A TMDL determines the maximum amount of a pollutant a receiving waterbody can assimilate while still achieving water quality standards and apportions load reductions among sources of pollutants. This TMDL study addresses impaired beaches in the Duluth Urban Area in northeastern Minnesota. The Duluth Area Beaches TMDL is the first beach TMDL in Minnesota; however, beach TMDLs have been developed and approved for other Great Lakes beaches. The Duluth Area Beaches TMDL includes *Escherichia coli (E. coli)* TMDLs for five impaired beaches within the St. Louis River Watershed (Hydrologic Unit Code [HUC] 04010201) and the Lake Superior South Watershed (HUC 04010102). The impaired beaches are also located within the St. Louis River Area of Concern (AOC), designated under the United States and Canada Great Lakes Water Quality Agreement in 1987. The MPCA applies the CWA's Coastal Waters definition as well as the federal Beaches Environmental Assessment and Coastal Health (BEACH) Act water quality standards to all bacteria monitoring sites on the Lake Superior shoreline and in the mouths of tributaries that are representative of shoreline/Lake Superior conditions. The BEACH Act addresses pathogens and pathogen indicators in coastal recreation waters. Routine beach monitoring to quantify *E. coli* bacteria levels is conducted by the Minnesota Department of Health (MDH) and partners at various locations as part of the BEACH Act. This assessment includes monitoring sites along the St. Louis River Estuary, Duluth-Superior Harbor, and Lake Superior shoreline.

The State of Minnesota has adopted a watershed approach to address the state's 80 major watersheds, denoted by an 8-digit HUC. This watershed approach incorporates water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results into a 10-year cycle that addresses both restoration and protection. The scientific findings regarding water quality conditions and strategies for addressing them are incorporated into a Watershed Restoration and Protection Strategy (WRAPS) report. The Duluth Urban Area WRAPS (MPCA 2020b) Report was completed in October 2020 and addresses the impaired beaches that are the subject of this TMDL study. This document was developed over a multi-year process with extensive stakeholder engagement.

To better identify the source contributions to impaired beaches and therefore support TMDL implementation, a detailed, multi-step source assessment was conducted for this TMDL. The source identification process included: a planning level source assessment to identify the "first-cut" of potential sources of pathogens to the impaired beaches and potential areas influencing beach water quality; field data collection to obtain water quality data and observe beach conditions; followed by microbial source tracking (MST) analysis in order to confirm potential sources using DNA biomarker assessment. Potential sources of *E. coli* to impaired beaches include stormwater (permitted and nonpermitted); human sources including leaky wastewater infrastructure, sewer backups, inadequate bathroom facilities, bathers, transient populations, illegal sump pump discharges, and failing septic systems; pet and wildlife waste; influences from nearby by waters including *E. coli* impaired streams discharging nearby; and near-shore areas outside of direct drainage areas to the beaches. Limited data are available to evaluate the fate and transport of *E. coli* from sources upstream of the direct drainages to the beaches; however, *E. coli* may migrate and be carried through the St. Louis River and Estuary Watershed, Nemadji River Watershed, and Duluth-Superior Harbor to the beaches. The extent of naturalized *E. coli,* or *E. coli* that persists in the environment outside of a warm-blooded host, is unknown at this time and there is no evidence at this time to suggest that natural background sources are a major driver of any of the beach impairments.

Concentration-based TMDLs are provided for each of the impaired beaches where the loading capacity equals the numeric value of the standard, which is the monthly geometric mean standard of 126 org/100 mL. It is assumed that practices that are implemented to meet the geometric mean standard will also address the individual sample standard (235 org/100 mL)[1]. The *E. coli* numeric criteria are only applicable during Minnesota's aquatic recreation season (April 1 through October 31) because most aquatic recreation (e.g., swimming) in Minnesota occurs during this time. Overall estimated percent reductions for impaired beaches in the Duluth Area Beaches TMDL range from 4% to 84%, based on *E. coli* concentration data collected at the beaches in 2009 through 2018.

The overall implementation strategy highlights an adaptive management process to achieving water quality standards and restoring beneficial uses. Implementation strategies for impaired beaches are largely encompassed within the recommendations provided in the completed Duluth Urban Area Streams TMDL and WRAPS and include addressing discharge of untreated wastewater (e.g., failing septic systems, leaky wastewater infrastructure, lack of restrooms in strategic locations), stormwater management, land use planning and ordinance development, education and outreach activities, and pet and wildlife waste management. If current Municipal Separate Storm Sewer Systems (MS4) permit requirements for bacteria wasteload allocations (WLAs) remain similar in the next MS4 general permit (expected to be issued in 2025), MS4s would be required to maintain a written or mapped inventory of bacteria sources, as well as a prioritization plan to reduce those bacteria sources.

A Core Team of local, state, and federal resource management agency staff supported the TMDL process and provided valuable input. The TMDL study is supported by previous work including the Duluth Urban Area Streams TMDL (MPCA 2020a), the Duluth Urban Area WRAPS (MPCA 2020b), Nemadji River TMDL (MPCA 2017b) and WRAPS (MPCA 2017a) and two recent MST studies: Bacterial Source Tracking at Impaired Beaches in the St. Louis River AOC (Prihoda et al. 2017) and The Duluth Stream Bacterial Source Identification Study (Burns & McDonnell Engineering Company, Inc. 2020).

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[1] Minnesota's water quality standards are discussed in Section 2. As relevant to the aquatic recreation use, Minnesota has adopted two numeric criteria to protect primary contact recreation. For an assessment unit to attain such a use, both criteria must be met:

- *E. coli* bacteria must not exceed 126 org/100 mL, as a geometric mean of not less than five samples representative of conditions during any calendar month
- *E. coli* bacteria must not exceed 235 org/100 mL in more than 10% of all the individual samples taken during any calendar month

1. Project overview

1.1 Purpose

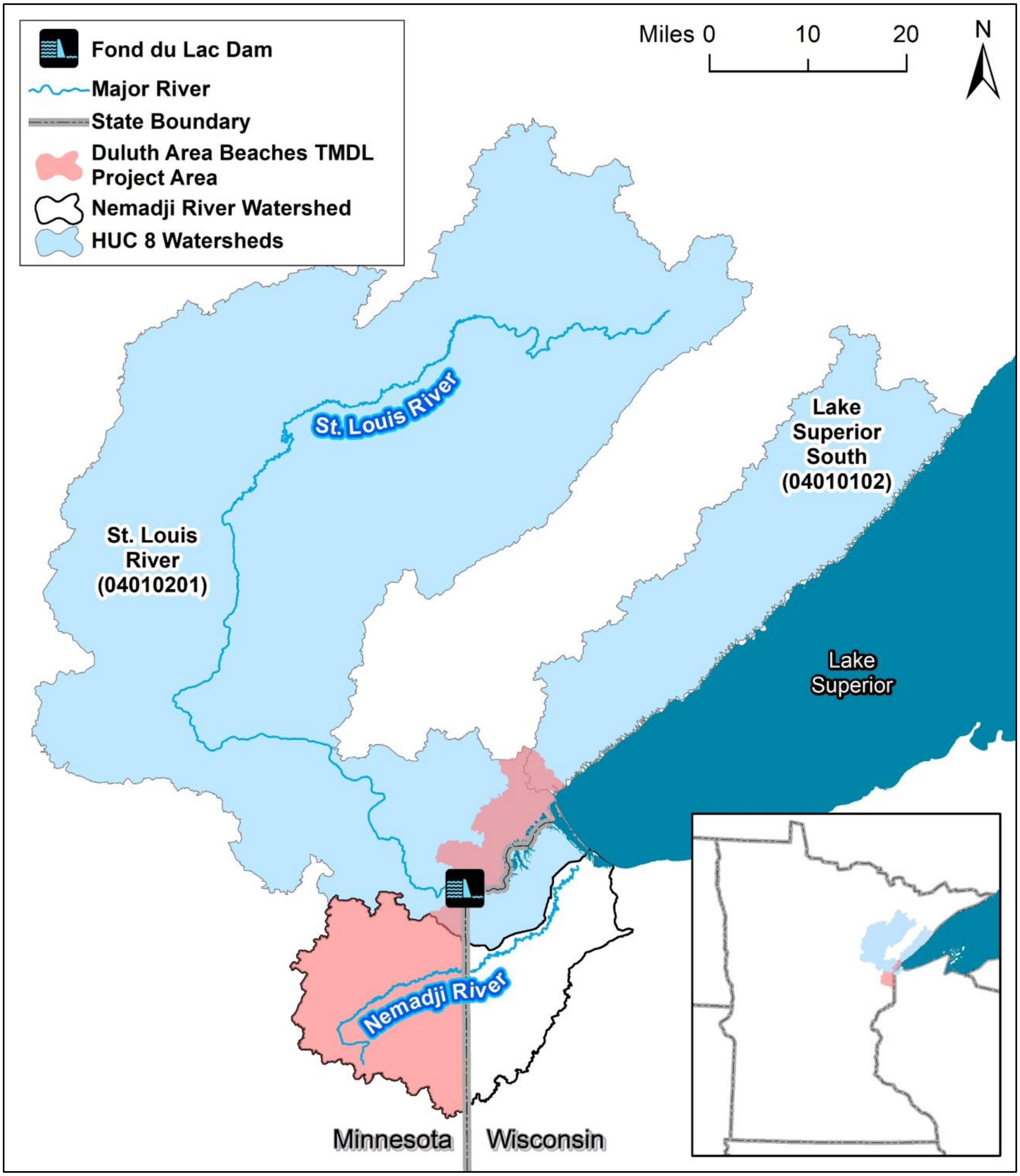
Section 303(d) of the federal CWA requires that TMDLs be developed for waters that do not support their designated uses. These waters are referred to as "impaired" and are listed in Minnesota's list of impaired water bodies. The term "TMDL" refers to the maximum amount of a given pollutant a water body can receive on a daily basis and still achieve water quality standards. A TMDL study determines what pollutant reductions are needed to attain and maintain water quality standards in waters that are not currently meeting them. A TMDL study identifies pollutant sources and allocates those pollutants among those sources. The allocations, including WLAs for permitted sources, load allocations (LAs) for nonpermitted sources (including natural background), and the margin of safety (MOS), which is implicitly or explicitly defined, cannot exceed the maximum allowable amount of the pollutant.

This TMDL study addresses impaired beaches within the St. Louis River Watershed (HUC 04010201) and the southern portion of the Lake Superior South Watershed (HUC 04010102) (Figure 1). The TMDL project area consists of portions of the St. Louis River Watershed (HUC 04010201), Lake Superior South Watershed (HUC 04010102), and the Minnesota-portion of the Nemadji River Watershed (HUC 04010301). The St. Louis River Watershed upstream of the Fond du Lac dam is not included in the project area. The Fond du Lac dam was selected as a boundary because the dam divides two St. Louis River assessment units. Additionally, in 2021, the St. Louis River above the dam was assessed and is not impaired due to *E. coli*. The project area is further discussed in Section 1.3 and boundary conditions are further discussed in sections 1.3 and 4.1.4.

The Duluth Area Beaches TMDL is the first beach TMDL in Minnesota; however, beach TMDLs have been developed and approved for other Great Lake beaches. The impaired beaches addressed in this TMDL are located within the Duluth Urban Area for which the Duluth Urban Area Streams TMDL (MPCA 2020a) has been developed (Figure 2). This report focuses specifically on the Duluth area beaches and does not address the streams which discharge into Lake Superior, Duluth-Superior Harbor, or St. Louis River Estuary. The Duluth Urban Area WRAPS (MPCA 2020b) was previously developed and contains strategies that could be undertaken to restore the impaired beaches that are the subject of this TMDL study. This document was developed over a multi-year process with extensive stakeholder engagement.

There are many other ongoing efforts to protect and improve water quality; these efforts involve citizens, civic organizations, businesses, and government organizations.

Figure 1. Duluth beach TMDLs project area and key HUC-8 watersheds.



1.2 Identification of water bodies

Six beaches in the Duluth area are impaired for recreation use through criteria set forth by the CWA and Great Lakes Water Quality Agreement. This TMDL report was prepared by MPCA to fulfill Minnesota's obligations under the CWA. Projects, planning efforts, and policies of the Great Lakes Water Quality Agreement are presented for reference.

1.2.1 Clean Water Act

Section 305(b) of the CWA requires states to identify waters that do not meet the states' water quality standards. The MPCA has identified a total of six beaches in the Duluth area that do not meet Minnesota water quality standards. This report addresses five beaches in the Duluth area that have aquatic recreation impairments due to high concentrations of *E. coli*, a bacterial indicator of fecal contamination (Figure 1 and Table 1, including notes regarding impairments for which TMDLs are not developed). Addressing one of the impaired beaches, the Clyde Ave Boat Launch (04010201-A91; also known as Munger Landing), has been deferred until after it is addressed as part of an AOC remediation effort. The Duluth Urban Area WRAPS (MPCA 2020b) includes additional information on all beaches in the watershed.

Table 1. Duluth area impaired beaches.

Pollutant or stressor	AUID	Water body name	Nearby tributary	Major watershed name	Listing year
Escherichia coli (*E. coli*)	04010102-C21	Leif Erikson Park Beach	Chester Creek	Lake Superior – South	2014
	04010201-A90	Minnesota Point 15th Street Harbor Side Beach	Harbor	St. Louis River	2014
	04010201-A89	Park Point 20th Street/Hearding Island Canal Beach	Harbor	St. Louis River	2014
	04010201-A87	Park Point Sky Harbor Parking Lot Beach	Harbor	St. Louis River	2016
	04010201-A91	*Clyde Ave Boat Launch (deferred)*	*Harbor*	*St. Louis River*	*2014*
	04010201-A92	Boy Scout Landing Beach	Sargent Creek	St. Louis River	2020

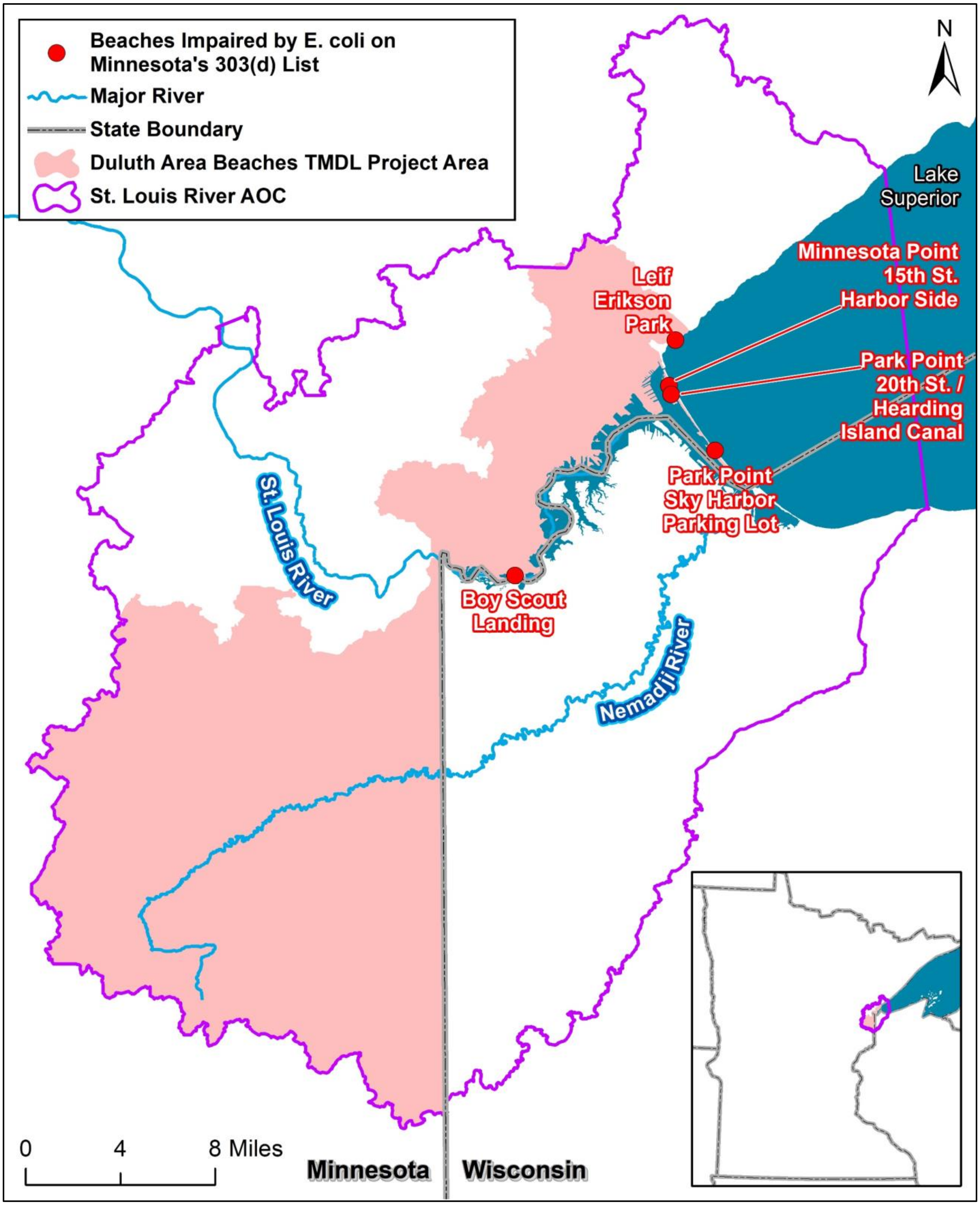
Italics: The TMDL for Clyde Ave boat launch has been deferred. The beach water quality will be reevaluated after completion of the St. Louis River AOC Munger Landing remediation project.

1.2.2 Great Lakes Water Quality Agreement

The United States-Canada Great Lakes Water Quality Agreement of 1987 established 43 Areas of Concern (AOCs), defined 14 beneficial use impairments (BUIs), and initially identified which beneficial uses were impaired in each AOC. Through development of remedial action plans (RAPs), AOCs refined their lists of BUIs. Generally, the AOC program was established to address environmental damage that occurred before environmental regulations existed.

The beaches addressed in this TMDL are located within the St. Louis River AOC (Figure 2). The St. Louis River AOC efforts focus on legacy pollution and degraded habitats while ongoing water quality impairments are addressed through existing permits and programs.

Figure 2. Duluth Beach TMDLs project area, the St. Louis River AOC, and the impaired beaches.



The St. Louis River AOC identified nine BUIs, three of which have been removed. The Beach Closings and Body Contact Restrictions BUI (#7), is one of the six remaining BUIs. Six beaches in Minnesota and four beaches in Wisconsin are on Minnesota's Draft 2020 303(d) list or Wisconsin's 2020 303(d) list for recreational use impairments due to bacterial contamination within the St. Louis River AOC:

Minnesota

- Leif Erikson Park Beach
- Minnesota Point 15th Street Harbor Side Beach
- Park Point 20th Street/Hearding Island Canal
- Park Point Sky Harbor Parking Lot Beach
- Boy Scout Landing Beach
- Clyde Avenue Boat Launch

Wisconsin

- Barker's Island Inner
- WI Point #1
- WI Point #2
- WI Point #3

Additionally, three advisories for body contact are present in the AOC: U.S. Steel/Spirit Lake (Minnesota; "No Swimming" sign), Munger Landing (Minnesota; "Warning" sign), and Crawford Creek (Wisconsin; "Warning" sign). At the time the St. Louis River AOC was listed, two sources of potential microbial contamination were a concern: sewage bypasses during storm events and marine traffic discharges. Under a Consent Decree, the City of Duluth implemented many capital improvements to address sewage bypasses. The city constructed several large storage basins to temporarily store wastewater, replaced sewers (to address inflow and infiltration [I&I]), and separated storm drains from homes (foundation drains and gutters were connected to sanitary sewers).

The St. Louis River AOC RAP (MPCA et al. 2020) describes the removal targets for the beach closings and body contact restrictions BUI, as follows:

> *Sources of stormwater and wastewater discharge to the St. Louis River Area of Concern have been identified and measures to reduce the risk of human exposures to disease causing microorganisms have been implemented.*
>
> *There are no body contact advisories due to the presence of harmful chemicals at contaminated sites.*
>
> *No water bodies within the AOC are included on the list of nonattaining waters due to controllable sources of disease causing microorganisms or chemicals in the most recent State of Wisconsin and State of Minnesota Section 303(d) programs. (MPCA and WDNR 2011).*

With regards to the beach closings portion of the BUI, "controllable sources" are defined as sources of pathogens of human origin. The RAP goes on to explain that removal will be justified when no water bodies within the AOC are included on the list of nonattaining waters due to contamination with pathogens from sewer overflows (defined as sanitary sewer overflows or combined sewer overflows) in either state's most recent CWA Water Quality and Pollution Control Section 303(d) and 305(b) Integrated Report.

In cases where the water bodies within the AOC are on the list of nonattaining waters due to the presence of sewer overflows originating within the AOC, this BUI will be considered restored when sewer overflows have been eliminated, are being treated, or are otherwise being managed as follows:

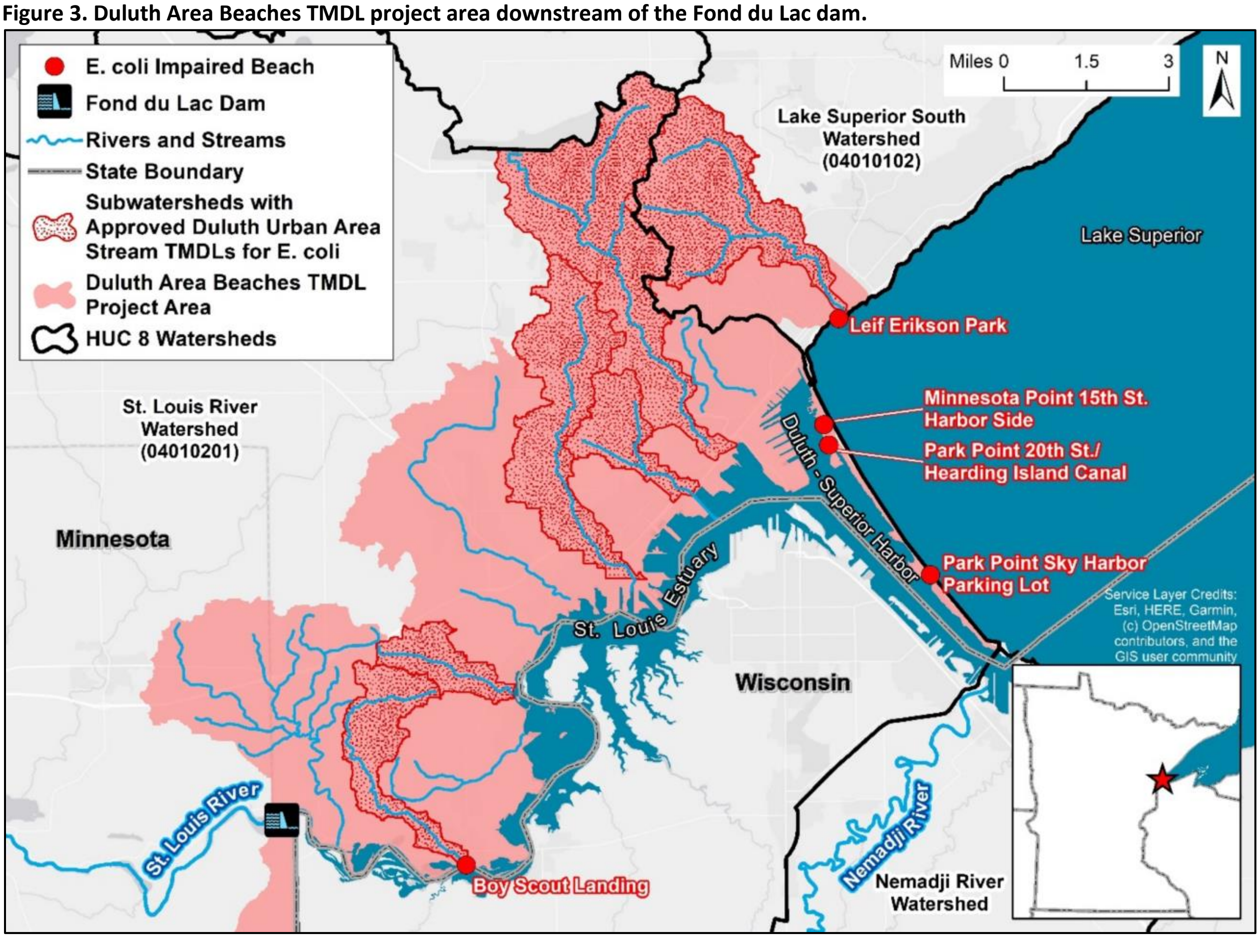
a. Municipalities and municipal wastewater treatment plants within the AOC are in compliance with the National Pollutant Discharge Elimination System (NPDES) wastewater discharge permit conditions or are otherwise entered into an agreement or order addressing sewer overflows, and

b. Municipalities within the AOC are in compliance with their municipal separate storm sewer system NPDES permit conditions.

1.3 TMDL project area

The Duluth Area Beaches TMDL project area is comprised of the area draining to the five impaired beaches and includes a portion of the Duluth Urban Area and upstream areas that drain to the impaired beaches via the St. Louis River, St. Louis Estuary, Duluth-Superior Harbor, and the Nemadji River (Figure 2). The Duluth Area Beaches TMDL project area is shown in Figure 1 and Figure 2; additionally, Figure 3 shows the project area downstream of the Fond du Lac dam.

Figure 3. Duluth Area Beaches TMDL project area downstream of the Fond du Lac dam.



All of the beaches are within the Duluth Urban Area Watershed in northeastern Minnesota. A full description of the Duluth Urban Area Watershed is provided in the Duluth Urban Area WRAPS (MPCA 2020b); excerpts are provided below:

"The Duluth Urban Area Watershed is in Northeastern Minnesota in the Lake Superior Basin, and in the Northern Lakes and Forests ecoregion. The watershed is 141 square miles and covers portions of Carlton and St. Louis counties. The entire study area of this WRAPS is in the St. Louis River Area of Concern

AOC)...The dominant land use in the watershed is residential and the dominant land cover is forest. Various types of development constitute the majority of the remaining land cover, with grassland/shrub, outcrops and wetlands each making up less than 5% of the watershed as a whole."

The project area includes portions of the St. Louis River Watershed downstream of the Fond du Lac dam (Figure 3), a portion of the Lake Superior South Watershed, and the portion of the Nemadji River Watershed located in Minnesota. The Fond du Lac dam was selected as a boundary because the dam divides two St. Louis River assessment units. Additionally, in 2021, the St. Louis River above the dam was assessed and is not impaired due to *E. coli*. Therefore, the St. Louis River Watershed upstream of the Fond du Lac dam is not included in the project area. The St. Louis River and tributaries downstream of the Fond du Lac dam can be transport pathways for bacteria to migrate to Boy Scout Landing Beach. The St. Louis River and Estuary, Duluth-Superior Harbor, Nemadji River, and their tributaries can be transport pathways for bacteria to migrate to the impaired beaches: MN Point 15th Street Harbor Side Beach, Park Point 20th Street/Hearding Island Canal Beach, and Park Point Sky Harbor Parking Lot Beach

Leif Erikson Park Beach on the shore of Lake Superior is also included in this TMDL. Bacteria loading from the St. Louis River and Nemadji River watersheds is not expected to contribute to the impairment of Leif Erikson Park Beach. Using a weight of evidence approach, Lake Superior was also determined to not contribute to *E. coli* impairments because:

- Generally, bacteria counts are low in Lake Superior due to its volume and lack of shading (i.e., exposure to ultraviolet light) that increase die-off.
- Except for Leif Erikson Park Beach, five Duluth area beaches on the northshore and lakeside of Park Point are not impaired (MPCA 2020b). In addition, the 42nd Avenue Beach and Duluth Lakewalk Beach are very similar to Leif Erikson Park Beach and neither of these beaches are impaired.

The information suggests that the impairment of the Leif Erikson Park Beach is due to local sources[2] and not Lake Superior.

No part of the project area is located within the boundary of a federally recognized Native American reservation, but it is within the 1854 ceded territories area where tribal rights are retained. Monitoring and assessment reports for the St. Louis River (MPCA 2013), Nemadji River (MPCA 2014b), and Lake Superior South (MPCA 2014a) watersheds provide additional descriptions of the project area, including discussions of ecoregions, soils, land cover, surface hydrology, precipitation trends, hydrogeology, groundwater quality, and wetlands.

[2] The Chester Creek watershed and storm sewersheds adjacent to Leif Erikson Park Beach are included in the TMDL project area (refer to Section 3.1.1 for a discussion of land area evaluated for Leif Erikson Park Beach).

1.4 Existing stream *E. coli* TMDLs within the project area

The project area for this Duluth Area Beaches TMDL corresponds and overlaps with two other existing stream *E. coli* TMDL reports, the Duluth Urban Area Streams TMDL report and the Nemadji River Watershed TMDL Report. Both of these reports have *E. coli* impaired streams that drain to the Duluth Area Beaches TMDL project area and could be influencing the beach impairments; therefore, any restoration activities done to improve the water quality for these outlined TMDLs would be beneficial to the Duluth Area Beaches TMDL.

- The Duluth Urban Area Streams TMDL report was completed in November 2020 and contains six impaired streams for *E. coli* that drain to the Duluth Area Beaches TMDL project area. These streams include:
- Keene Creek from Headwater to St. Louis River (AUID 04010201-627)
- Miller Creek from Headwater to St. Louis River (AUID 04010201-512)
- Sargent Creek from Headwater to St. Louis River (AUID 04010201-848)
- Stewart Creek from T49 R15W S21 west line to St. Louis River (AUID 04010201-884)
- Unnamed Creek (Merritt Creek) from Unnamed Creek to St. Louis River (AUID 04010201-987)
- Chester Creek from East Branch Chester Creek to Lake Superior (AUID 04010102-545)

While the Duluth Urban Area Streams TMDL report contains other impaired waters and associated TMDLs, the six streams listed above are those that correspond to this TMDL.

The Nemadji River Watershed TMDL was completed in August 2017 and contains two *E. coli* impaired streams that drain to the project area. These streams are Nemadji River from Unnamed Creek to the Wisconsin/Minnesota border (AUID 04010301-758) and Nemadji River South Fork from Stony Brook/Anderson Creek to Net River (AUID 04010301-558).

These impaired streams could be contributing *E. coli* to the beaches within the Duluth Area Beaches TMDL; therefore, any restoration activities done to improve the water quality for the *E. coli* impaired streams outlined within the Duluth Urban Area Streams TMDL and Nemadji River Watershed TMDL would be beneficial to the Duluth Area Beaches TMDL.

1.5 Priority ranking

The Minnesota Pollution Control Agency's (MPCA) schedule for TMDL completions, as indicated on Minnesota's Section 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned TMDL priorities with the watershed approach. The timing for TMDL completion corresponds to the WRAPS report completion schedule. The MPCA developed a state plan, [Minnesota's TMDL Priority Framework Report], to meet the needs of the EPA's national measure (WQ-27) under [EPA's Long-Term Vision] for Assessment, Restoration, and Protection under the CWA Section 303(d) Program. As part of these efforts, the MPCA identified water quality impaired segments that will be addressed by TMDLs by 2022. The beaches addressed in this TMDL report are part of the MPCA's prioritization plan to meet the EPA's national measure. This is the first beach TMDL in the state of Minnesota.

2. Applicable water quality standards and numeric water quality targets

The federal CWA requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards consist of several parts:

- Beneficial uses—Identify how people, aquatic communities, and wildlife use our waters
- Numeric criteria—Amounts of specific pollutants allowed in a body of water that still protect it for the beneficial uses
- Narrative criteria—Statements of unacceptable conditions in and on the water
- Antidegradation protections—Extra protection for high-quality or unique waters and existing uses

Numeric and narrative criteria, collectively referred to as water quality standards, for Minnesota streams, lakes, and wetlands are in Minnesota Rules. In the case of beaches, water quality standards are derived from the federal BEACH Act, described below. Together, the beneficial use designations, antidegradation protections, and water quality standards provide the framework for achieving CWA goals.

2.1 Beneficial uses

The beneficial uses for waters in Minnesota are grouped into one or more classes as defined in Minn. R. 7050.0140. The classes and associated beneficial uses are:

- Class 1 – domestic consumption
- Class 2 – aquatic life and recreation
- Class 3 – industrial consumption
- Class 4 – agriculture and wildlife
- Class 5 – aesthetic enjoyment and navigation
- Class 6 – other uses and protection of border waters
- Class 7 – limited resource value waters

All surface waters are protected for multiple beneficial uses, and numeric and narrative water quality criteria are adopted into rule to protect each beneficial use. TMDLs are developed to protect the most sensitive use of a water body; impaired beaches have a Class 2 beneficial use.

2.2 Antidegradation policies and procedures

The purpose of the antidegradation provisions in Minn. R. 7050.0250 through 7050.0335 is to achieve and maintain the highest possible quality in surface waters of the state. To accomplish this purpose:

- Existing uses and the level of water quality necessary to protect existing uses are maintained and protected.

- Degradation of high water quality is minimized and allowed only to the extent necessary to accommodate important economic or social development.
- Water quality necessary to preserve the exceptional characteristics of outstanding resource value waters is maintained and protected.
- Proposed activities with the potential for water quality impairments associated with thermal discharges are consistent with Section 316 of the CWA, United States Code, Title 33, Section 1326.

2.3 Duluth area beaches water quality standards – protection of aquatic recreation

The aquatic recreation beneficial use protects primary secondary body contact through *E. coli* numeric criteria (Minn. R. ch. 7052). Primary body contact recreation is swimming and other recreation where immersion and inadvertent ingestion of water is likely, while secondary body contact recreation is boating, wading, and other activities where ingestion of water is much less likely. The *E. coli* numeric criteria are only applicable during Minnesota's aquatic recreation season (April 1 through October 31) because most aquatic recreation (e.g., swimming) in Minnesota occurs during this time.

The MPCA applies the CWA's Coastal Waters definition that is designated under Section 303(c) of the CWA for the use of swimming, bathing, surfing, or similar water contact activities and BEACH Act water quality standards to the Duluth area beaches. Elevated fecal bacteria levels pose a human health threat, and beaches closed due to contamination can negatively impact tourism and the local economy. The BEACH Act addresses pathogens and pathogen indicators in coastal recreation waters. *E. coli* has been determined by EPA to be the preferred indicator of the potential presence of waterborne pathogens. Routine beach monitoring to quantify *E. coli* bacteria levels is conducted by the MDH and partners at various locations as part of the BEACH Act. This assessment includes monitoring sites along St. Louis River Estuary, Duluth-Superior Harbor, and Lake Superior shoreline.

These beaches are subject to *E. coli* water quality standards in the BEACH Act rule (November 2004 Water Quality Standards for Coastal and Great Lakes Recreation Waters rule [69 FR 67217, November 16, 2004], found at https://www.federalregister.gov/documents/2004/11/16/04-25303/water-quality-standards-for-coastal-and-great-lakes-recreation-waters), and in Minn. R. ch. 7052.0100, subp. 1.D. or 40 CFR §131.41(c)(1), as summarized below.

E. coli water quality standards are applicable to recreational uses of beaches between April 1 and October 31:

- 126 organisms per 100 milliliters (org/100 mL) of water not to be exceeded as the geometric mean of not less than five samples in a calendar month, and
- 235 org/100 mL of water not to be exceeded by 10% of all samples taken in a calendar month, individually.

3. Watershed and waterbody characterization

3.1 Beaches

Five beaches are included in the Duluth Area Beaches TMDL: Leif Erikson Park Beach, Minnesota Point 15th Street Harbor Side Beach, Park Point 20th Street/Hearding Island Canal Beach, Park Point Sky Harbor Parking Lot Beach, and Boy Scout Landing Beach.

Minnesota IT Services geographically delineates beaches using beach start and end points provided by the MPCA field staff and coastline feature lines from the National Hydrography Dataset. The MPCA field staff used specific criteria including public property, public access, specific beach characteristics, and best professional judgement to define the beach start and end points.

Beach characterization was based on in-field observations, results of beach surveys conducted by the South St. Louis Soil and Water Conservation District (SSLSWCD) in 2019 and 2020, and Core Team input during the TMDL development process.

With the exception of Leif Erickson Park Beach, direct drainage areas to each of the beaches were delineated based on topographic data and field observations and include the drainage area from the land surface only. The drainage area to Leif Erickson Park Beach was delineated from City of Duluth stormsewer data and includes the drainage area to Chester Creek and nearby stormsewer outfalls.

In addition to the direct drainage areas described in the previous paragraphs, the St. Louis River and Estuary Watershed downstream of the Fond du Lac dam, Minnesota-portion of the Nemadji River Watershed, Duluth-Superior Harbor, and nearby land areas and streams may be contributing to beach water quality impairments.

3.1.1 Leif Erikson Park Beach (04010102-C21)

Leif Erikson Park Beach is the only bacteria-impaired beach on the Lake Superior shoreline within the project area. Leif Erikson Park, located adjacent to the beach, has a stage with a large green space, is connected to the Duluth Lake Walk, and has several picnic areas. Portable bathrooms are available along the Duluth Lake Walk. Both the beach and park receive a high volume of visitors, especially during holidays and events. The beach is accessible through the park and from Duluth's Rose Garden. Vegetation on the beach is minimal with some shrubs surrounding the beach area. Substrate on the beach is largely pebbles with areas of exposed bedrock.

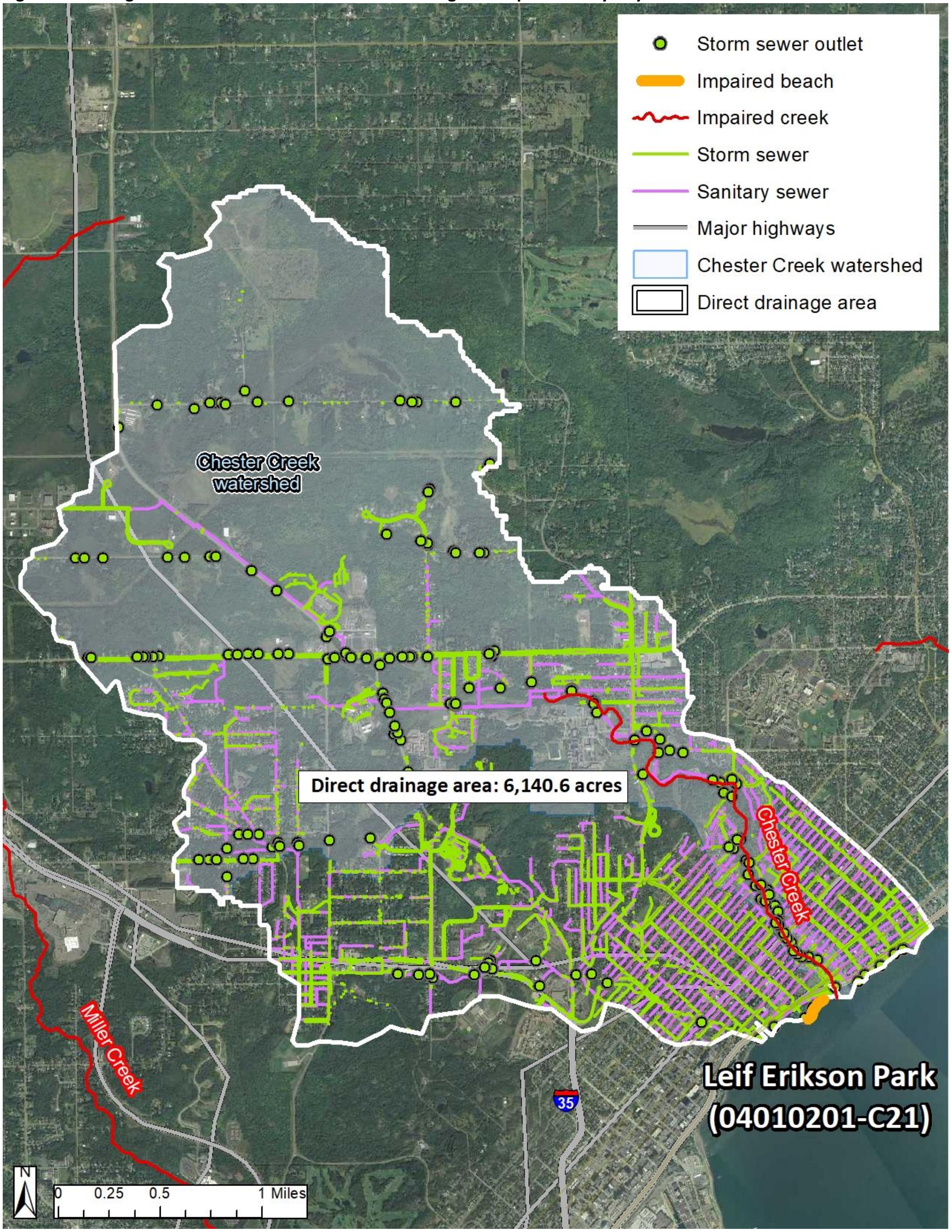
Recreational boats pass through the nearshore waters along Leif Erikson Park Beach but do not congregate near the beach. The beach is not known for recreational fishing. Recreation mostly occurs on the land and lakeshore and not in nearshore waters.

The drainage area for Leif Erikson Park Beach was delineated from City of Duluth stormsewer catchment information[3] and includes 6,141 acres (Figure 5). In this case, the drainage area includes nearby Chester Creek and several stormsewer outfalls.

[3] The City of Duluth storm sewer catchment information was previously used to support development of the Duluth Urban Area Streams TMDL and WRAPS (MPCA 2020a, b).

Figure 4. Leif Erikson Park Beach facing north (left) and south (right). Photos by SSLSWCD.

Figure 5. Drainage area to Leif Erikson Park Beach. Drainage areas provided by City of Duluth.



3.1.2 Minnesota Point 15th Street Harbor Side Beach (04010201-A90)

The Minnesota Point 15th Street beach is located on the harbor side of Park Point and is the inland-most *E. coli* impaired beach on Park Point. The area has a sand beach and Duluth's ports are located across the harbor from the beach. Vegetation on the beach includes grassy areas and bushes, with trees towards the margins of the beach. Substrate on the beach is sandy, with some pebbles on the southern half of the beach, and riprap on the northern end. A fence has been put up to prevent erosion.

The direct drainage area for Minnesota Point 15th Street Harbor Side Beach was delineated based on topographic data and field observations and includes the area that is directly draining to the beach, approximately 12.88 acres (Figure 7). In addition to the direct drainage area, upstream sources that migrate through the Duluth-Superior Harbor and tributaries, St. Louis River and Estuary, and Nemadji River may be influencing water quality at the beach (see Figure 2).

Figure 6. Minnesota Point 15th Street Beach facing east (left) and west (right). Photos by SSLSWCD.

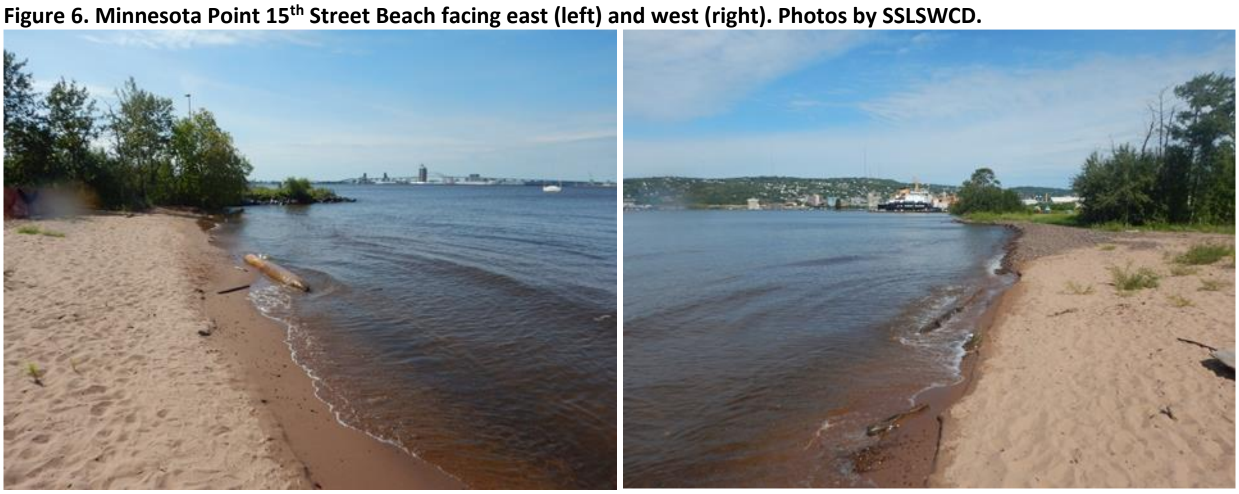
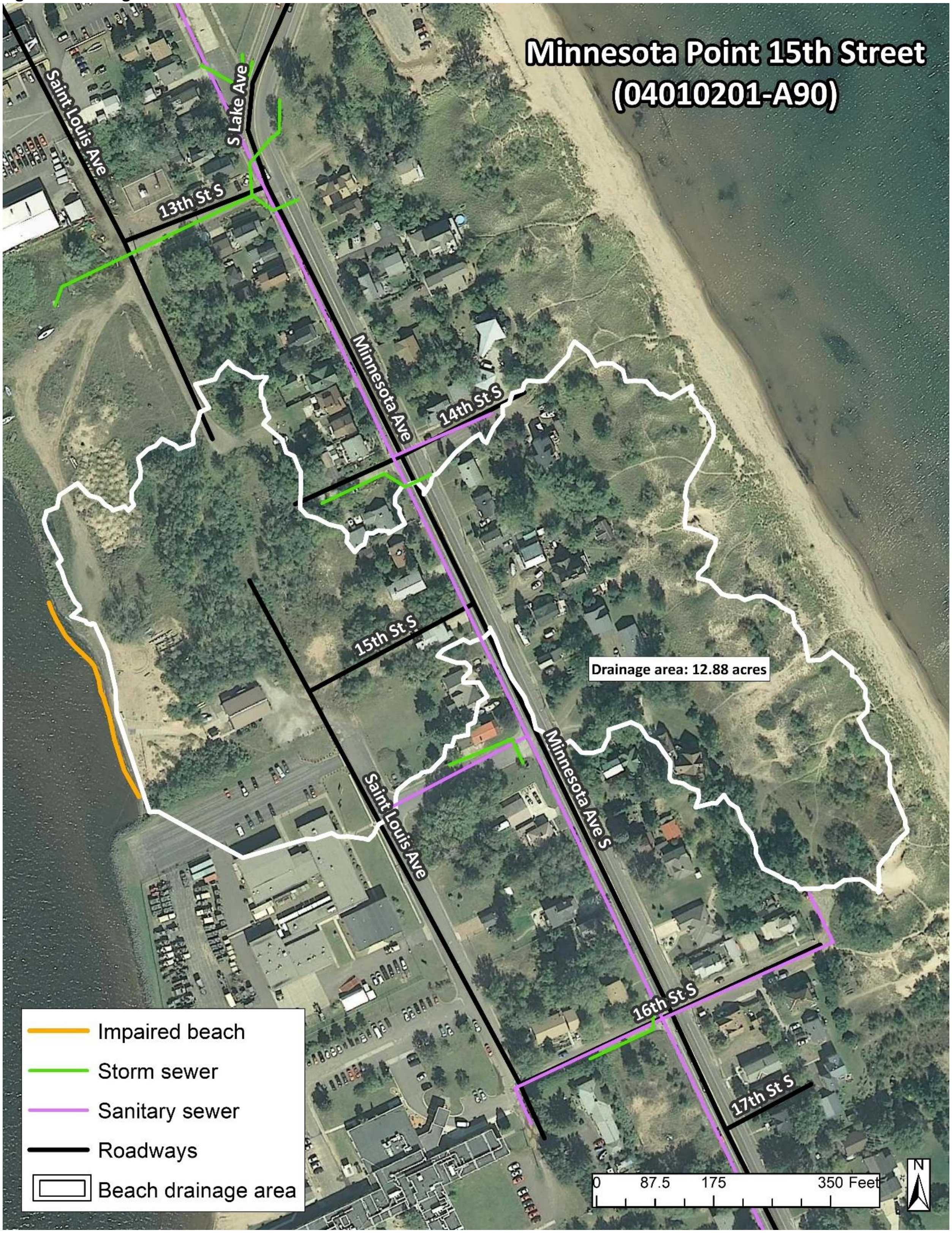


Figure 7. Drainage area to Minnesota Point 15th Street Harbor Side Beach.



3.1.3 Park Point 20th Street/Hearding Island Canal Beach (04010201-A89)

Park Point 20th Street/Hearding Island Canal Beach is located approximately midway along Park Point, on the Harbor side of the point. The beach is located adjacent to the Sand Point Yacht Club, which contains a private marina that is surrounded by houses with individual docks. Hearding Island, a state Wildlife Management Area, is just offshore. The beach is no longer actively monitored by the MDH because of low use. Duluth's ports are located across the harbor from the beach. Vegetation near the beach includes lawn grass with some pioneering plant species such as balsam, poplar, and butter and eggs. Substrate on the beach includes large materials such as rip rap and old fill material (bricks and concrete pieces), with some sand. There are large areas of erosion and the chain link fence that borders the access way is now in the water.

The drainage area for Park Point 20th Street/Hearding Island Canal Beach was delineated based on topographic data and field observations and includes the area that is directly draining to the beach, approximately 0.19 acres (Figure 9). In addition to the direct drainage area, upstream sources that migrate through the Duluth-Superior Harbor and tributaries, St. Louis River and Estuary, Nemadji River may be influencing water quality at the beach (see Figure 2).

Figure 8. Park Point 20th Street/Hearding Island Canal Beach facing west (left) and east (right). Photos by SSLSWCD.

Figure 9. Drainage area to Park Point 20th Street/Hearding Island Canal Beach.

3.1.4 Park Point Sky Harbor Parking Lot Beach (04010201-A87)

The Park Point Sky Harbor Parking Lot Beach is the farthest *E. coli* impaired beach in the harbor from Canal Park. The beach is near several athletic fields and an airport. The athletic fields are commonly populated with flocks of geese, gulls, and other shorebirds. A wastewater treatment facility, several ports, and the Barker's Island Marina are located on the opposite side of the harbor in Superior, Wisconsin. Vegetation on the beach includes grasses and tansy along the water's edge with algae growing by their roots. Willow trees overhang the water on the north end of the beach. Substrate on the beach is all sand.

The drainage area for Park Point Sky Harbor Parking Lot Beach was delineated based on topographic data and field observations and includes the area that is directly draining to the beach, approximately 10.53 acres (Figure 11). In addition to the direct drainage area, upstream sources that flow through the Duluth-Superior Harbor and tributaries, St. Louis River and Estuary, and Nemadji River may be influencing water quality at the beach (see Figure 2).

Figure 10. Park Point Sky Harbor Parking Lot Beach facing west (left) and east (right). Photos by SSLSWCD.

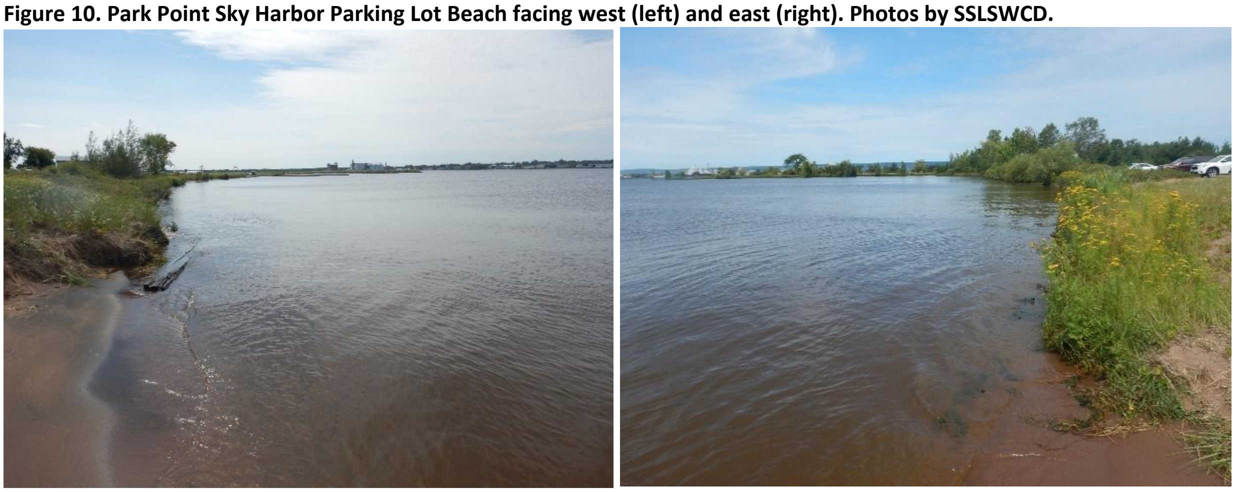


Figure 11. Drainage area to Park Point Sky Harbor Parking Lot Beach.

3.1.5 Boy Scout Landing Beach (04010201-A92)

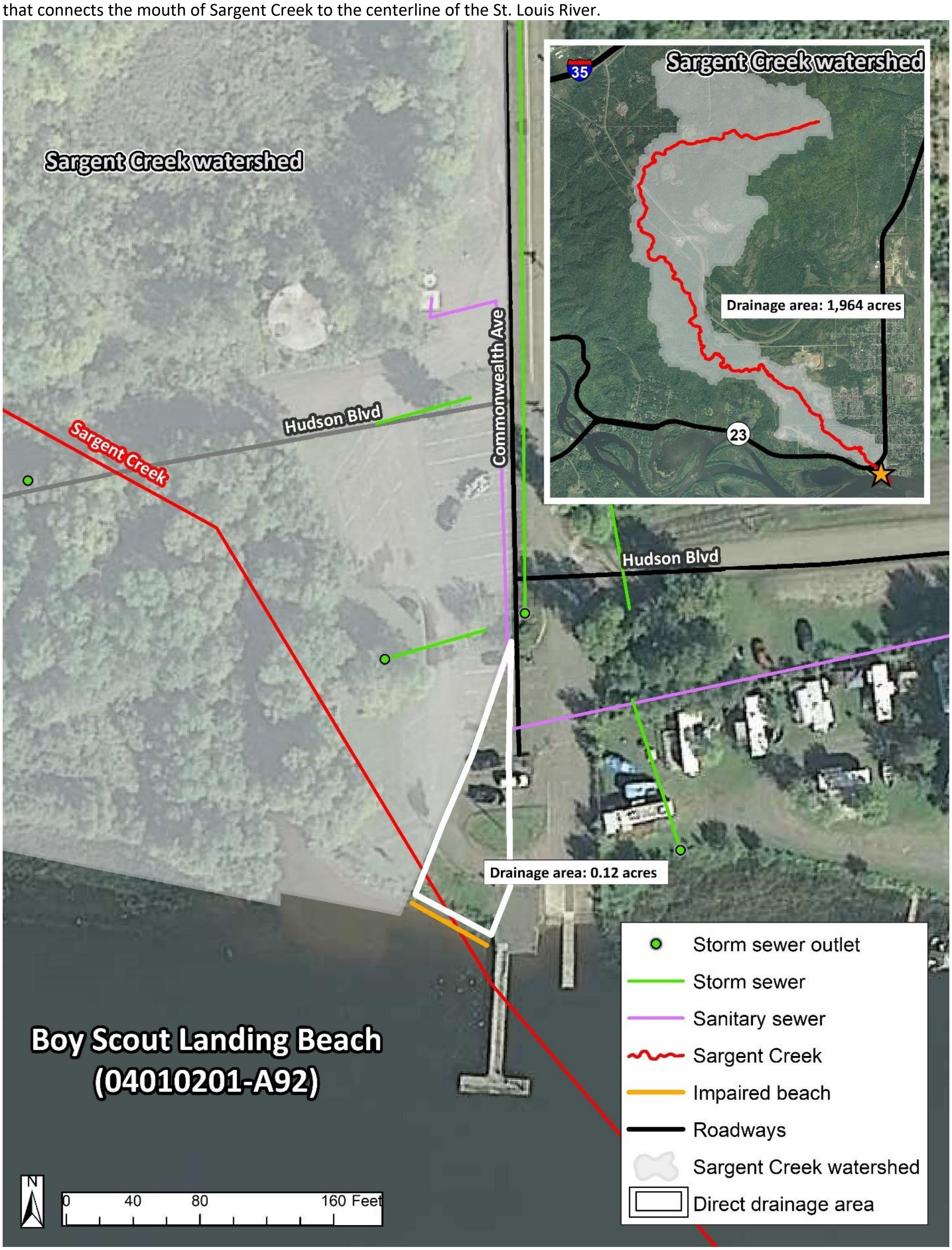
Boy Scout Landing Beach is on the north shoreline of the St. Louis River Estuary, near the mouth of Sargent Creek, which is impaired by *E. coli*. Boy Scout Landing also contains a T-shaped fishing pier, two boat ramps with adjacent floating dock, and a parking lot for automobiles with trailers. A portable bathroom facility was recently added to the beach; the parking lot and road was also recently reconstructed. Anecdotal information indicates that adults and children swim near the boat ramps.

The drainage area to Boy Scout Landing Beach is provided in Figure 13 and includes the area that is directly draining to the beach (0.12 acres) and the entire Sargent Creek Watershed (1,964 acres). In addition to the direct drainage area, upstream sources that migrate through the St. Louis River and tributaries may be influencing water quality at the beach (see Figure 2).

Figure 12. Sargent Creek discharging south of Boy Scout Landing Beach (right) and piers off Boy Scout Landing Beach (left). Photos by SSLSWCD.

Figure 13. Drainage area to Boy Scout Landing Beach.

Note: The Sargent Creek assessment unit (AUID 04010201-848), like all of Minnesota's stream assessment units is derived from the National Hydrography Dataset. In this case, the National Hydrography Dataset includes an artificial "connector" flowline that connects the mouth of Sargent Creek to the centerline of the St. Louis River.



3.2 Land use

Historically, the Duluth area was dominated by hardwood and evergreen forests as well as significant areas of marsh and wetland (DNR 2014). Much of the land area has since been developed. Current land use within the direct drainage areas to Park Point and Boy Scout Landing impaired beaches was determined using interpretation of air photos (MnGeo Web Map Service aerial imagery), as traditional land cover datasets do not provide enough resolution to discern the actual land covers within these smaller drainage areas (Table 2). The entire Sargent Creek Watershed drains to Boy Scout Landing Beach and a portion of the City of Duluth is contributing to Leif Erikson Park Beach; land cover and land use data for those two beaches were determined using the 2013 University of Minnesota land cover/land use data and are provided in Table 3.

Table 2. Land use in the Park Point and Boy Scout Landing impaired beach drainage areas.

Water body name (AUID)	Beach drainage area (acres)	Percent of watershed (%)			
		Green space/park	Residential	Road	Other Impervious (parking lot, paved walkways)
Minnesota Point 15th Street Harbor Side Beach (04010201-A90)	12.88	68	21	4	7
Park Point 20th Street/Hearding Island Canal Beach (04010201-A89)	0.19	93	0	0	7
Park Point Sky Harbor Parking Lot Beach (04010201-A87)	10.53	81	0	19	0
Boy Scout Landing (04010201-A92)	0.12 [a]	50	0	0	50

a. Beach drainage area does not include subwatershed of Sargent Creek (see Table 3).

Table 3. Land cover/land use in Sargent Creek Watershed and Leif Erikson Park Beach drainage area.
(source: University of Minnesota 2013)

Land cover/land use	Percent of area (%)	
	Sargent Creek	Leif Erikson Park
Forested	82	41
Wetlands	4	2
Managed/Natural Grass	3	1
Lakes/Ponds/Rivers	0	11
Hay and Pasture	1	2
0 – 25% Impervious	1	19
26 – 50% Impervious	3	13
51 – 75% Impervious	3	7
76 – 100% Impervious	3	4
Total watershed area	**1,964 acres**	**6,141 acres**

3.3 Current/historical water quality

The assessment of current and historic water quality is based on data from the MPCA's Environmental Quality Information System (EQuIS database, retrieved from EQuIS in April 2019). Water quality data from 2003 to 2018 were summarized for *E. coli* by year to evaluate trends in water quality, and by month to evaluate seasonal variation. This timeframe aligns with the monitoring data used to the support TMDL development, from 2009 through 2018. Precipitation data from the Duluth International Airport (National Oceanic and Atmospheric Administration [NOAA] Gage: USW00014913) were used to further evaluate the precipitation conditions under which *E. coli* exceedances occur. Additional sampling was conducted by MDH and SSLSWCD in 2019 and 2020 to help inform the *E. coli* source assessment. These data from 2019 and 2020 are not included in this section but are summarized in the *E. coli* source assessment methods Section 3.5. Microbial source tracking (MST) data were not used to evaluate current or historical water quality.

The summaries of data by year only consider data during the yearly time period that the standard is in effect, April through October for *E. coli*. The frequency of exceedances represents the number (n) of samples that do not meet the water quality standard of 235 org/100 mL.

The MDH conducts monitoring at the impaired beaches for inclusion in the EQuIS database. A tier classification is assigned to Lake Superior beaches based on their use. The frequency of MDH monitoring is determined through this tier classification system:

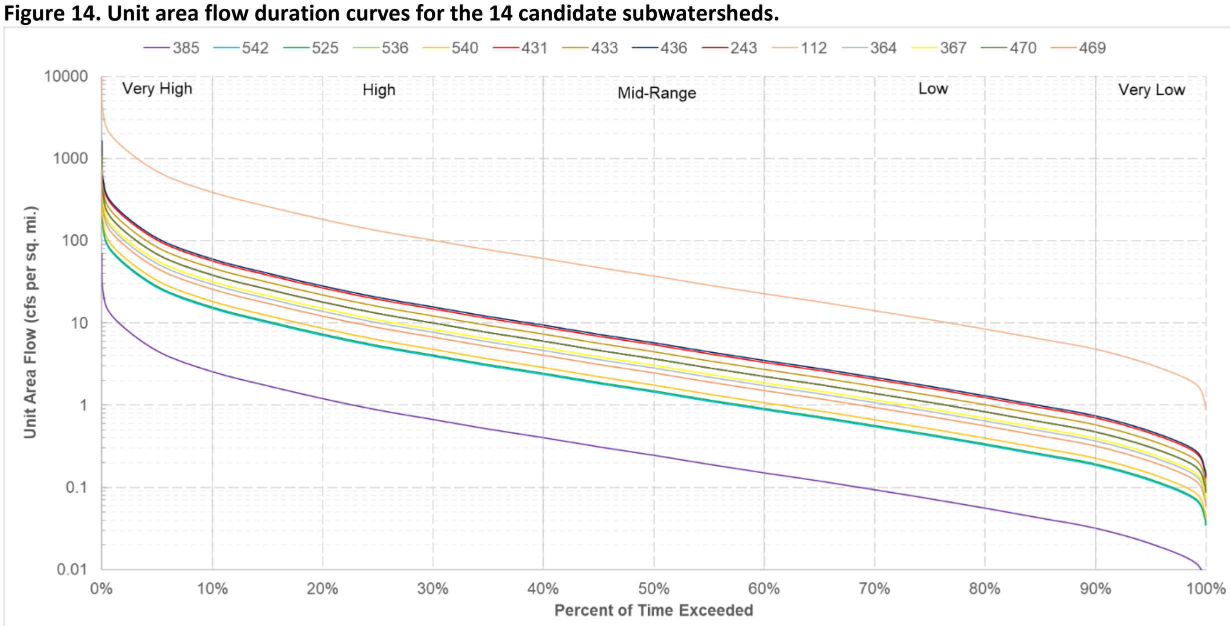
- Tier I beaches are those that receive the most use by the public for swimming, bathing, surfing, kayaking, or similar water contact activities and have the highest potential risk of pathogen pollution within the immediate area. Tier I beaches are classified as high priority beaches and are sampled twice per week. Leif Erikson Park Beach, Minnesota Point 15th Street Harbor Side Beach, and Park Point Sky Harbor Parking Lot Beach are classified as Tier I beaches.
- Tier II coastal recreational water sites usually receive moderate use by the public for water contact recreational purposes and have fewer sources of pathogen pollution in the area. Tier II beaches are classified as medium priority beaches and are sampled once per week. Boy Scout Landing is classified as a Tier II beach.
- Tier III sites typically receive sporadic use and few, if any, potential sources of pollution are in the area. Tier III beaches are classified as low priority beaches and will not be sampled unless beach use increases or environmental factors that may impact coliform levels change. Park Point 20th Street/Hearding Island Canal Beach is classified as a Tier III beach.

Water quality data was also evaluated using concentration-based duration curves to better determine conditions under which exceedances of the water quality standard occur. The concentration-based duration curve approach characterizes the observed data, impairments, and potential sources.

Development of concentration-based duration curves relies in part upon a flow duration curve (FDC) to assign flow duration intervals to individual beach *E. coli* samples. A FDC is developed by generating a flow frequency table and plotting the data points to form a curve. The data reflect a range of natural occurrences from extremely high flows to extremely low flows. As flow data are not available for the impaired beaches, year-round simulated daily average flows (1995 through 2016) for a surrogate stream from the Duluth Urban Area Watershed Hydrological Simulation Program Fortran (HSPF) model application were used. The model report (Tetra Tech 2019) describes the framework and the data that were used to develop the model and includes information on the calibration. Calibration years for the model are 1995 through 2016. The flow data are used only to represent a continuum of wet to dry conditions at the beaches for visual analysis of potential trends, and do not take into account flows in the St. Louis or Nemadji rivers, other tributary flows, or lake seiche. The flow data are not used to calculate loads or allocations.

Candidate surrogate streams representing 14 model subbasins in the project area were evaluated for assigning flow duration intervals. These 14 model subbasins were selected through a preliminary screening analysis of subbasin drainage area, predominant land cover, slope, and soil type. The flow duration intervals in each model subbasin on dates during the summer recreation seasons were compared. Unit area FDCs were plotted together and all the curves have very similar shapes (Figure 14). Only the flow duration interval (i.e., not the actual flow) is used in the concentration-based flow duration method; thus, the shape of the FDCs is more important than the flow value for selecting a surrogate stream.

Figure 14. Unit area flow duration curves for the 14 candidate subwatersheds.



The FDC for model subbasin 367[4] plots in the middle of 14 FDCs of candidate model subbasins, and its distribution of flow duration intervals is consistent with the other 13 candidates (i.e., the shapes of the curves are very similar). Therefore, flow duration intervals for model subbasin 367 were selected. The flow duration interval for subbasin 367 was then assigned to individual *E coli* samples using the sample date to determine the flow duration interval for individual samples. For example, on July 10, 2012, an *E. coli* sample (89 org/100 mL) was collected from Park Point Sky Harbor Parking Lot Beach and the flow

[4] This small headwater tributary is in the Miller Creek Watershed; it is 347 acres in size and the predominant land cover is forest.

duration interval of 53% for July 10, 2012, for the surrogate stream was assigned to the beach *E. coli* sample.

In concentration-based duration curve graphs, the observed concentrations are plotted with the water quality standard, with the flow duration interval as the independent axis (x-axis) and the concentration of the water quality parameter as the dependent axis (y-axis). The water quality standard is plotted as a line. Each observed (i.e., monitored) sample concentration is plotted as a point on the graph. Points plotting above the line represent deviations from the water quality standard and the daily allowable concentration. Those plotting below the curve represent compliance with standards and the daily allowable concentration.

The stream flow duration intervals displayed on the concentration-based duration curves were grouped into hydrologic zones:

- Very high flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows
- High flow zone: flows in the 10 to 40-percentile range, related to wet weather conditions
- Mid-range flow zone: flows in the 40 to 60-percentile range, median stream flow conditions
- Low flow zone: flows in the 60 to 90-percentile range, related to dry weather flows
- Very low flow zone: flows in the 90 to 100-percentile range, related to drought conditions

A duration curve can help identify the issues surrounding the impairment, roughly differentiate among sources, and therefore also help identify appropriate implementation activities. For example, exceedances at the right side of the duration curve graph occur during lower flow conditions, and may be derived from sources such as failing septic systems. Exceedances on the left side of the duration curve graph occur during higher flow events, and may be derived from sources such as runoff.

3.3.1 Leif Erikson Park Beach (04010102-C21)

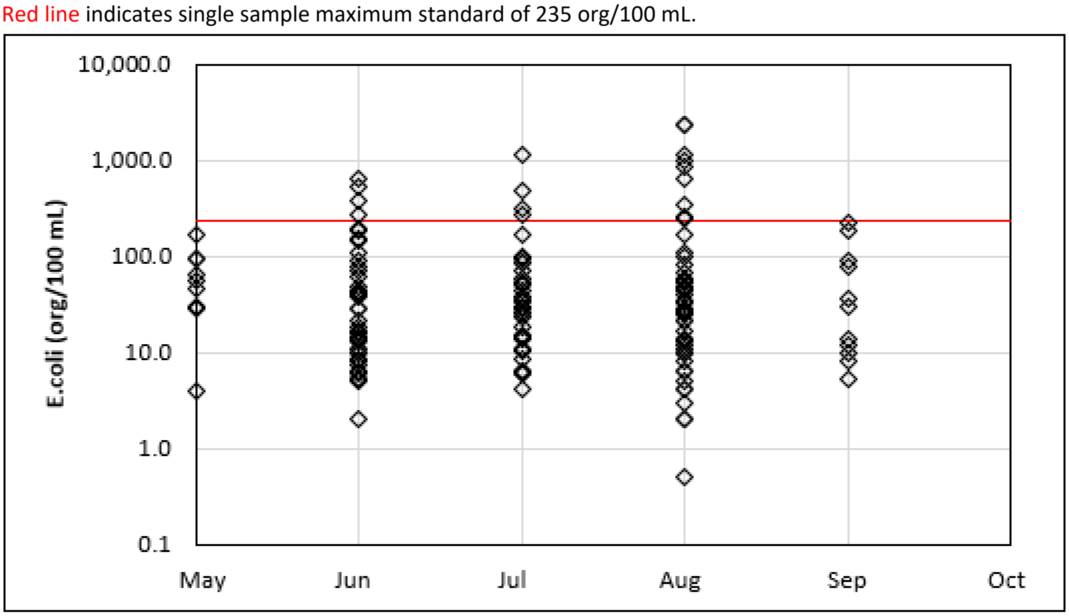
At Leif Erikson Park Beach (Table 4, Figure 15), 15% of the August samples exceeded 235 org/100 mL. The single sample standard was exceeded most frequently in August (8 of 16 Augusts, 50%), followed by June and July (5 of 15 Junes and Julys, 33% each). The single sample standard was also exceeded 50% of the time in October; however, the sample size for this month was only two. The only exceedance of the monthly geometric mean standard occurred in August 2014. In the study of bacterial source tracking, Prihoda et al. (2017) found that 45% of samples collected at four monitoring locations exceeded the instantaneous *E. coli* standard in the 2015 and 2016 beach seasons.

Table 4. Summary *of E. coli* exceedances at Leif Erikson Park Beach (monitoring site 16-0001-00-B009).
Red text indicates months when the geometric mean standard of 126 org/100 mL was exceeded.

Year	Number of sampling days (n) and number of sampling days > 235 org/100 mL (>235) (maximum concentration in org/100 mL)											
	May		Jun		Jul		Aug		Sep		Oct	
	n	>235	n	>235	n	>235	N	>235	n	>235	n	>235
2003	1	0	5	0	6	0	4	0	2	0	-	–
2004	1	0	5	0	7	1 (400)	5	0	2	0	-	–
2005	2	0	4	0	4	0	5	0	2	0	2	1 (2,270)
2006	2	0	4	0	5	0	4	0	2	0	-	–
2007	2	0	4	0	5	0	6	2 (1,100)	2	0	-	–
2008	2	0	5	0	5	1 (579)	4	0	2	0	-	–
2009	2	0	4	0	5	1 (388)	4	0	2	0	-	–
2010	-	–	-	–	-	–	5	2 (>2,420)	3	0	-	–
2011	1	0	3	0	1	0	6	1 (610)	5	1 (870)	-	–
2012	-	–	5	1 (1,300)	5	0	5	2 (390)	-	–	-	–
2013	-	–	8	0	10	0	7	0	4	1 (290)	-	–
2014	2	0	9	1 (649)	10	1 (490)	13	5 (2,400)	3	0	-	–
2015	1	0	9	0	9	0	9	1 (340)	6	0	-	–
2016	1	0	9	1 (378)	8	1 (313)	11	2 (1,120)	-	–	-	–
2017	3	0	9	1 (276)	8	2 (1,120)	10	0	2	0	-	–
2018	2	0	9	1 (517)	8	0	9	1 (261)	-	–	-	–

–: No data

Figure 15. *E. coli* concentrations by month for the last five years of available data (2014–2018) at Leif Erikson Park Beach (monitoring site 16-0001-00-B009).
Red line indicates single sample maximum standard of 235 org/100 mL.



A multi-linear regression model developed by Prihoda et al. (2017) to determine the sanitary survey, water quality, and climate parameters having the most influence on *E. coli* concentrations, found that 48-hour rainfall, wave height, and current speed all have a high relative influence on *E. coli* concentration at the beach center.

Precipitation data (2003 through 2018) from the Duluth International Airport (NOAA Gage: USW00014913) were used to further evaluate the precipitation conditions under which *E. coli* exceedances occur. Daily precipitation, precipitation over two-day periods (day before *E. coli* sample collection, day of *E. coli* sample collection), and precipitation over three-day periods (day before, day of, and day after *E. coli* sample collection) were evaluated. Linear regressions of these three precipitation datasets with *E. coli* concentrations yielded low coefficients of determination (R^2=0.07, R^2=0.13, and R^2=0.10 [respectively]). The coefficient of determination, or "goodness of fit", indicates how much of the variance of the dependent variable is due to the independent variable. The coefficient of determination ranges from 0 (no predictive relationship) to 1 (perfect predictive relationship). In this case, the low coefficient of determination indicates that *E. coli* concentration cannot be predicted from these three measures of precipitation. As an example, an evaluation of daily precipitation is presented in Figure 16.

A similar coefficient of determination was yielded for linear regressions of *E. coli* concentration with water temperature (R^2<0.01). Too few data were available to regress *E. coli* concentration and turbidity.

Evaluation of time series of daily precipitation and *E. coli* concentration indicated that *E. coli* concentrations sometimes increased considerably during and after precipitation. However, low *E. coli* concentrations were sometimes detected after precipitation and high *E. coli* concentrations were sometimes detected following periods of no precipitation. Such results generally indicate that *E. coli* concentrations can increase considerably following precipitation, but other factors during dry weather or lower flows also can increase concentrations.

An analysis of *E. coli* concentrations with categorized precipitation over two-day periods (Figure 17) indicated a slight increase in concentrations from dry conditions (no precipitation), to mid-range conditions (less than 0.5 inches of precipitation), to wet conditions (more than 0.5 inches of precipitation). This trend generally occurred when evaluating results by month and was most evident during June through August; in May and September, the ranges and interquartile ranges of *E. coli* concentrations were very similar during dry and mid-range conditions.

The Leif Erikson Park Beach concentration-based duration curve is provided in Figure 18. Exceedances of water quality standard are seen across the very high through low flow zones.

Figure 16. Daily precipitation and *E. coli* concentration for Leif Erikson Park Beach (2003-2018).
(Note: The maximum detection limit is assumed to be 2,420 org/100 mL.).

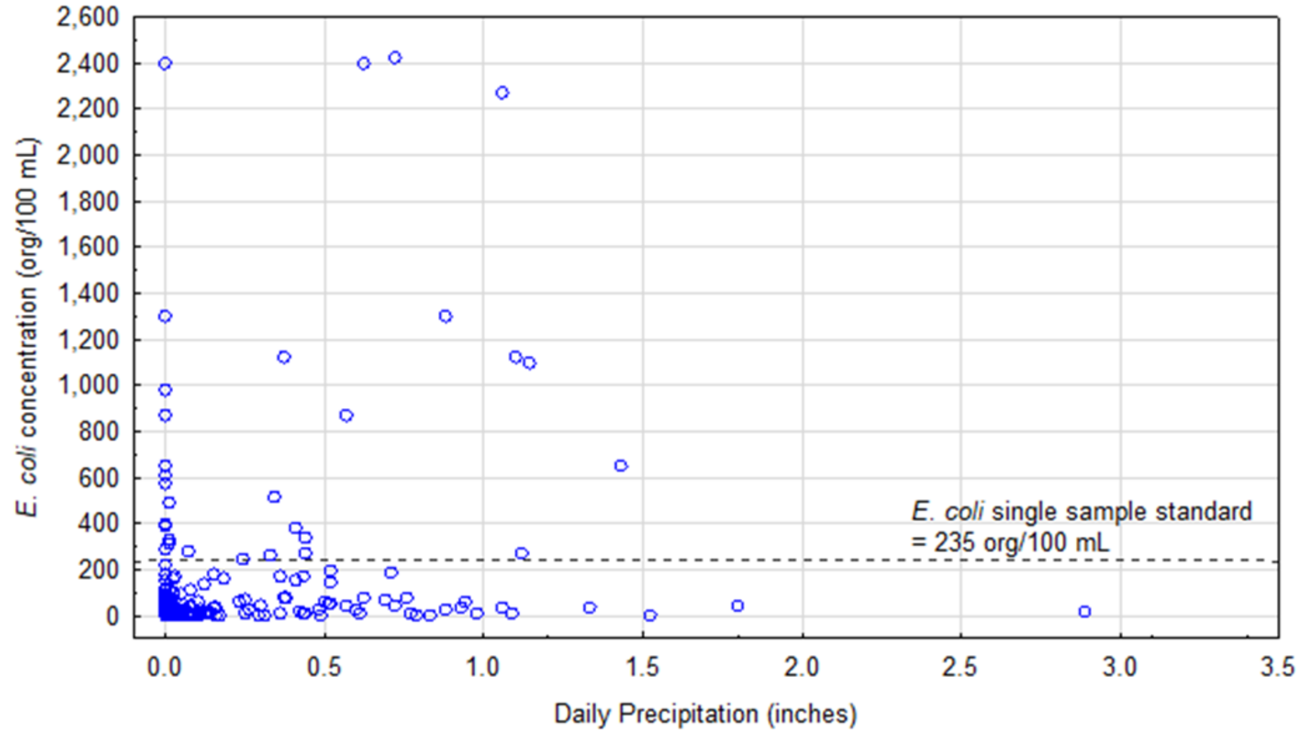


Figure 17. Two-day precipitation and *E. coli* concentration for Leif Erikson Park Beach.
Note: Two-day precipitation is the summation of precipitation that occurred on the day of the *E. coli* sample collection and the day before. "Dry" indicates no precipitation either day, "Mid" represents a summation 0.5 inches precipitation or less across the two days, and "Wet" represents a summation of more than 0.5 inches across the two days.

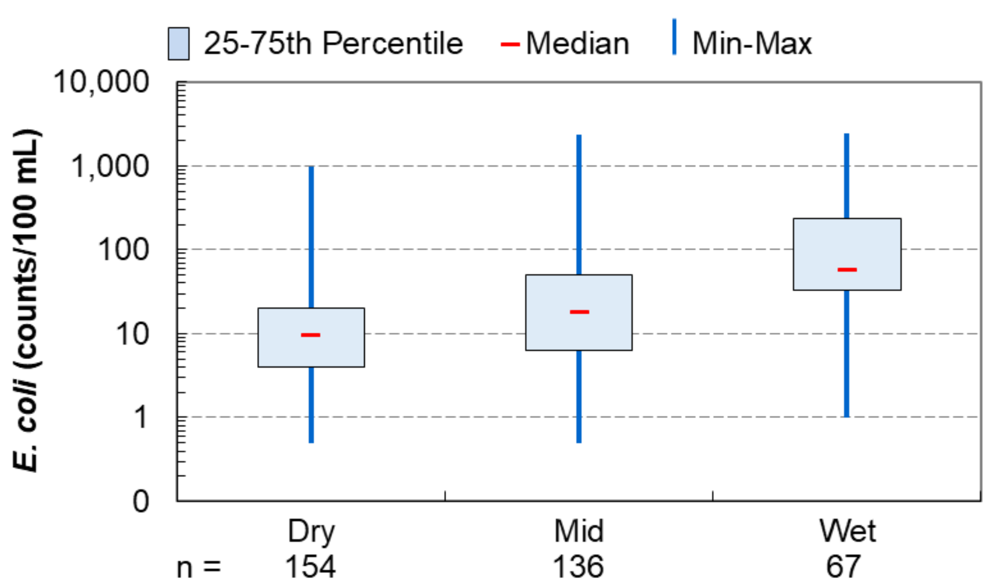
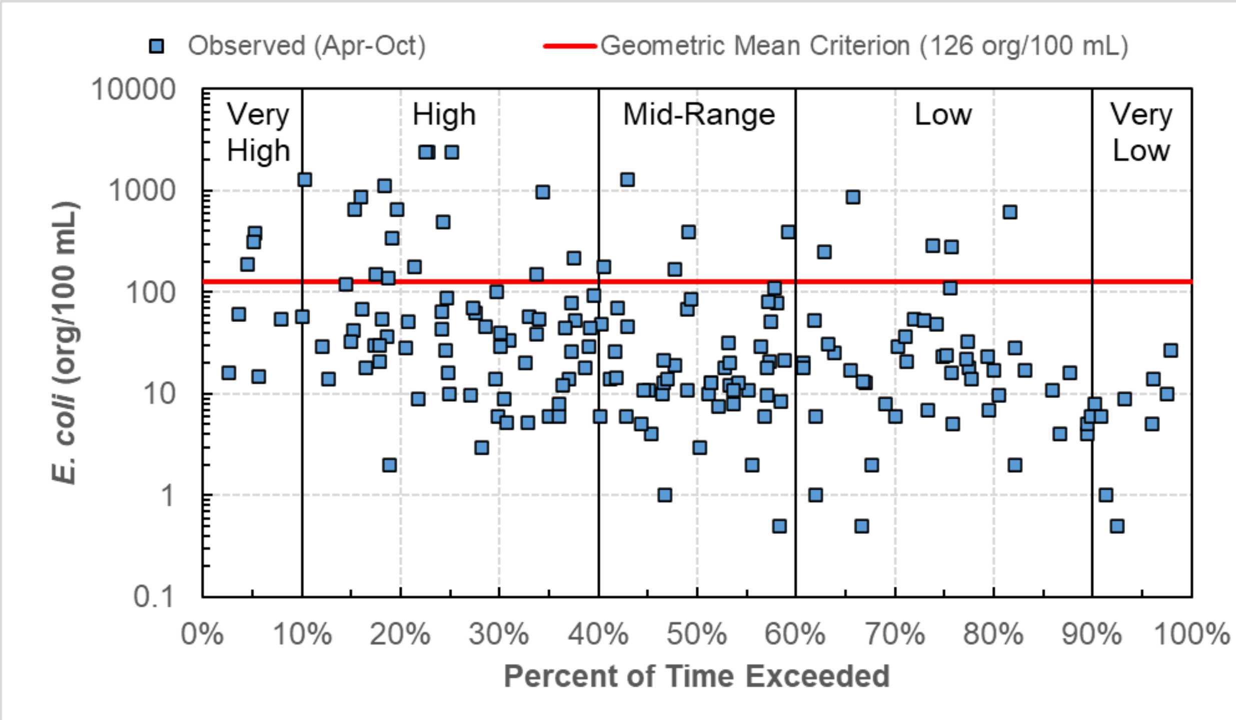


Figure 18. *E. coli* water quality duration curve, Leif Erikson Park Beach (04010102-C21).
E. coli concentrations from 2009 through 2016 are plotted; no flow data are available for 2017 and 2018 *E. coli* samples.



3.3.2 Minnesota Point 15th Street Harbor Side Beach (04010201-A90)

At Minnesota Point 15th Street Harbor Side Beach (Table 5, Figure 19), 25% of the August samples exceeded 235 org/100 mL. The single sample standard was exceeded most frequently in July (12 of 15 Julys, 80%), followed by August (11 of 16 Augusts, 69%). Exceedances of the monthly geometric mean standard occurred across all sampling months, with the exception of May. Additional monitoring was also conducted at monitoring site 16-0001-00-B107 in 2007. Exceedances of both standards were observed at this monitoring site.

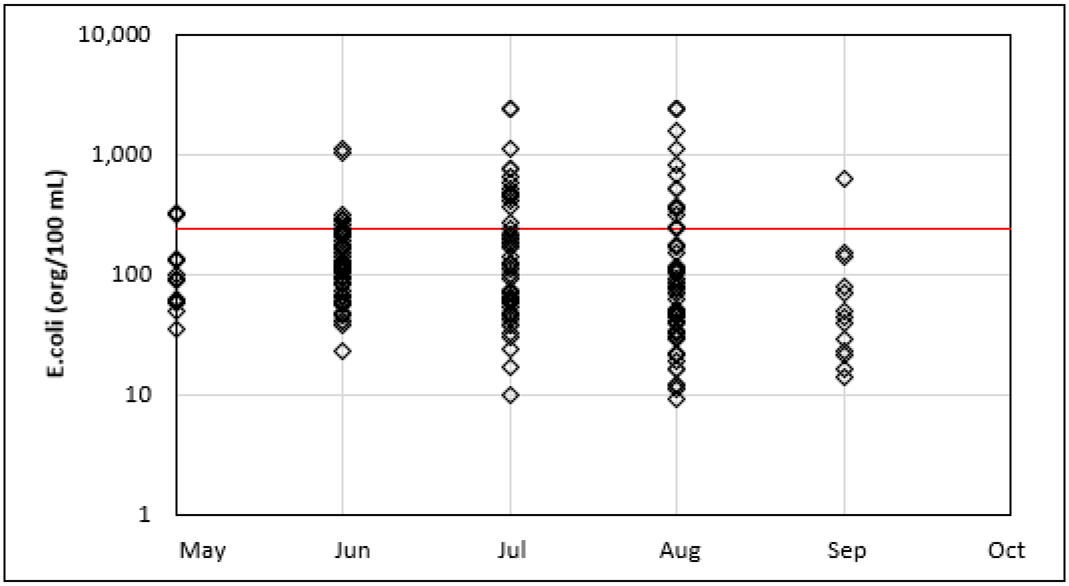
Table 5. Summary *of E. coli* exceedances at Minnesota Point 15th Street Harbor Side Beach (monitoring site 16-0001-00-B007).

Red text indicates months when the geometric mean standard of 126 org/100 mL was exceeded.

Year	Number of sampling days (n) and number of sampling days > 235 org/100 mL (>235) (maximum concentration in org/100 mL)											
	May		Jun		Jul		Aug		Sep		Oct	
	n	>235	n	>235	n	>235	n	>235	n	>235	n	>235
2003	1	0	5	0	11	3 (600)	11	5 (1,360)	9	4 (1,100)	4	0
2004	5	0	9	0	15	5 (700)	13	0	7	2 (500)	4	0
2005	6	0	9	2 (800)	12	2 (950)	13	3 (920)	10	2 (1,500)	7	3 (3,280)
2006	6	0	13	2 (816)	15	4 (6,158)	13	1 (247)	6	1 (670)	7	0
2007	6	0	22	6 (1,000)	30	1 (283)	36	6 (2,000)	17	1 (1,800)	6	0
2008	7	1 (249)	11	1 (308)	9	3 (1,414)	11	1 (397)	7	0	4	0
2009	5	0	10	1 (326)	9	1 (248)	10	1 (238)	4	0	-	–
2010	-	–	-	–	-	–	5	2 (1,050)	5	0	-	–
2011	3	0	9	1 (460)	3	1 (2,400)	15	7 (2,400)	13	4 (920)	-	–
2012	1	0	13	5 (2,400)	15	5 (2,400)	15	4 (650)	7	1 (240)	-	–
2013	2	0	8	0	14	4 (1,700)	11	1 (390)	6	1 (1,600)	-	–
2014	2	0	10	2 (308)	11	1 (270)	8	1 (820)	4	0	-	–
2015	2	0	10	2 (290)	10	0	9	1 (310)	6	0	-	–
2016	1	0	9	0	13	6 (>2,420)	18	8 (>2,420)	1	1 (613)	-	–
2017	4	0	12	1 (1,046)	11	5 (770)	14	3 (2,420)	2	0	-	–
2018	3	2 (326)	11	2 (1,120)	11	4 (649)	12	4 (>2,420)	-	–	-	–

–: No data

Figure 19. *E. coli* concentrations by month for the last five years of available data (2014–2018) at Minnesota Point 15th Street Harbor Side Beach (monitoring site 16-0001-00-B007).
Red line indicates single sample maximum standard of 235 org/100 mL.



A multi-linear regression model developed by Prihoda et al. (2017) to determine the sanitary survey, water quality, and climate parameters having the most influence on *E. coli* concentrations, found that one-week average flow rate through the Duluth Entry was the single most influential factor on *E. coli* concentration at the beach center. *E. coli* concentrations were typically lower when most of the water mass was moving into the St. Louis River Estuary from Lake Superior. Concentrations were typically higher when most of the water mass was moving out of the Estuary into the lake, which may represent runoff conditions from the St. Louis River and its tributaries.

Precipitation data from the Duluth International Airport (NOAA Gage: USW00014913) were used to determine the precipitation conditions under which *E. coli* exceedances occur. Daily precipitation, precipitation over two-day periods, and precipitation over three-day periods were evaluated. Linear regressions of these three precipitation datasets with *E. coli* concentrations yielded low coefficients of determination (R^2<0.01, R^2=0.02, R^2=0.02 [respectively]). Similar coefficients of determination were yielded for linear regressions of *E. coli* concentration with water temperature (R^2=0.05) and turbidity (R^2<0.01).

An analysis of *E. coli* concentrations with categorized precipitation over two-day periods (Figure 20) indicated a slight increase in concentrations from mid-range conditions (less than 0.5 inches of precipitation) to wet conditions (more than 0.5 inches of precipitation). Dry conditions (no precipitation) and mid-range conditions were very similar.

In a similar evaluation by month, in May, July, and August, *E. coli* concentrations varied over similar ranges for dry, mid-range, and wet conditions (Figure 21). In May, concentrations slightly increased from dry, to mid, to wet conditions. In September, concentrations during dry and mid-range conditions varied over the same range and concentrations during wet conditions varied over a higher interquartile range.

The Minnesota Point 15th Street Harbor Side Beach concentration-based duration curve is provided in Figure 22. Exceedances of the water quality standard are observed under all flow conditions.

Figure 20. Two-day precipitation and *E. coli* concentration for Minnesota Point 15th Street Harbor Side Beach.
Note: Two-day precipitation is the summation of precipitation that occurred on the day of the *E. coli* sample collection and the day before. "Dry" indicates no precipitation either day, "Mid" represents a summation 0.5 inches precipitation or less across the two days, and "Wet" represents a summation of more than 0.5 inches across the two days.

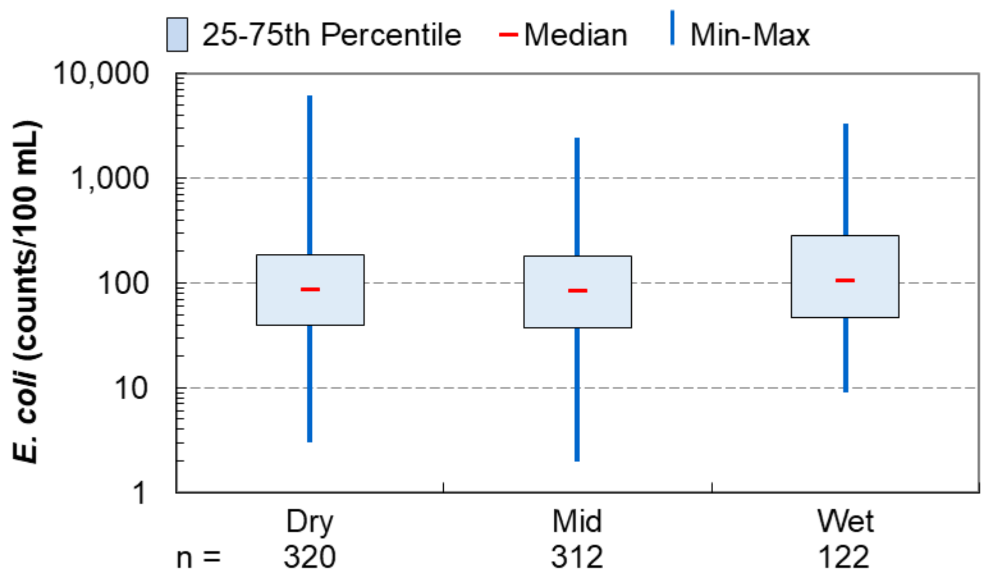


Figure 21. Two-day precipitation and *E. coli* concentration by month for Minnesota Point 15th Street Harbor Side Beach.
Note: Two-day precipitation is the summation of precipitation that occurred on the day of the *E. coli* sample collection and the day before *E. coli* sample collection. "Dry" indicates no precipitation either day, "Mid" represents a summation 0.5 inches precipitation or less across the two days, and "Wet" represents a summation of more than 0.5 inches across the two days.

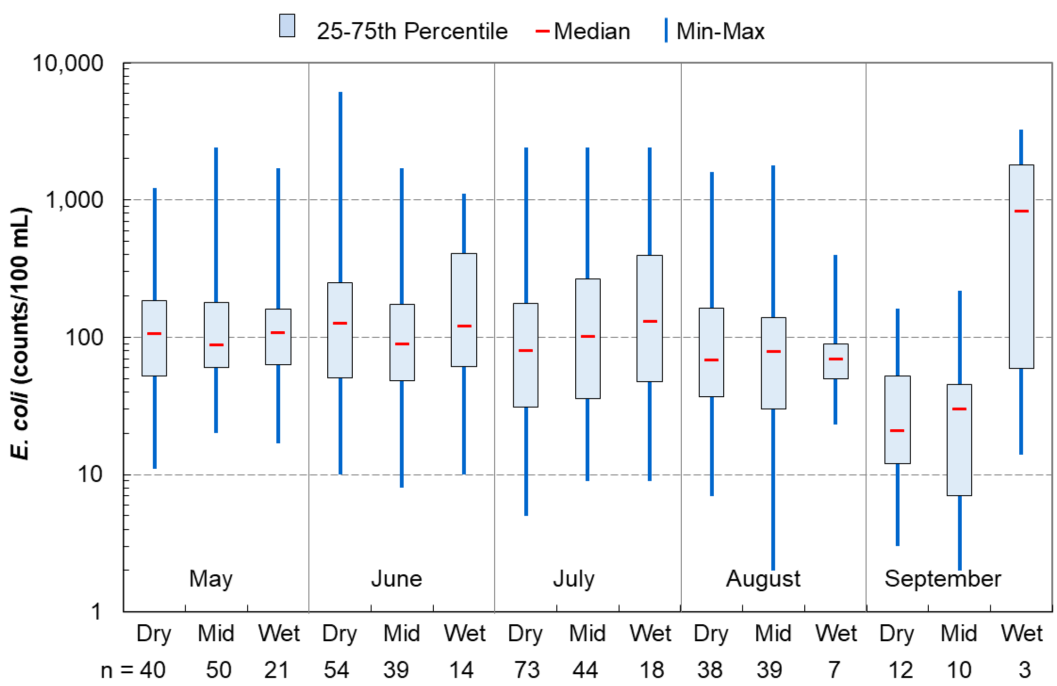
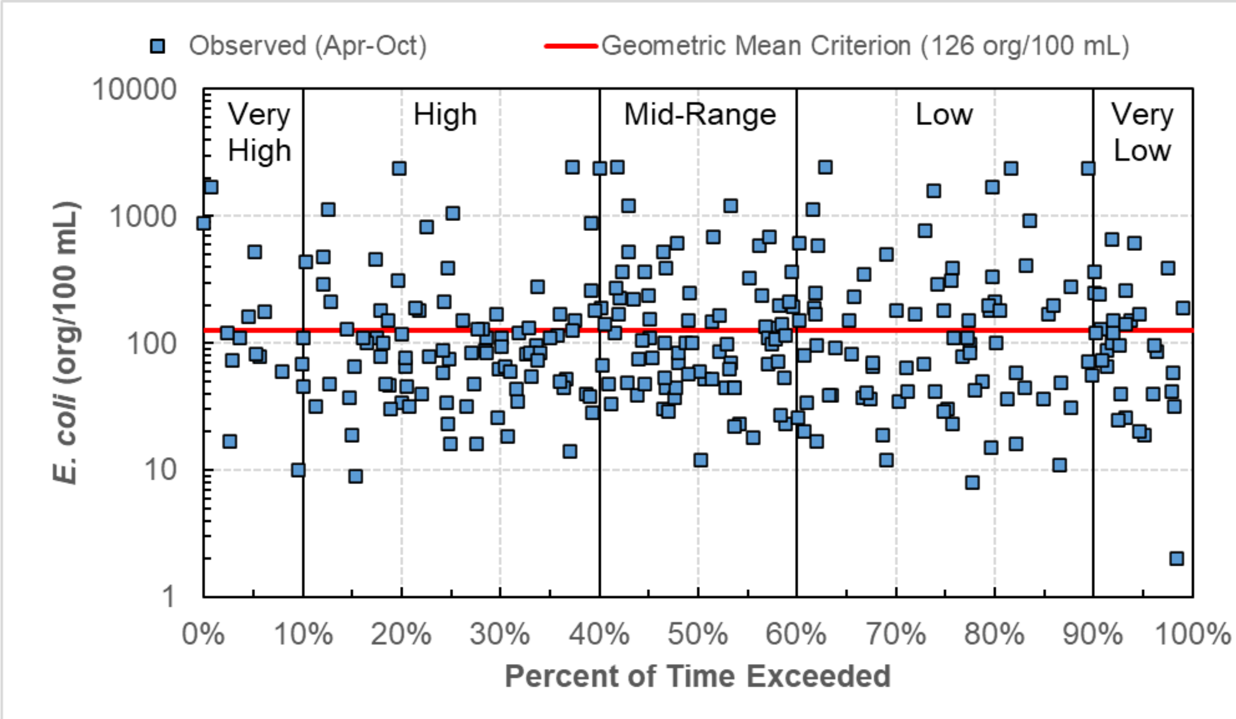


Figure 22. *E. coli* water quality duration curve, Minnesota Point 15th Street Harbor Side Beach (04010201-A90).
E. coli concentrations from 2009 through 2016 are plotted; no flow data are available for 2017 and 2018 *E. coli* samples.



3.3.3 Park Point 20th Street/Hearding Island Canal Beach (04010201-A89)

At Park Point 20th Street/Hearding Island Canal Beach (Table 6, Figure 23), 41% of the August samples exceeded 235 org/100 mL. The single sample standard was exceeded most frequently in August (9 of 10 Augusts, 90%) and July (8 of 9 Julys, 88%). Exceedances of the monthly geometric mean standard occurred across all months, with the exception of May.

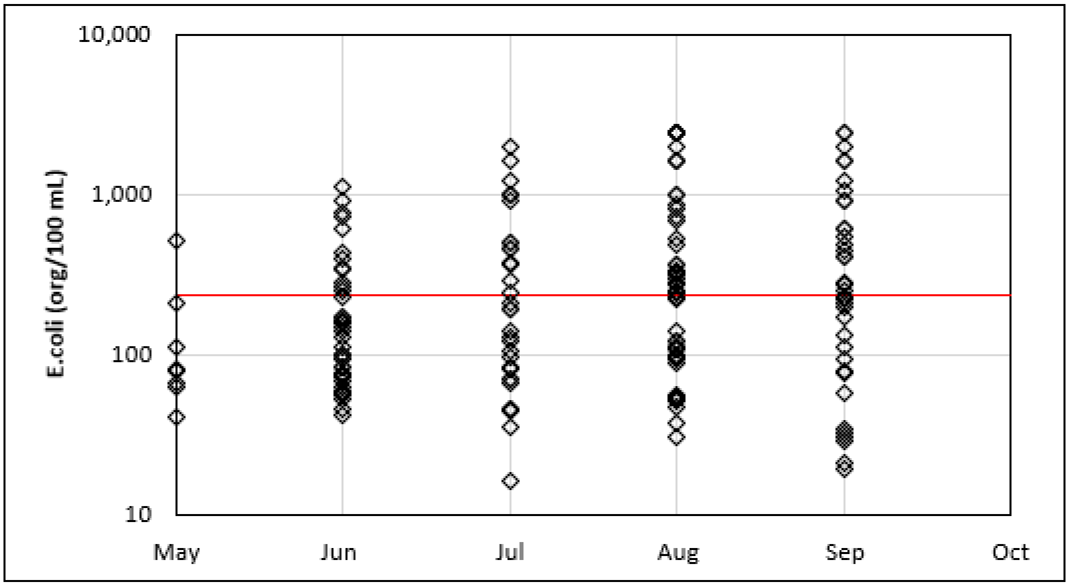
Table 6. Summary *of E. coli* exceedances at Park Point 20th Street/Hearding Island Canal Beach (monitoring site 16-0001-00-B037).
Red text indicates months when the geometric mean standard of 126 org/100 mL was exceeded.

Year	Number of sampling days (n) and number of days > 235 org/100 mL (>235) (maximum concentration in org/100 mL)											
	May		Jun		Jul		Aug		Sep		Oct	
	n	>235	n	>235	n	>235	n	>235	n	>235	n	>235
2004	5	0	11	1 (600)	16	7 (3,370)	16	7 (1,600)	8	4 (650)	4	1 (240)
2005	6	0	9	0	14	7 (830)	16	4 (2,000)	13	6 (900)	4	1 (348)
2006	6	0	13	1 (251)	15	4 (1,620)	17	3 (700)	7	3 (1,300)	7	2 (1,000)
2007	6	1 (414)	13	5 (541)	10	2 (631)	15	8 (4,000)	9	5 (1,200)	6	3 (1,500)
2008	6	0	10	0	10	3 (345)	8	0	6	0	4	0
2009	5	0	13	4 (488)	9	0	9	3 (488)	5	1 (387)	-	–
2010	-	–	-	–	-	–	5	2 (727)	7	4 (1,050)	-	–
2011	3	1 (517)	13	4 (1,100)	4	4 (2,000)	19	17 (2,400)	15	9 (2,400)	-	–
2012	1	0	13	6 (920)	16	7 (1,600)	16	8 (2,400)	11	6 (2,000)	-	–
2013	2	0	11	2 (730)	13	4 (1,000)	12	3 (330)	3	0	-	–
2014	2	0	5	1 (280)	-	–	-	–	-	–	-	–

–: No data

Figure 23. *E. coli* concentrations by month for the last five years of available data (2010–2014) at Park Point 20th Street/Hearding Island Canal Beach (monitoring site 16-0001-00-B037).

Red line indicates single sample maximum standard of 235 org/100 mL.



Precipitation data from the Duluth International Airport (NOAA Gage: USW00014913) were used to determine the precipitation conditions under which *E. coli* exceedances occur. Daily precipitation, precipitation over two-day periods, and precipitation over three-day periods were evaluated. Linear regressions of these three precipitation datasets with *E. coli* concentrations yielded low coefficients of determination (R^2<0.01, R^2=0.01, and R^2<0.01 [respectively]). Similar coefficients of determination were yielded for linear regressions of *E. coli* concentration with water temperature (R^2=0.06) and turbidity (R^2<0.01).

An analysis of *E. coli* concentrations with categorized precipitation over two-day periods (Figure 24) indicated a slight increase in concentrations from mid-range conditions (less than 0.5 inches of precipitation) to wet conditions (more than 0.5 inches of precipitation). Dry conditions (no precipitation) and mid-range conditions were very similar.

A similar evaluation by month was inconclusive. The interquartile range of *E. coli* concentrations during wet conditions was often at higher *E. coli* concentrations. However, the ranges and interquartile ranges of *E. coli* concentration for each condition tended to vary over similar ranges and interquartile ranges of at least one other condition.

The concentration-based duration curve for Park Point 20th Street/Hearding Island Canal Beach is provided in Figure 25. Exceedances of the water quality standard are seen across all flow conditions.

Figure 24. Two-day precipitation and *E. coli* concentration for Park Point 20th Street/Hearding Island Canal Beach.
Note: Two-day precipitation is the summation of precipitation that occurred on the day of the *E. coli* sample collection and the day before. "Dry" indicates no precipitation either day, "Mid" represents a summation 0.5 inches precipitation or less across the two days, and "Wet" represents a summation of more than 0.5 inches across the two days.

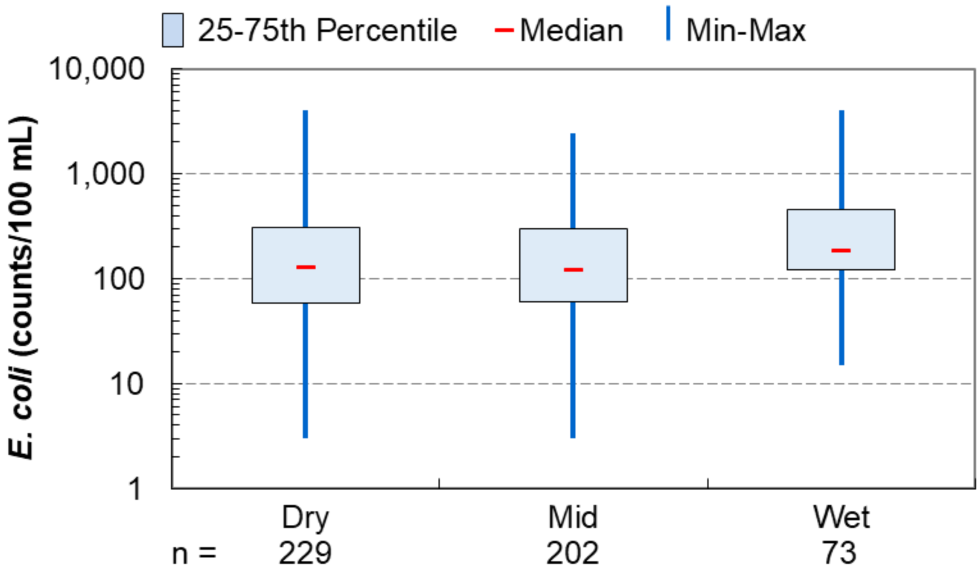
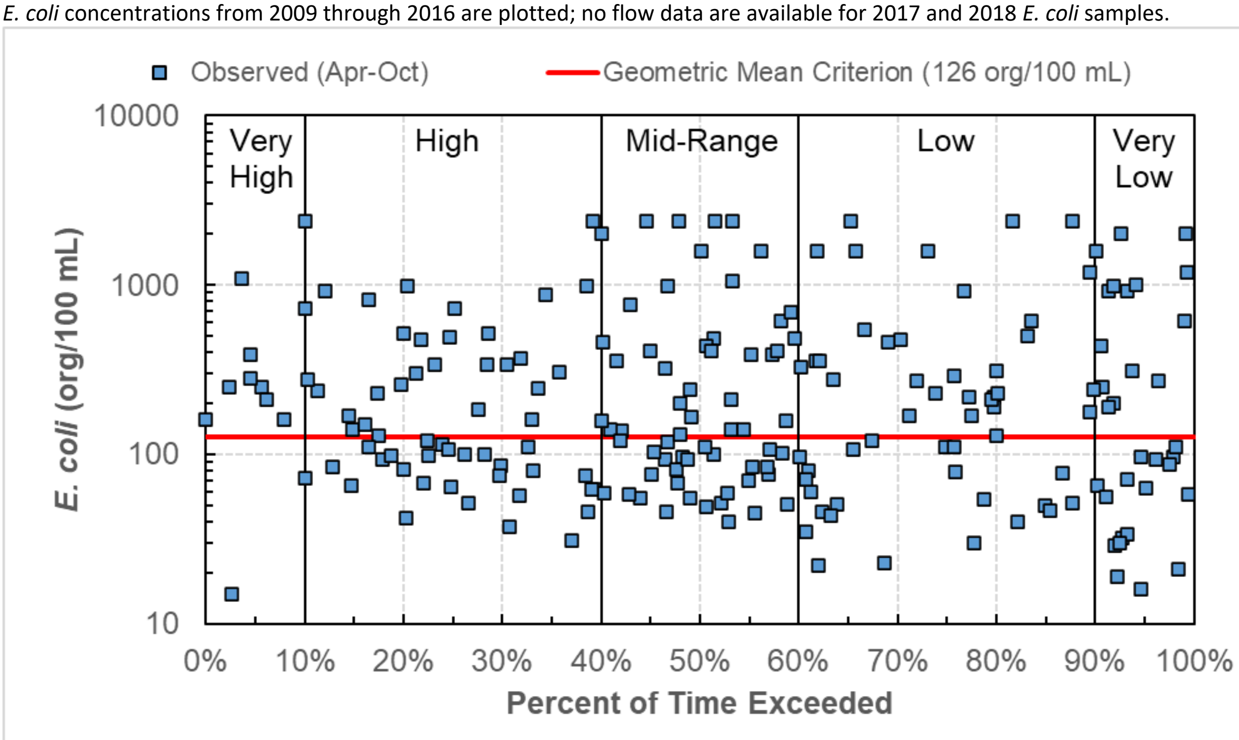


Figure 25. *E. coli* water quality duration curve, Park Point 20th Street/Hearding Island Canal Beach (04010201-A89).
E. coli concentrations from 2009 through 2016 are plotted; no flow data are available for 2017 and 2018 *E. coli* samples.



3.3.4 Park Point Sky Harbor Parking Lot Beach (04010201-A87)

At Park Point Sky Harbor Parking Lot Beach (Table 7, Figure 26), 14% of the August samples exceeded 235 org/100 mL. The single sample standard was exceeded most frequently in July (10 of 15 Julys, 67%), followed by August (7 of 16 Augusts, 44%). Exceedances of the monthly geometric mean standard were observed in July and August.

Table 7. Summary *of E. coli* exceedances at Park Point Sky Harbor Parking Lot Beach (monitoring site 16-0001-00-B004).

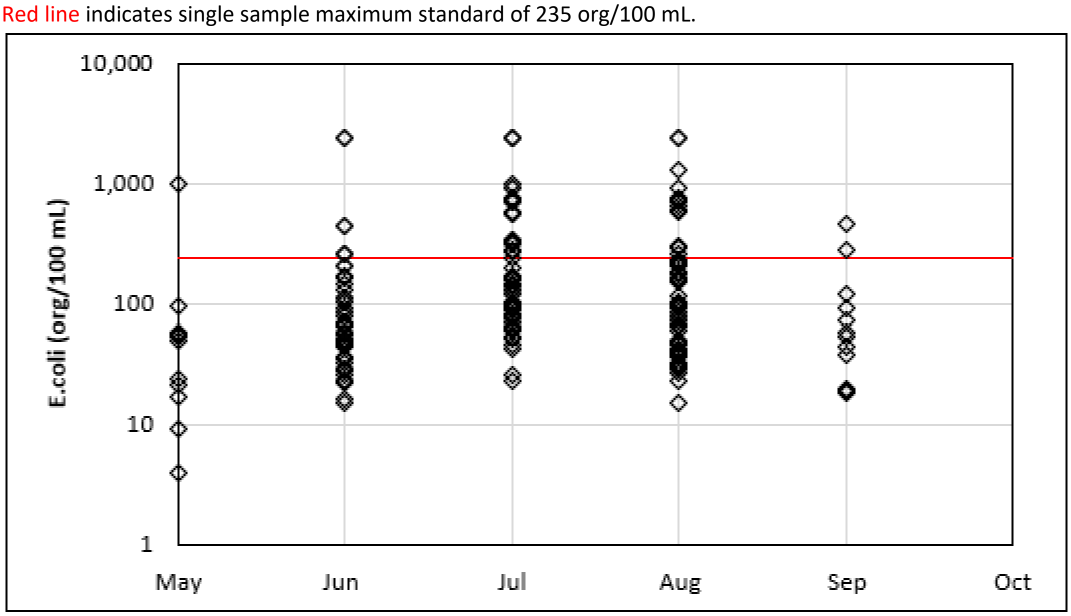
Red text indicates months when the geometric mean standard of 126 org/100 mL was exceeded.

Year	Number of sampling days (n) and number of sampling days > 235 org/100 mL (>235) (maximum concentration in org/100 mL)											
	May		Jun		Jul		Aug		Sep		Oct	
	n	>235	n	>235	n	>235	n	>235	n	>235	n	>235
2003	1	0	5	0	4	0	5	0	5	0	4	0
2004	5	0	9	0	9	0	9	0	7	0	4	0
2005	6	0	9	0	8	1 (800)	9	0	7	0	4	0
2006	6	0	9	0	9	0	9	0	6	0	5	0
2007	6	0	10	1 (283)	7	0	9	0	6	0	5	0
2008	6	0	9	0	8	2 (1,553)	10	1 (236)	6	0	4	0
2009	5	0	9	0	9	1 (308)	11	2 (488)	4	0	-	–
2010	-	–	-	–	-	–	4	1 (2,420)	6	2 (488)	-	–
2011	2	0	8	0	2	0	11	2 (610)	8	0	-	–
2012	1	0	9	3 (2,400)	17	9 (2,000)	10	1 (1,700)	6	0	-	–
2013	2	0	8	0	14	4 (649)	10	2 (310)	5	0	-	–
2014	2	0	9	0	11	4 (730)	15	9 (2,400)	4	2 (460)	-	–
2015	2	0	14	3 (2,400)	15	7 (2,400)	9	0	6	0	-	–
2016	1	0	9	0	13	6 (2,420)	13	1 (261)	-	–	-	–
2017	4	1 (980)	9	4 (2,420)	10	2 (579)	9	1 (727)	2	0	-	–
2018	2	0	8	0	8	2 (326)	11	2 (2,420)	-	–	-	–

–: No data

Figure 26. *E. coli* concentrations by month for the last five years of available data (2014–2018) at Park Point Sky Harbor Parking Lot Beach (monitoring site 16-0001-00-B004).

Red line indicates single sample maximum standard of 235 org/100 mL.



Precipitation data from Duluth International Airport (NOAA Gage: USW00014913) were used to determine the precipitation conditions under which *E. coli* exceedances occur. Daily precipitation, precipitation over two-day periods, and precipitation over three-day periods were evaluated. Linear regressions of these three precipitation datasets with *E. coli* concentrations yielded low coefficients of determination (R^2<0.01, R^2=0.04, and R^2=0.03 [respectively]). Similar coefficients of determination were yielded for linear regressions of *E. coli* concentration with water temperature (R^2=0.02) and turbidity (R^2<0.01).

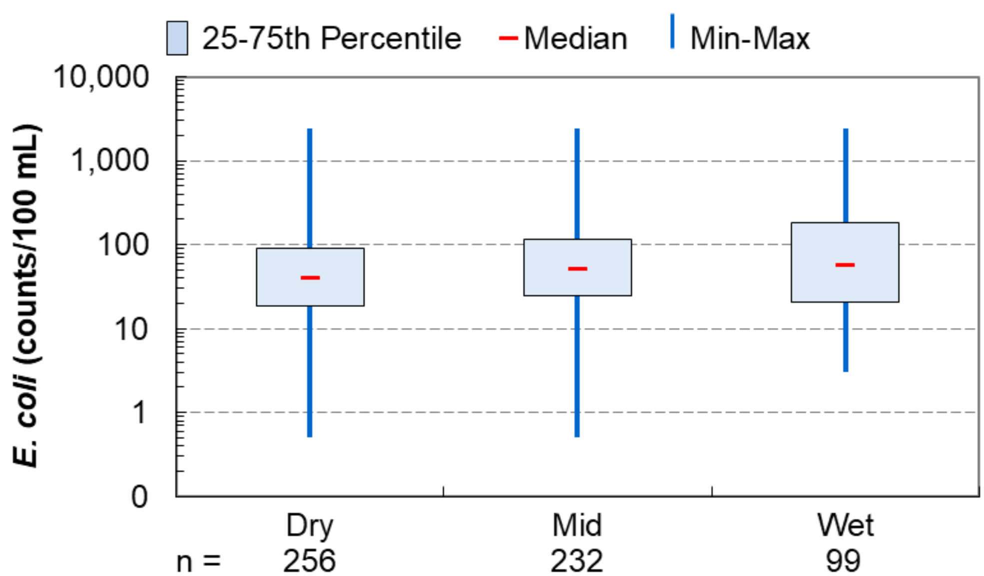
A Kendall Tau correlation analysis was conducted for bacteria-impaired beaches in the Duluth Urban Area WRAPS (MPCA 2020b). There was an increasing trend (p<0.05) of annual percent of the *E. coli* measurements that exceed the maximum standard (235 org/100 mL) for Park Point Sky Harbor Parking Lot Beach from 2003 through 2016.

An analysis of *E. coli* concentrations with categorized precipitation over two-day periods was conducted (Figure 27). *E. coli* concentrations varied over similar ranges and interquartile ranges during dry conditions (no precipitation), mid-range conditions (less than 0.5 inches of precipitation), and wet conditions (more than 0.5 inches of precipitation).

A similar evaluation by month was inconclusive. Except for July, which showed a very slight increase from dry, to mid-range, to wet conditions, the ranges and interquartile ranges of *E. coli* concentrations during for each condition tended to vary over similar ranges and interquartile ranges of at least one other condition.

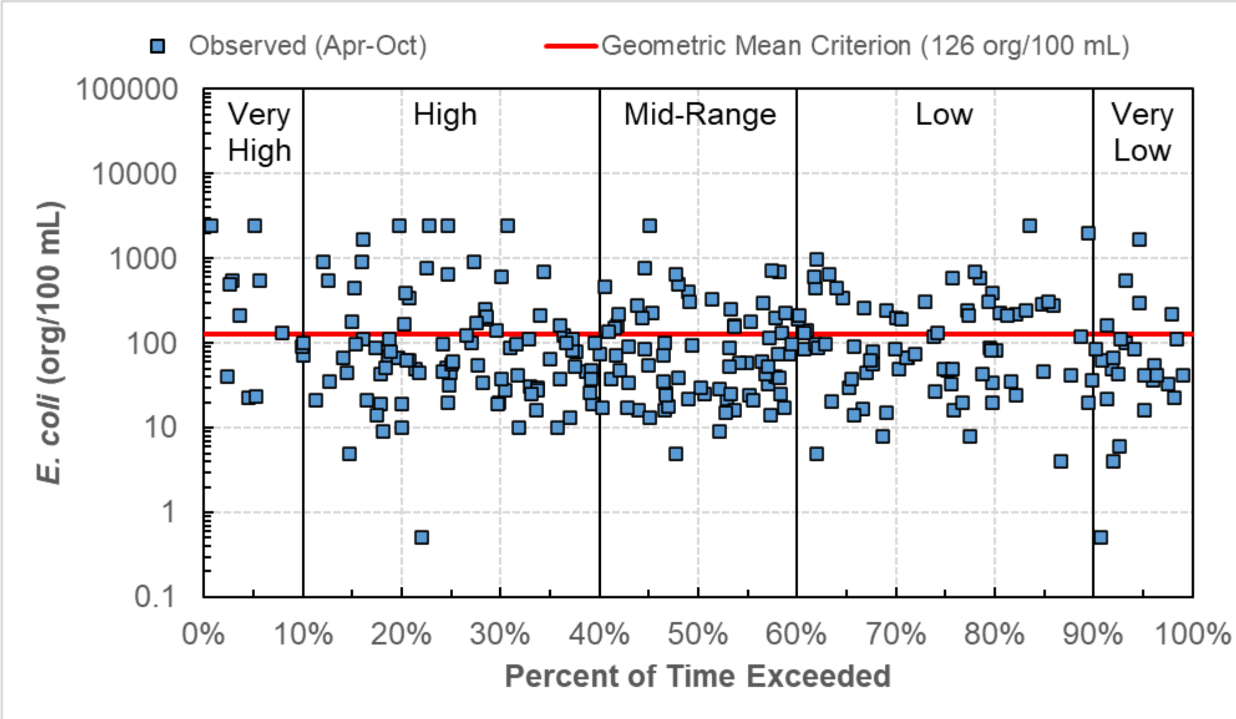
The concentration-based duration curve for Park Point Sky Harbor Parking Lot Beach is provided in Figure 28. Exceedances of the water quality standard are seen across all flow conditions.

Figure 27. Two-day precipitation and *E. coli* concentration for Park Point Sky Harbor Parking Lot Beach.



Note: Two-day precipitation is the summation of precipitation that occurred on the day of the *E. coli* sample collection and the day before. “Dry” indicates no precipitation either day, “Mid” represents a summation 0.5 inches precipitation or less across the two days, and “Wet” represents a summation of more than 0.5 inches across the two days.

Figure 28. *E. coli* water quality duration curve, Park Point Sky Harbor Parking Lot Beach (04010201-A87).
E. coli concentrations from 2009 through 2016 are plotted; no flow data are available for 2017 and 2018 *E. coli* samples.



3.3.5 Boy Scout Landing Beach (04010201-A92)

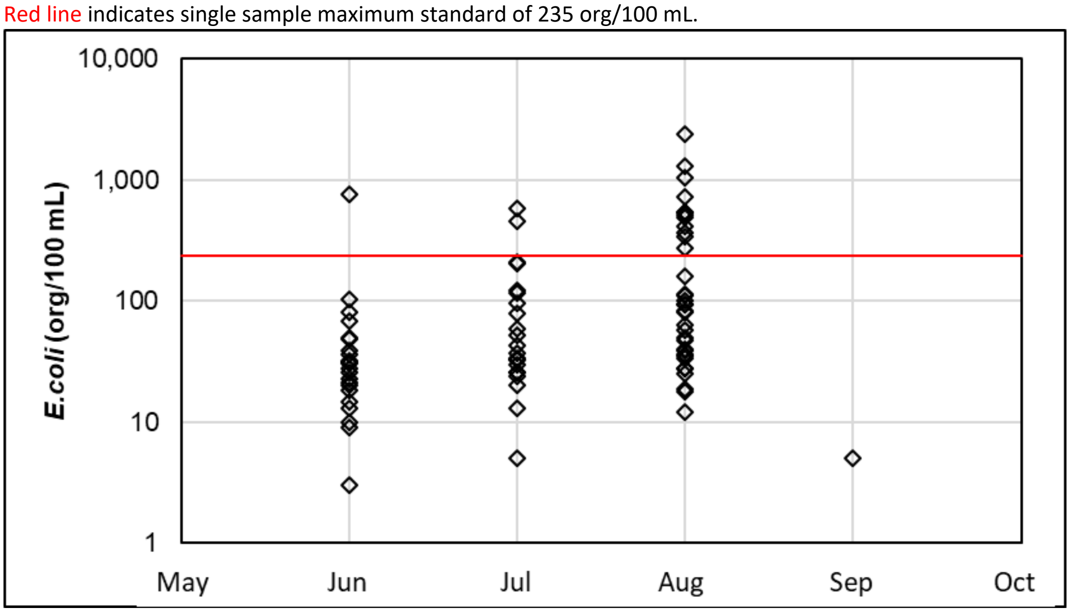
At Boy Scout Landing Beach (Table 8, Figure 29), 18% of the August samples exceeded 235 org/100 mL. The single sample standard was exceeded most frequently in June (4 of 14 Junes, 29%) and August (3 of 14 Augusts, 21%). Exceedances of the monthly geometric mean standard were observed in August 2016 and August 2017.

Table 8. Summary *of E. coli* exceedances at Boy Scout Landing Beach (monitoring site 16-0001-00-B001).
Red text indicates months when the geometric mean standard of 126 org/100 mL was exceeded.

Year	Number of sampling days (n) and number of sampling days > 235 org/100 mL (>235) (maximum concentration in org/100 mL)											
	May		Jun		Jul		Aug		Sep		Oct	
	n	>235	n	>235	n	>235	n	>235	n	>235	n	>235
2003	1	0	5	1 (265)	7	0	5	0	2	0	-	--
2004	1	0	5	0	4	0	5	0	2	0	-	--
2005	2	0	6	0	6	0	5	0	3	1 (386)	3	1 (1,710)
2006	2	0	4	0	5	0	4	0	2	0	-	--
2007	2	0	-	--	-	--	4	0	2	0	-	--
2008	1	0	3	0	4	0	4	0	2	0	-	--
2009	2	0	4	0	6	1 (299)	4	0	2	0	-	--
2010	-	--	-	--	-	--	2	0	2	0	-	--
2011	1	0	4	0	1	0	11	3 (1,700)	4	0	-	--
2012	-	--	4	1 (1,600)	5	0	3	0	-	--	-	--
2013	-	--	6	2 (395)	2	0	-	--	-	--	-	--
2014	-	--	5	0	4	0	4	0	-	--	-	--
2015	-	--	5	0	4	0	4	0	1	0	-	--
2016	-	--	4	0	6	2 (579)	11	4 (517)	-	--	-	--
2017	-	--	4	0	3	0	13	8 (>2,420)	-	--	-	--
2018	-	--	5	1 (770)	6	--	3	--	-	--	-	--

–: No data

Figure 29. *E. coli* concentrations by month for the last five years of available data (2014–2018) at Boy Scout Landing Beach (monitoring site 16-0001-00-B001).
Red line indicates single sample maximum standard of 235 org/100 mL.



Precipitation data from the Duluth International Airport (NOAA Gage: USW00014913) were used to determine the precipitation conditions under which *E. coli* exceedances occur. Daily precipitation, precipitation over two-day periods, and precipitation over three-day periods were evaluated. Linear regressions of these three precipitation datasets with *E. coli* concentrations yielded low coefficients of determination (R^2=0.04, R^2=0.13, and R^2=0.20 [respectively]).

An analysis of *E. coli* concentrations with categorized precipitation over two-day periods (Figure 30) indicated a slight increase in concentrations from mid-range conditions (less than 0.5 inches of precipitation) to wet conditions (more than 0.5 inches of precipitation). Dry conditions (no precipitation) and mid-range conditions were very similar.

In a similar evaluation by month, in May, June, and July, *E. coli* concentrations varied over similar ranges for dry, mid-range, and wet conditions (Figure 31). However, the interquartile ranges of the wet conditions tended to have larger concentrations than the other conditions. Too few data are available for August and September to draw any conclusions.

The concentration-based duration curve for Boy Scout Landing Beach is provided in Figure 32. Exceedances of the water quality standard were seen across the very high through low flow zones.

Figure 30. Two-day precipitation and *E. coli* concentration for Boy Scout Landing Beach.

Note: Two-day precipitation is the summation of precipitation that occurred on the day of the *E. coli* sample collection and the day before. "Dry" indicates no precipitation either day, "Mid" represents a summation 0.5 inches precipitation or less across the two days, and "Wet" represents a summation of more than 0.5 inches across the two days.

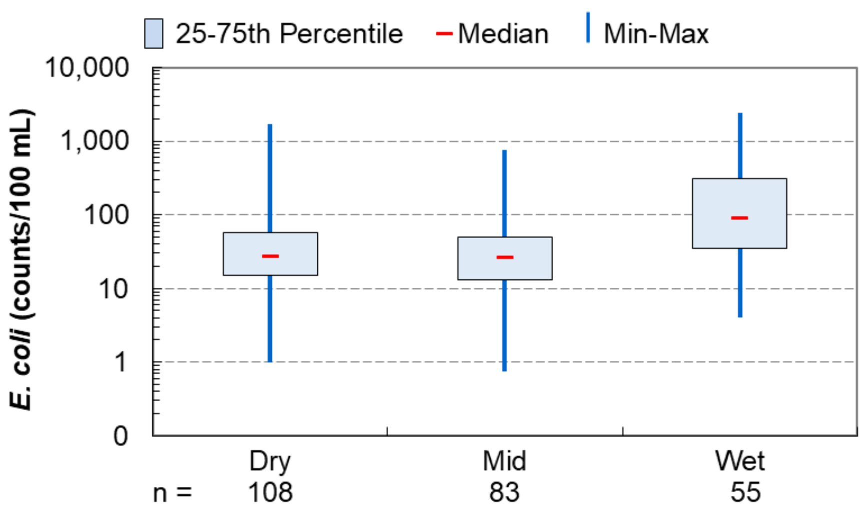


Figure 31. Two-day precipitation and *E. coli* concentration by month for Boy Scout Landing Beach.
Note: Two-day precipitation is the summation of precipitation that occurred on the day of the *E. coli* sample collection and the day before. "Dry" indicates no precipitation either day, "Mid" represents a summation 0.5 inches precipitation or less across the two days, and "Wet" represents a summation of more than 0.5 inches across the two days.

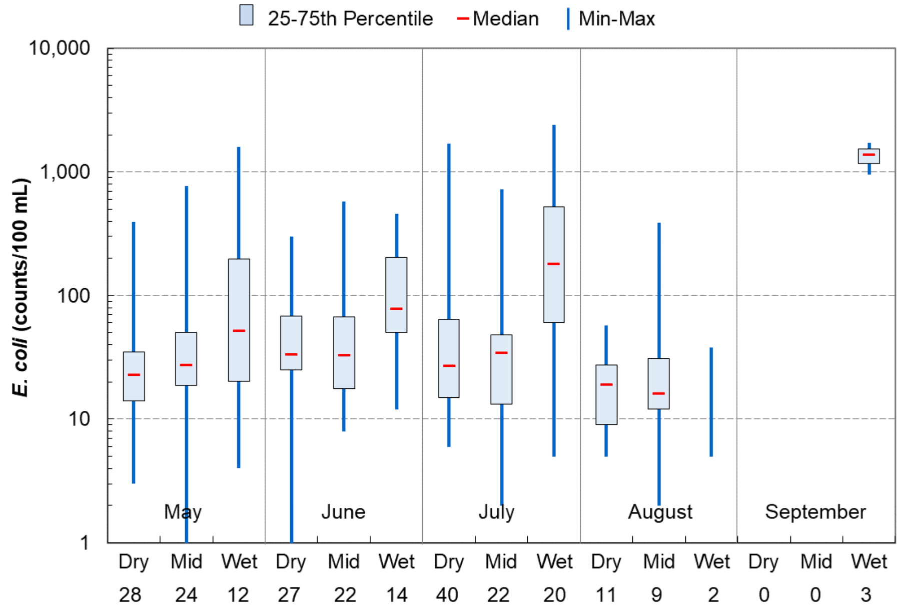
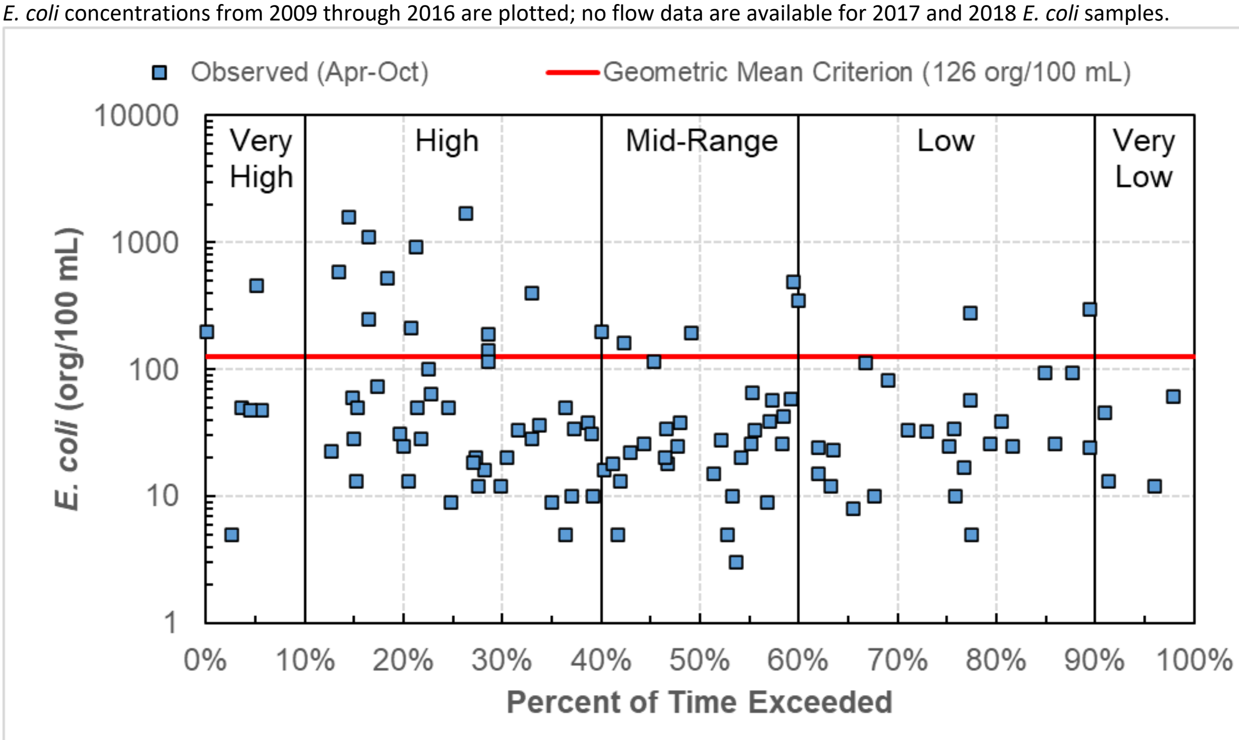


Figure 32. *E. coli* water quality duration curve, Boy Scout Landing Beach (04010201-A92).
E. coli concentrations from 2009 through 2016 are plotted; no flow data are available for 2017 and 2018 *E. coli* samples.



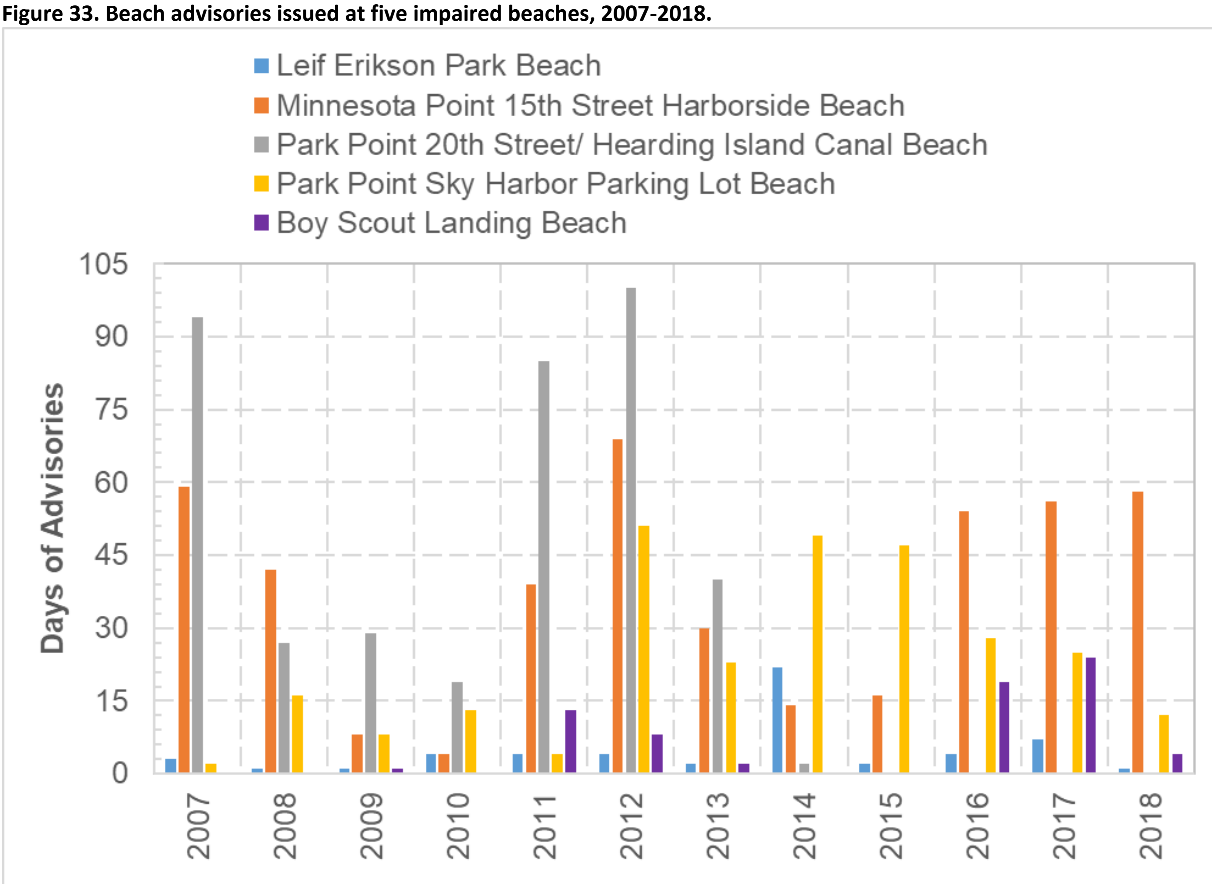
3.4 Beach advisory days

Many Great Lakes beaches in Minnesota are monitored by the MDH or local agencies to determine if the beaches are suitable for recreation. When bacteria levels exceed acceptable levels, health advisories are posted. Beaches along the north shore of Lake Superior are regularly monitored as part of the Coastal

Swimming Beach Monitoring Program that is funded by EPA under the BEACH Act of 2000. In addition to water quality monitoring at the beaches, the Minnesota Lake Superior Beach Monitoring Program includes nowcast models that predict water quality. The water quality nowcast models provide information *on E. coli* levels similar to the way a daily weather forecast provides the likelihood of rain or sun. The nowcast models use available weather and physical data (e.g., rainfall, cloud cover, wave height, water clarity, and temperature) to estimate *E. coli* counts. Based upon nowcast predictions, MDH can issue same-day beach closures, in lieu of waiting for sample collection and laboratory analysis. Monitoring data, nowcast predictions, and beach advisories data are stored in EPA's Beach Advisory and Closing Online Notification (BEACON) 2.0[5].

Beach advisories data were available for all five impaired beaches addressed in this TMDL. The period of record varied by beach, beginning in 2004, 2005, and 2007. Except for Park Point 20th Street/Hearding Island Canal Beach, data were available through 2018. The number of beach advisories per year at each impaired beach are presented in Figure 33.

Figure 33. Beach advisories issued at five impaired beaches, 2007-2018.



Note: No beach advisory data are available for Park Point 20th Street/Hearding Island Canal Beach after 2014.

[5] Minnesota data are accessible using EPA's BEACON 2.0 website: https://watersgeo.epa.gov/beacon2/.

3.5 *E. coli* source assessment

An *E. coli* source assessment project was conducted in 2019 and 2020 by MPCA, Tetra Tech, MDH, SSLSWCD, Source Molecular, and Pace Analytical to better inform this TMDL of potential sources of *E. coli* to the impaired beaches. Results of the source assessment are provided in Section 3.6. Sources of *E. coli* are widespread and often intermittent. Some sources, such as human derived sources, pose a greater risk to human health than others. Understanding the different source contributions and their potential risk to human health is important to overall TMDL implementation and prioritizing implementation activities that address the recreational use impairments due to *E. coli*. To better identify the source contributions to impaired beaches and therefore support TMDL implementation, a detailed, multi-step source assessment was conducted. The source identification process included the following steps:

1. **A Planning Level Source Assessment** to identify the "first-cut" of potential sources of pathogens to the impaired beaches and potential areas influencing beach water quality
2. **Field Data Collection** to obtain water quality data and observe beach conditions
3. **MST** in order to confirm potential sources using DNA biomarker assessment

A summary of each step of the source identification process is provided in the following subsections.

3.5.1 Planning level source assessment

The planning level source assessment was conducted using: GIS desktop analyses; aerial photo and street view assessments; an evaluation of water quality data; findings from previous studies, including the Bacterial Source Tracking at Impaired Beaches in the St. Louis River AOC final report (Prihoda et al. 2017) and the Duluth Urban Area Streams TMDL (MPCA 2020a); and an initial review of information collected online, from stakeholders, and other local sources. The information gathered in this planning level source assessment was used to guide the monitoring and surveying recommendations for the field data collection step and "first-cut" assessment results were refined in the next steps of the source assessment process.

3.5.2 Field data collection

Field data collection further refined the results of the planning level source assessment and consisted of two efforts: water sample collection and beach surveys and observations. Data collection occurred during 2019 and 2020. These data were used only in the *E. coli* source assessment process for the Duluth Beaches TMDL. Sampling was conducted by the MDH with support from the SSLSWCD. Beach surveys were conducted by the SSLSWCD.

3.5.2.1 Water sample collection

MDH, with support from the SSLSWCD, conducted water quality sampling on impaired beaches to support source assessment analysis for this TMDL in 2019 and 2020. MDH sampled beaches on Tuesdays and Wednesdays from the last week in May through the first week in September (note, MDH no longer samples at 20th Street/Hearding Island Canal Beach). Additional sampling by the SSLSWCD was conducted to ensure that both wet and dry conditions were represented in the samples. Daily rainfall data were tracked by the SSLSWCD to determine when to conduct the additional wet and dry sampling. Samples were also collected for Leif Erikson Park Beach at the outlet of Chester Creek and at a stormsewer outfall southwest of the beach, following the recommendation by Prihoda et al. (2017), and at the mouth of Sargent Creek for Boy Scout Landing Beach. Locations of sample collection are provided in Table 9 and in Figure 34 through Figure 36. Results of the 2020 water sample collection are provided in Appendix A.

Table 9. Water sample collection locations for the *E. coli* source assessment analysis.

Beach	Location (Latitude, Longitude)
Leif Erikson Park Beach	MDH routine monitoring site (46.796663, -92.081868)
	North Leif Erikson (46.79719, -92.08122)
	South Leif Erikson (46.795648, -92.083167)
	Stormwater outfall (south end of beach) (46.79585, -92.08289)
	Chester Creek outlet (46.797383, -92.079322)
Minnesota Point 15th Street Harbor Side Beach	MDH routine monitoring site (46.769025, -92.089823)
Park Point 20th St/Hearding Island Canal Beach	Previous MDH routine monitoring site (46.762762, -92.086212)
Park Point Sky Harbor Parking Lot Beach	MDH routine monitoring site (46.727892, -92.048487)
Boy Scout Landing Beach	MDH routine monitoring site (46.653409, -92.226583)
	Sargent Creek outlet (46.654253, -92.227659)

Figure 34. Water sample collection locations for Leif Erikson Park Beach *E. coli* source assessment analysis.

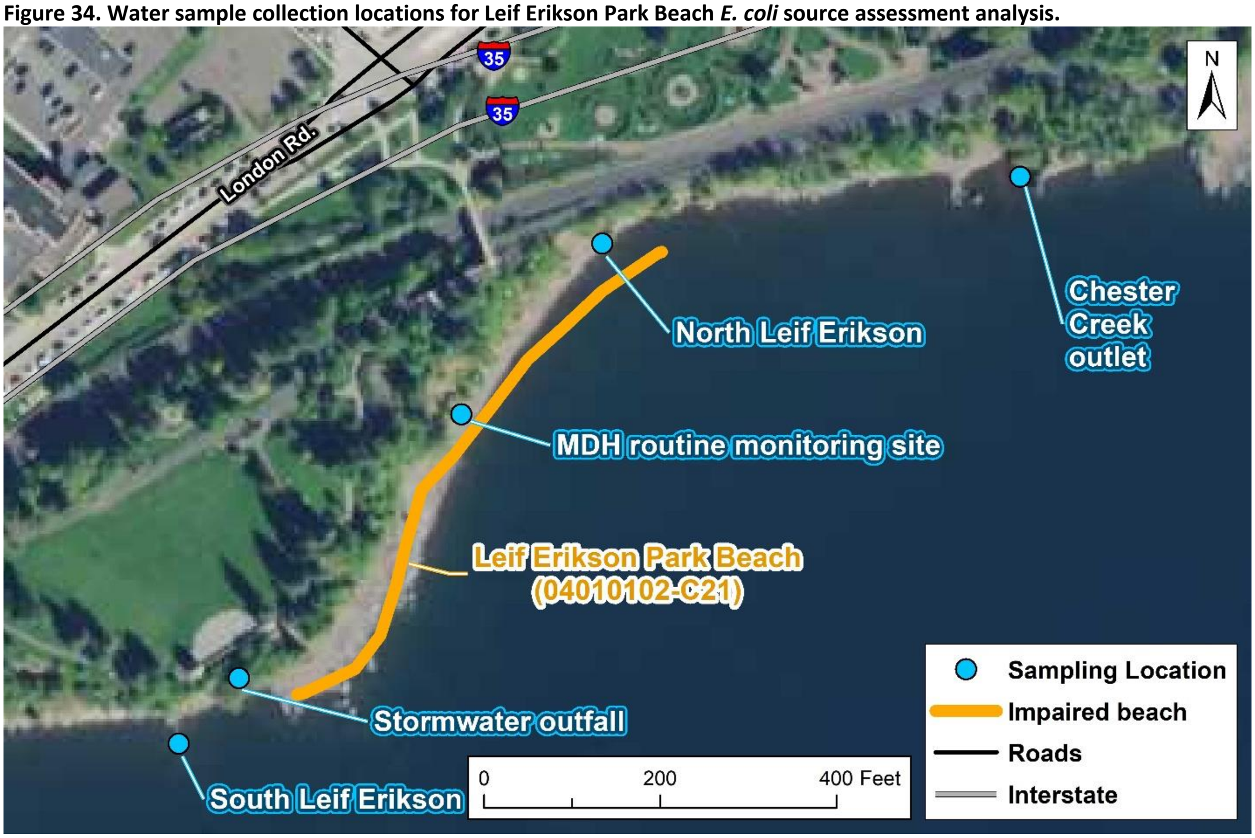
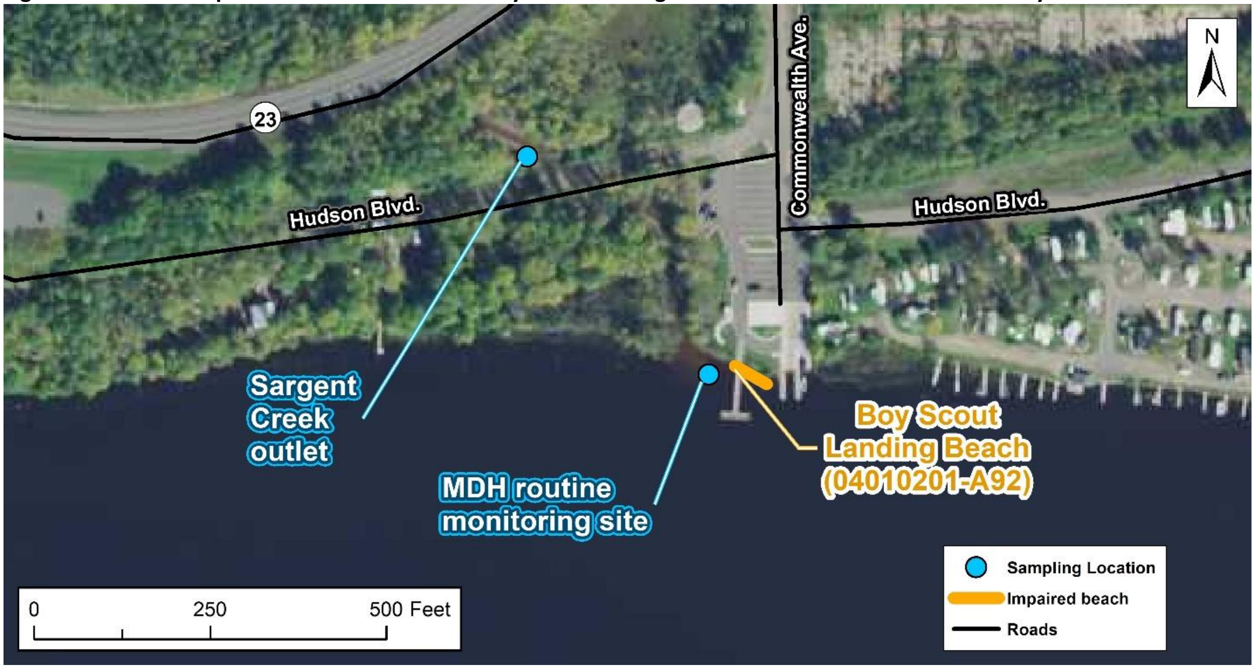


Figure 35. Water sample collection locations for Park Point beaches *E. coli* source assessment analysis.

Figure 36. Water sample collection locations for Boy Scout Landing Beach *E. coli* source assessment analysis.



3.5.2.2 Beach Surveys and Field Observations

Beach surveys were conducted at each beach to better understand conditions and uses of each beach. Beach surveys occurred during one peak weekend and one average weekday for each beach, and included observations of the weather, water, beach, visitors, wildlife and domestic animals, and other potential pollutant sources. The presence of erosion and dog and bird waste was also noted. In addition, field observations were documented during each water sampling collection event.

3.5.3 Microbial source tracking

Following field data collection, MST was conducted on a select set of samples to help differentiate sources of *E. coli.* Fecal Bacteroidetes, or fecal indicator bacteria, are used in MST. Human markers along with a variety of other bird and animal markers can be identified. MST results were used in a weight-of-evidence approach to support source identification and assessment; MST data were not used to develop TMDLs or allocations.

Samples were selected based on *E. coli* concentrations, targeting samples that exceeded the water quality standard, and weather conditions representative of wet, average, and dry conditions. A total of 47 samples were evaluated for human, dog, bird (geese and gulls), and/or ruminant DNA markers. At the end of the sampling season, samples with the highest *E. coli* exceedances were considered for MST analysis. In addition, samples across all weather conditions were analyzed at each beach. A total of 47 samples were selected based on the following process:

1. Removed all nonfiltered samples and duplicates;
2. Selected all samples that exceeded 235 org/100mL;
3. Added samples to ensure representative precipitation conditions for each beach (wet, dry, mid);
4. Added in any remaining stream/outfall samples and select paired beach samples (e.g., such that all Leif Erikson samples were included for a specific date).

Samples were analyzed for human (HF183 and HumM2), dog (BacCan-UCD), bird (GFD) and ruminant (Rum2Bac) genetic markers. Appendix B includes the MST lab methods from Source Molecular, now referred to as LuminUltra. A full summary of results from the MST analysis is provided in Section 3.6.8 and results are presented in Appendix C.

3.6 *E. coli* source summary

A summary of *E. coli* sources to impaired beaches was developed using information collected during the multi-step source assessment process described in previous sections. Exceedances of the water quality standard are seen across most flow zones for each impaired beach, as shown in sections 3.3.1 through 3.3.5, suggesting that sources of *E. coli* are from both direct and watershed-based sources.

Sources of *E. coli* to the Duluth area beaches include permitted and nonpermitted sources. The permitted sources discussed in this section are pollutant sources that require a NPDES permit. Nonpermitted sources are pollutant sources that do not require an NPDES permit. All Minnesota NPDES permits are also state disposal system (SDS) permits, but some pollutant sources require SDS permit coverage alone without NPDES permit coverage.

The phrase “nonpermitted” does not indicate that the pollutants are illegal, but rather that they do not require an NPDES permit. Some nonpermitted sources are unregulated, and some nonpermitted sources are regulated through non-NPDES programs and permits such as state and local regulations.

3.6.1 Permitted sources

Permitted sources can include wastewater (municipal and industrial), stormwater (municipal, industrial and construction), and confined animal feeding operations (CAFOs). Permitted sources in the project area include one regional wastewater treatment facility (Western Lake Superior Sanitary District; WLSSD) and regulated stormwater.

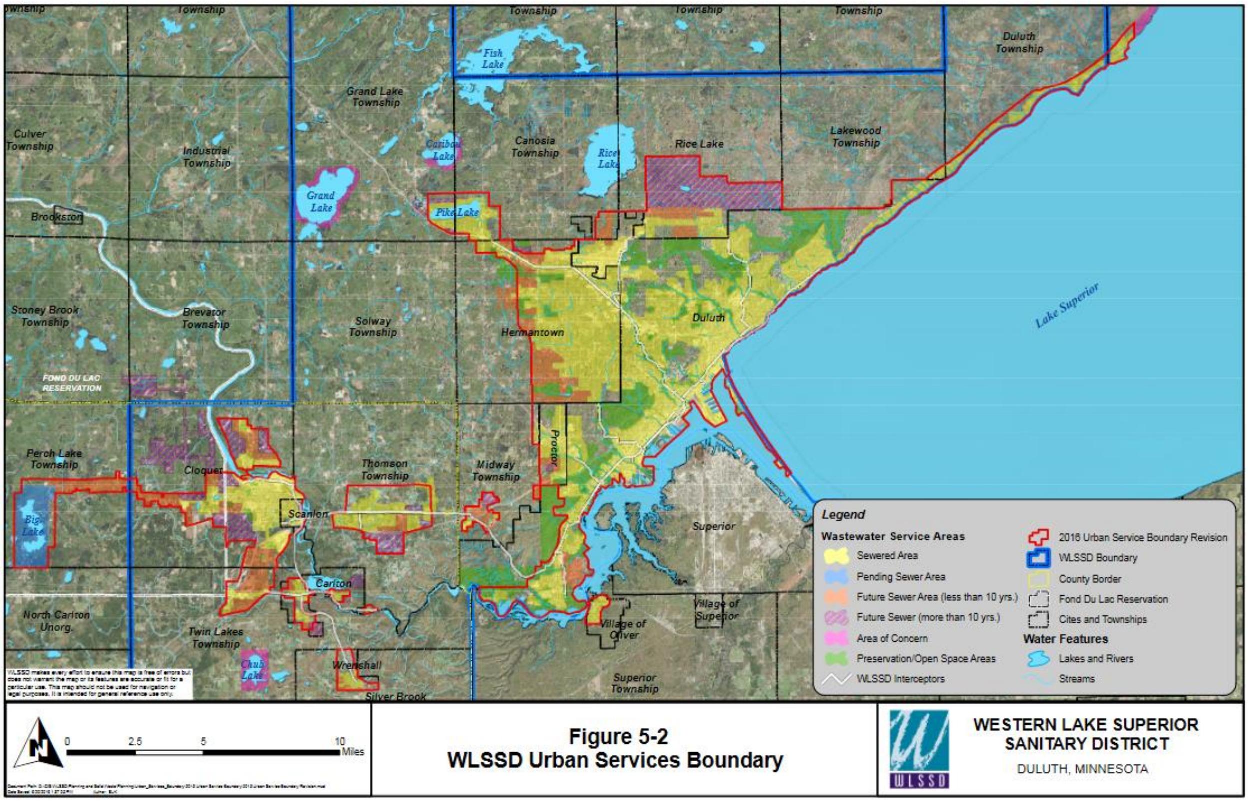
In the project area defined as the watersheds draining to the St. Louis River and Estuary downstream of Fond du Lac dam, the Nemadji River (in Minnesota), and the Duluth-Superior Harbor, the permitted point sources include the WLSSD and regulated stormwater. Construction and industrial stormwater are not expected to be sources of bacteria; as such, their permits do not include monitoring requirements or limits for bacteria.

3.6.1.1 Western Lake Superior Sanitary District

Western Lake Superior Sanitary District (WLSSD) provides wastewater and solid waste services and oversight for a 530 square mile region around Duluth, Minnesota that includes the cities of Duluth, Cloquet, Hermantown, Proctor, Rice Lake, Carlton, Scanlon, Thomson and Wrenshall, and eight surrounding townships (Figure 37).

Figure 37. WLSSD service area.

Source: [Western Lake Superior Sanitary District Comprehensive Wastewater Services Master Plan](#) (June 2016).



WLSSD's wastewater collection system includes approximately 76 miles of sewage interceptors and force mains and 18 pumping stations. The Cities, Townships and Sanitary Districts connected to WLSSD's collection system operate overt 544 miles of sanitary sewer infrastructure. WLSDD's NPDES/SDS permit does prohibit unauthorized overflows, discharges, spills, or other releases of wastewater or materials to the environment. In the event of the discovery of an unauthorized release, WLSSD staff are required to

1. Take all reasonable steps to immediately end the release.
2. Immediately notify the Minnesota Department of Public Safety Duty Officer.
3. Recover as rapidly and as thoroughly as possible all substances and materials released or immediately take other action as may be reasonably possible to minimize or abate pollution to waters of the state or potential impacts to human health
4. Collect representative samples of the release.
5. Report sampling results to the MPCA.

Although the Cities, Townships and Sanitary Districts connected to the WLSSD collection system are not directly subject to the requirements of WLSSD's NPDES/SDS permit, the same release prohibitions and management requirements are applicable in accordance with the Minnesota Rules and Statutes:

Minn. Stat. § 115.03 POWERS AND DUTIES.

Minn. Stat. § 115.061 DUTY TO NOTIFY; AVOIDING WATER POLLUTION.

Minn. R. ch. 7053.0205 GENERAL REQUIREMENTS FOR DISCHARGES TO WATERS OF THE STATE.

WLSSD Wastewater Treatment Facility provides regional wastewater treatment with an average wet weather design flow of 48.4 MGD and discharges to the Duluth-Superior Harbor. WLSSD provides disinfection of wastewater during the recreation season (April through October) and is subject to both (1) an *E. coli* permit limit of 126 org/ 100 mL calendar month geometric mean and (2) a fecal coliform organism group effluent limit of 200 org/100 mL calendar month geometric mean from April through October. [Minn. R. ch. 7053.0215](), subp. 1, which defines the minimum secondary treatment requirements for municipal point source and other point source dischargers of sewage, includes the following notation:

> *Disinfection of wastewater effluents to reduce the levels of fecal coliform organisms to the stated value is required from April 1 through October 31 for Class 2 waters and May 1 through October 31 for Class 7 waters, except that where the effluent is discharged 25 miles or less upstream of a water intake supplying a potable water system, the reduction to the stated value is required all year. The stated value is not to be exceeded in any calendar month as determined by the geometric mean of all the samples collected in a given calendar month. The application of the fecal coliform group organism limit is limited to sewage or other effluents containing admixtures of sewage and do not apply to industrial wastes, except when the presence of sewage, fecal coliform organisms, or viable pathogenic organisms in such wastes is known or reasonably certain. Analysis of samples for fecal coliform group organisms by either the multiple tube fermentation or the membrane filter techniques is acceptable.*

The WLSSD Wastewater Treatment Facility receives wastewater from domestic, commercial, industrial and institutional sources, with a significant contribution from the Sappi pulp and paper mill in Cloquet. Pulp and paper industry wastewater, which amounts to approximately 50% of the total influent flow and organic loading, contains natural organic compounds such as lignin and tannin that combine with chlorine to form organochlorine molecules. The formation of organochlorine compounds exerts a heavy demand on chlorine added to the effluent for disinfection, such that large amounts of chlorine must be used to provide effective effluent disinfection and meet discharge requirements. The result of disinfection with chlorine is the generation and discharge of chlorinated organic compounds, also known as absorbable organic halides (AOX). The AOX category includes a mixture of chemicals, which are persistent in the environment, can be toxic to aquatic life, and can accumulate in the food chain.

In January 1985, the WLSSD NPDES/SDS Permit was reissued and a variance was granted from the disinfection requirement (Minn. R. 7050.0210, subp. 1), during the winter months (November 1 through April 15). The variance was granted in accordance with Minn. R. 7050.0190 Variance From Standards. The decision to grant the variance was based on reducing the need for chlorination unless necessary, in order to reduce the generation and discharge of AOX to the St Louis River, St. Louis River Estuary, Duluth-Superior Harbor and to Lake Superior.

WLSSD’s variance from winter disinfection requirements has been reevaluated and updated during each subsequent NPDES permit reissuance. In June 2016, the WLSSD permit was reissued and included the variance from year-round disinfection. The permit required (1) compliance with the fecal coliform limit from April 1 through October 31, and (2) year-round monitoring of the discharge and intervention disinfection treatment limits, if monitoring results for fecal coliform at two drinking water intakes (Duluth, MN - SW002 and Superior, WI - SW004) exceeded the intervention limit of 100 org/100 mL. The

2016 permit also required an evaluation of alternative disinfection options. WLSSD contracted with CDM Smith to develop the Technical Memorandum 2 Disinfection Alternatives Evaluation: Basis of Design Development, Alternatives Screening and Life Cycle Cost/Non-Economic Factor Evaluation dated December 2016 Rev 4 (TM-2). The report's recommendation is that chlorine disinfection remains the most effective alternative.

In 2021, WLSSD applied for a continuation of the variance from the year round disinfection requirement for fecal coliform as found in Minn. R. 7053.0215, subp. 1.

A review of the facility's monitoring data since 2015 indicates no exceedances of the permit limit during the recreation season. The existing limit is consistent with this TMDL's WLA.

3.6.1.2 Municipal Separate Storm Sewer Systems

MS4s are defined as the conveyance systems owned or operated by an entity such as a state, city, township, county, district, or other public body having jurisdiction over management of stormwater. The conveyance system includes ditches, roads, storm sewers, stormwater ponds, etc. The MS4 stormwater permit holds regulated permittees responsible for stormwater discharging from the conveyance system they own and/or operate. There are 10 regulated MS4s within the project area (Table 10, Figure 38, and Figure 39).[6]

Table 10. Regulated MS4s in the TMDL project area

	Beach name (AUID)				
Regulated MS4	Leif Erikson Park Beach (04010201-C21)	Minnesota Point 15th Street Harbor Side Beach (04010201-A90)	Park Point 20th Street/Hearding Island Canal Beach (04010201-A89)	Park Point Sky Harbor Parking Lot Beach (04010201-A87)	Boy Scout Landing Beach (04010201-A92)
Duluth City (MS400086)	✓	✓	✓	✓	✓
Hermantown (MS400093)		✓	✓	✓	
Midway Township 6 (MS400146)		✓	✓	✓	✓
Proctor 6 (MS400114)		✓	✓	✓	
Thomson Township (MS400280)		✓	✓	✓	✓
Rice Lake 6 (MS400151)	✓				

[6] In 2019, legislation was passed affecting the MS4 regulated area, such that certain townships and cities are only required to manage stormwater within an urbanized area or within a platted area.

Regulated MS4	Beach name (AUID)				
	Leif Erikson Park Beach (04010201-C21)	Minnesota Point 15th Street Harbor Side Beach (04010201-A90)	Park Point 20th Street/Hearding Island Canal Beach (04010201-A89)	Park Point Sky Harbor Parking Lot Beach (04010201-A87)	Boy Scout Landing Beach (04010201-A92)
University of Minnesota Duluth (MS400214)	✓	✓	✓	✓	
Lake Superior College (MS400225)		✓	✓	✓	
St. Louis County (MS400158)	✓	✓	✓	✓	
MnDOT Outstate District (MS400180)	✓	✓	✓	✓	✓

Note: A check (✓) indicates that the regulated MS4 is upstream of the impaired beach, and as such, MS4 stormwater has the potential to migrate downstream to the impaired beach.

Figure 38. City and township MS4s within the study area.

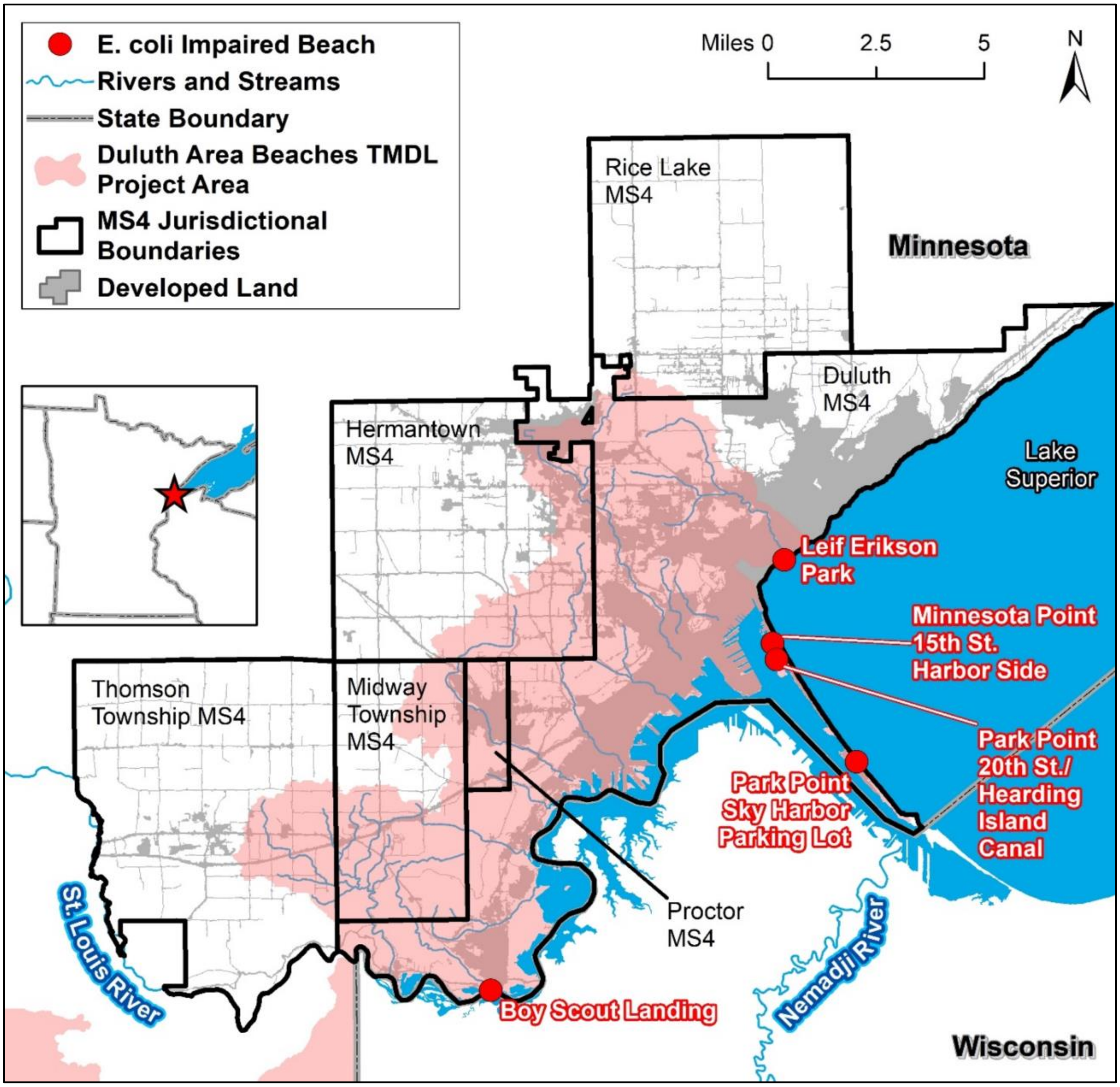
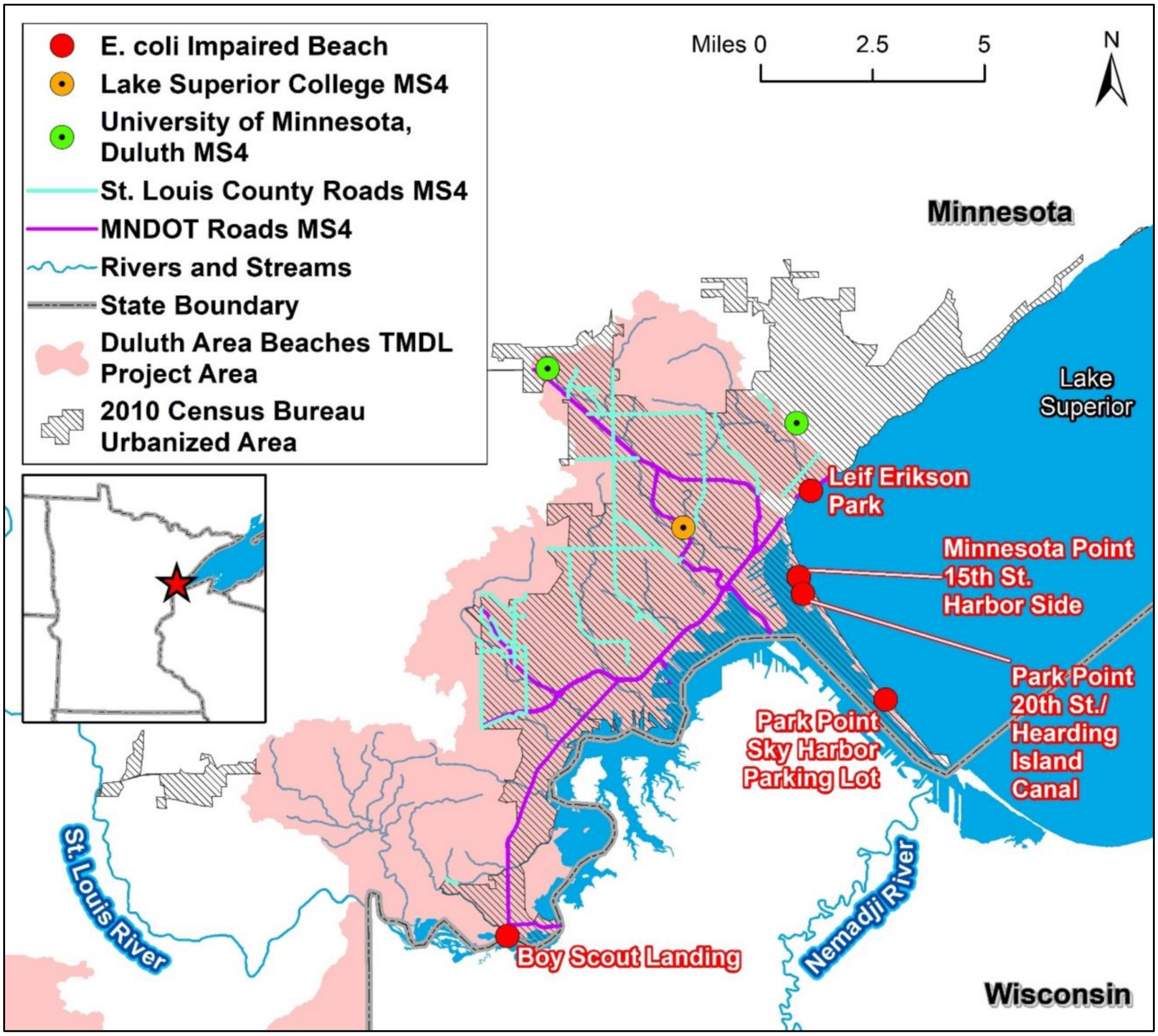


Figure 39. Road authority and other MS4s within the study area.



3.6.2 Human sources

Potential human sources of *E. coli* to impaired beaches include leaky wastewater infrastructure through broken or damaged pipes and manholes including sanitary sewer overflows, inadequate bathroom facilities, bathers, transient populations, illegal sump pump discharges, sewer backups, and failing septic systems.

- The City of Duluth has experienced intermittent sanitary sewer overflows on Park Point from 2017 to 2019. These overflows primarily occurred in late fall near the 19th Street South intersection of Minnesota Ave, which then discharged to the St. Louis River Estuary. These overflows are typically a result of high winds that push lake water into the sanitary sewer system, causing pressurized conditions. Record high and near record high lake water levels in recent years also potentially contributed to sanitary sewer overflows. These sanitary sewer overflows are actively being addressed by the City of Duluth and no overflows occurred during 2020 along Park Point (personal correspondence with City of Duluth Utility Programs Coordinator on 12/14/2020).

- Intermittent sanitary sewer overflows have also been documented within the Chester Creek Watershed and have been attributed to multiple causes including clogs from rags and disposable wipes, tree roots, and I&I. The City of Duluth has proposed to conduct a comprehensive evaluation of sanitary sewer infrastructure within the impaired reaches of Chester Creek and in locations of past sanitary sewer overflows. This work will aid in identifying infrastructure deficiencies, and aid prioritizing and targeting improvements.
- A mobile home park was noted directly east of Boy Scout Landing Beach. The mobile home park is served by City of Duluth sanitary and storm sewers. The storm sewers discharge to the St. Louis River east (i.e., downstream of Boy Scout Landing Beach).
- Portable restrooms were noted at Leif Erikson Park Beach and Boy Scout Landing Beach.
- Although the majority of the drainage areas to impaired beaches are urbanized and wastewater is treated by a regional treatment plant (i.e., WLSSD), septic systems can still be found in less developed areas, and also within the developed areas where homes are not connected to regional sewer services. Septic systems that function properly do not contribute *E. coli* to surface waters. Failing septic systems that discharge untreated sewage to the land surface are considered an imminent public health threat and can contribute *E. coli* to surface waters. There are no data on the number of septic systems within the impaired beach drainage areas or their failure rate. However, clay soils, shallow depth to bedrock, and high groundwater levels found in the city of Duluth and surrounding areas can increase the likelihood of failing septic systems.
- Prihoda et. al (2017) detected human genetic markers at both Leif Erikson Park Beach and Minnesota Point 15th Street Harbor Side Beach. At Leif Erikson Park Beach, human genetic markers were detected in both wet and dry sampling events in samples collected from a storm sewer outlet at the beach (site LEIF-ST) and from Chester Creek (site LEIF-CH). At Minnesota Point 15th Street Harbor Beach, human genetic markers were quantified at three beach locations during or following several precipitation events.
- Human genetic markers were detected in sampling from all five impaired beaches during the 2020 MST study conducted to support TMDL development. These results are discussed in Section 3.6.8. Data tables of MST results are provided in Appendix C.
- During the public notice period for this TMDL, a release of untreated domestic wastewater was detected from a privately owned sewer lateral along Central Entrance in the City of Duluth. The discharge to Brewery Creek had likely been ongoing for some time. The break was several hundred feet from the property, down a slope in the trees. The City of Duluth reported the release to the MPCA's reporting requirements. The property owner (with City assistance/oversight) completed repairs to the private service lateral and the release was stopped 3/10/2022. The City collected upstream, downstream and release samples in Brewery Creek, as well as posted signs that were in place from March 9, 2022 to March 28, 2022 to warn people of the release to surface waters. The discharge point for Brewery Creek is approximately 1,200 feet from Leif Erickson Park Beach.

3.6.3 Stormwater runoff

Stormwater runoff acts as an important delivery mechanism of multiple *E. coli* sources. Stormwater runoff from impervious surfaces, such as roads and parking lots, can directly connect the location where *E. coli* is deposited on the landscape to surface waters. Impervious surfaces were noted in every impaired beach drainage area. The following additional information on the significance of stormwater runoff were provided by Prihoda et al. (2017) and the MPCA:

- For Leif Erikson Park Beach, stormwater and parking lot runoff and the storm drain at the south end of the beach were identified as contributors to *E. coli* exceedances in Prihoda et al. (2017).
- The MPCA stormwater wiki (https://stormwater.pca.state.mn.us) provides the following information as related to fecal bacteria in stormwater, specifically from roads:
    - Residential lawns, driveways, and streets are the major source areas for fecal bacteria, while rooftops and parking lots are usually smaller source areas. Irrigated lawns, in particular, are high contributors.
    - Sartor and Gaboury (1984) reported nearly 92% of the fecal bacteria originated from streets in the residential-institutional land use site, whereas only about 33 and 19% of the fecal bacteria originated from streets in the industrial and commercial land use sites, respectively.
    - Bannerman et al. (1993) reported that 78% of the fecal coliform bacteria load originated from streets in a residential land use study.

3.6.4 Pets and wildlife

Potential sources of *E. coli* from pets and wildlife to the impaired beaches include waste from dogs, birds (including geese, gulls, and ducks) raccoons, and deer.

- Pets and wildlife observed during beach surveys conducted in summer 2019 and 2020 include dogs, seagulls, mallards, and geese; in addition, raccoon populations have been noted in the city of Duluth (MPCA 2020a).
- Trash and trash cans can also encourage wildlife presence on and near the impaired beaches.
- White tail deer populations were noted by MPCA (2020a) in the impaired *E. coli* stream subwatersheds; however, forested and grassland habitat areas are limited to the Sargent Creek Watershed within this TMDL, suggesting that deer are not a likely source of *E. coli* loading to the remaining impaired beaches.
- Prihoda et al. (2017) detected geese, gull, and ruminant genetic markers at Minnesota Point 15th Street Harbor Side Beach. Geese were regularly observed at the beach during that study and all sampling locations exhibited high abundance of *Enterococcus* genetic markers that may indicate geese contributions.
- Bird and dog genetic markers were detected in sampling from all five impaired beaches during the 2020 MST study conducted to support TMDL development. Refer to Section 3.6.8 for discussion of bird and dog genetic markers detection and visual observations of birds, dogs, and their feces at the beaches. Data tables of MST results are provided in Appendix C.

- Potential for upstream bird congregating areas, such as the wildlife management area at Interstate Island and historic waterfowl populations in the vicinity of the CHS grain elevators to contribute *E. coli* to MN 15th Street Harbor Side Beach, Park Point 20th Street/Hearding Island Beach and Park Point Sky Harbor Parking Lot Beach. More *E. coli* monitoring and MST needed within the Duluth-Superior Harbor.

3.6.5 Influence from nearby waters

Nearby waters that may be influencing bacteria levels of impaired beaches in this TMDL include impaired streams that discharge near the impaired beaches, such as Chester and Sargent Creeks, and potential near-shore interactions from areas of influence beyond the impaired beach delineations.

- The outlet of Chester Creek is near Leif Erikson Park Beach and included within the drainage area of the beach. Chester Creek is impaired due to high levels of *E. coli* and is subject to the Duluth Urban Area Streams TMDL. The overall estimated percent reduction needed for Chester Creek is 92% (MPCA 2020a). Chester Creek's watershed is highly developed with known populations of unhoused persons. Pools of stagnant water are found where the creek passes through storm tunnels below Superior Street, potentially providing a breeding ground for bacteria. Prihoda et al. (2017) collected data from four sample locations at Leif Erikson Park Beach. Stormwater and parking lot runoff, the storm drain at the south end of the beach, contributions from Chester Creek, and recreation were identified as contributors to *E. coli* exceedances in Prihoda et al. (2017). The spatial analysis of the data collected from the sample sites Chester Creek, North Leif Erikson, and South Leif Erikson conducted by Prihoda et al. (2017) indicates that bacteria levels decrease as one moves from Chester Creek towards the impaired beach.
- Sargent Creek discharges directly onto Boy Scout Landing Beach and is included within the drainage area of the beach. Sargent Creek is impaired due to high levels of *E. coli* and is subject to the Duluth Urban Area Streams TMDL. The overall estimated percent reduction needed for Sargent Creek is 45% (MPCA 2020a). Sargent Creek's watershed is largely forested, and the creek flows through the Napolean B. Merritt Park and Magney-Snively Natural Area. The MPCA (2020a) found that exceedances of *E. coli* in Sargent Creek typically occur during or after precipitation events.
- Areas of influence beyond the direct drainage areas of the impaired beach may also be influencing *E. coli* concentration at impaired beaches. Potential sources include nearby stormwater outfalls or stream discharges, boats, and marinas, etc. Streams and rivers in the St. Louis River and Estuary Watershed downstream of the Fond du Lac dam, in the Nemadji River Watershed in Minnesota, and Duluth-Superior Harbor are transport pathways that bacteria could flow through from watershed sources to the beaches. The full extent of influence from sources beyond the impaired beach delineations is unknown at this time but could contribute significantly depending on factors such as wave and wind direction, water temperature, bacterial die-off rates, the amount of water entering the Duluth-Superior Harbor from the St. Louis and Nemadji River watersheds, and seiche events in Lake Superior. These are the waters that flow to the beach swimming area and are being sampled directly at the beach swimming area. More monitoring is needed to help clarify the extent of influence from sources beyond the impaired beach delineations.

- Ballast water discharged to Lake Superior and the Duluth-Superior Harbor is not considered a significant source of pathogens at this time and more studies are needed. Cangelosi et al. (2018) studied the movement of laker ballast water from other Great Lakes to Lake Superior in an effort to characterize the movement of organism through ballast water. *E. coli* results in ballast water were typically low, with 10 of 15 trials yielding nondetects or detection less than 10 org/100mL. Only one of 15 trials yielded results (189.8 org/100 mL) greater than the geometric mean standard (126 org/100 mL) (Cangelosi et al. 2018).

3.6.6 Natural background sources

"Natural background" is defined in both Minnesota statute and rule. The Clean Water Legacy Act (Minn. Stat. § 114D.15, subd. 10) defines natural background as "characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence." Minn. R. 7050.0150, subp. 4 states, "'Natural causes' means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a water body in the absence of measurable impacts from human activity or influence."

Natural background sources are inputs that would be expected under natural, undisturbed conditions. However, for each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment and, therefore, natural background is accounted for and addressed through the MPCA's water body assessment process.

Based on the MPCA's water body assessment process and the TMDL source assessment exercises, each impaired beach and their associated drainage area shows evidence of human activity that is contributing to an increase in wildlife as compared to that expected under natural, undisturbed conditions (e.g., presence of trash cans). As such, there is no evidence at this time to suggest that natural background sources are a major driver of any of the impairments and/or affect the waterbodies' ability to meet water quality standards.

3.6.7 Naturalized *E. coli*

The relationship between *E. coli* sources and *E. coli* concentrations found in waters is complex, involving precipitation and flow, temperature, sunlight and shading, wildlife contributions, *E. coli* survival rates, land use practices, and other environmental factors. Research in the last 15 years has found the persistence of *E. coli* in soil, beach sand, and sediments throughout the year in the north central United States without the continuous presence of sewage or warm-blooded animal sources. This *E. coli* that persists in the environment outside of a warm-blooded host is referred to as naturalized *E. coli* (Jang et al. 2017). Naturalized *E. coli* can originate from different types of *E. coli* sources, including natural background sources, such as wildlife, and human-attributed sources, such as pets and human wastewater. Therefore, whereas naturalized *E. coli* can be related to natural background sources, naturalized *E. coli* is not always from a natural background source.

An Alaskan study (Adhikari et al. 2007) found that total coliform bacteria in soil were able to survive for six months in subfreezing conditions. Two studies near Duluth, Minnesota found that *E. coli* were able to grow in agricultural field soil (Ishii et al. 2010) and soils in temperate climates (Ishii et al. 2006). A study by Chandrasekaran et al. (2015) of ditch sediment in the Seven Mile Creek Watershed in southern

Minnesota found that strains of *E. coli* had become naturalized to the water−sediment ecosystem. Survival and growth of fecal coliform has been documented in storm sewer sediment in Michigan (Marino and Gannon 1991), and *E. coli* regrowth was documented on concrete and stone habitat within an urban Minnesota watershed (Burns & McDonnell Engineering Company, Inc. 2017). This ability of *E. coli* to survive and persist naturally in watercourse sediment can increase *E. coli* counts in the water column, especially after resuspension of sediment (e.g., Jamieson et al. 2005).

There are currently no methods in place to estimate (using an equation or model) or measure (using a laboratory analysis) what proportion of *E*. *coli* is naturalized. While a measurement is preferable over an estimate, it is also more expensive, because it involves a laboratory component. The adaptation and evolution of naturalized *E*. *coli* that allows it to survive and reproduce in the environment makes it physically and genetically distinct from *E*. *coli* that cannot survive outside of a warm-blooded host. Laboratory methods target those physical and genetic differences and quantify their presence to provide a measurement.

3.6.8 Results of MST and beach surveys

Results of MST analysis conducted as part of this TMDL project (and first reported in this document) and observations from beach surveys and field data collection days are provided below by beach. Overall, a human marker was detected at all beaches during the 2020 sampling season. Data tables of MST results are provided in Appendix C.

MST data were used to support the identification and assessment of sources of pathogens. MST data were not used to develop the *E. coli* TMDLs or allocations.

3.6.8.1 Leif Erikson Park Beach

Human, dog, and bird genetic markers were detected in samples from Leif Erikson Park Beach during the 2020 MST effort conducted during this TMDL study (Table 11). At the MDH monitoring location (Leif Erikson), the detection rate for human, dog, and bird markers were each individually detected in 75% of analyzed samples (number [n]=8). Bird marker was detected in 100% of samples (n=3) from the Leif Erikson – North sampling location and human markers were detected in 100% of samples (n=3) at the Leif Erikson – South sampling location, which is just south of the beach’s stormwater outfall. Overall, human and bird markers were each individually detected in 79% of samples taken directly on the shoreline (Leif Erikson, North Leif Erikson-North, and South Leif Erikson) (n=14). These locations were not analyzed for the ruminant marker.

Only human (50%, n=2) and bird (100%, n=2) genetic markers were detected at the stormwater outfall monitoring station for Leif Erikson Park Beach. As the stormwater outfall monitoring location is the only monitoring location for Leif Erikson Park Beach that is directly at the outfall of a storm sewer system, these results may indicate that dog sources of *E. coli* are only present directly on the beach or in the water close by and that human and bird sources are entering the beach from the storm sewer system.

The Chester Creek outlet was also analyzed for human, dog, bird, and ruminant genetic markers as part of the MST effort. Human, dog, and bird markers were detected in 100% (n=2) of samples analyzed. The ruminant marker was not detected in any samples analyzed (n=2).

At all locations where the human (HF183) genetic marker was detected, for individual samples, significantly more copies of human genetic markers were detected than dog or bird genetic markers. For example, on July 9, 2020, 28,400 copies per 100 mL of human genetic marker were detected, versus 742 copies per 100 mL of dog genetic markers and an unquantified number between 100 and 500 copies per 100 mL of bird genetic markers.

Table 11. 2020 MST analysis summary for Leif Erikson Park Beach (number of samples with genetic markers detected and total number of samples).

Sampling location	Human (HF183)		Dog		Bird		Ruminant	
	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections
Leif Erikson	8	6	8	6	8	6	Not analyzed	
Leif Erikson - North	3	2	3	2	3	3	Not analyzed	
Leif Erikson - South	3	3	3	2	3	2	Not analyzed	
Storm water outfall	2	1	2	0	2	2	Not analyzed	
Chester Creek Outfall	2	2	2	2	2	2	2	0

There was no evidence of runoff during beach surveys but a large area of erosion was noted along the shrub and beach line where there is a steeper slope. No wildlife feces were found onshore during beach surveys but seagulls and mallards were noted in the water and on the beach (survey conducted by SSLSWCD on August 5, 2019 and August 11, 2019). In addition, field observations during regular water quality data collection in the 2020 monitoring season noted the presence of humans and dogs on the shore and in the water, and some trash along the beach. Dog waste bags were noted at the outlet of Chester Creek on June 15, 2020.

3.6.8.2 Minnesota Point 15th Street Harbor Side Beach

Human, dog, and bird genetic markers were detected in samples from Minnesota Point 15th Street Harbor Side Beach during the 2020 MST effort (Table 12). Samples from this beach were not analyzed for the ruminant marker. The bird genetic marker was detected in 100% (n=3) of samples analyzed, and the human marker (n=6) and dog marker (n=3) were each individually detected in 66% of samples analyzed. These results indicate that sources of *E. coli* at the Minnesota Point 15th Street Harbor Side Beach are from a mix of sources, including human.

Table 12. 2020 MST analysis summary for Minnesota Point 15th Street Harbor Side Beach (number of samples with genetic markers detected and total number of samples).

Sampling location	Human (HF183)		Dog		Bird		Ruminant	
	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections
Minnesota Point 15th Street	6	4	3	2	3	3	Not analyzed	

Both goose and dog feces were found during beach surveys (conducted by SSLSWCD on July 25, 2019 and August 3, 2019). Field observations during regular water quality data collection in the 2020 monitoring season also noted the presence of geese and goose feces on the beach. No beach visitors were noted.

3.6.8.3 Park Point 20th Street/Hearding Island Canal Beach

Human, dog, and bird genetic markers were detected in samples from Park Point 20th Street/Hearding Island Canal Beach during the 2020 MST effort (Table 13). Samples from this beach were not analyzed for the ruminant marker. The bird genetic marker was detected in 100% (n=3) of samples analyzed, the human marker (n=3) was detected in 66% of samples analyzed, and the dog marker was detected in 33% (n=3) of samples analyzed. These results indicate that sources of *E. coli* at the Park Point 20th Street/Hearding Island Canal Beach are from a mix of sources, including human.

Table 13. 2020 MST analysis summary for Park Point 20th Street/Hearding Island Canal Beach (number of samples with genetic markers detected and total number of samples).

Sampling location	Human (HF183)		Dog		Bird		Ruminant	
	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections
Hearding Island	3	2	3	1	3	3	Not analyzed	

Large amounts of geese feces were noted on a nearby apartment complex's lawn during beach surveys (conducted by SSLSWCD on August 4, 2019 and August 12, 2019). In addition, field observations during regular water quality data collection in the 2020 monitoring season noted the presence of dogs and dog feces, geese offshore, and beach goers on the shore in in the water (kayakers and swimmers).

3.6.8.4 Park Point Sky Harbor Parking Lot Beach

Human, dog, and bird genetic markers were detected in samples from the Park Point Sky Harbor Parking Lot Beach during the 2020 MST effort (Table 14). Samples from this beach were not analyzed for the ruminant marker. As with the Minnesota Point 15th Street Harbor Side Beach, the bird genetic marker was detected in 100% (n=3) of samples analyzed, while the human marker (n=6) and dog marker (n=3) were each detected in 66% of samples analyzed. These results indicate that sources of *E. coli* at the Park Point Sky Harbor Parking Lot Beach are from a mix of sources, including human.

Table 14. 2020 MST analysis summary for Park Point Sky Harbor Parking Lot Beach (number of samples with genetic markers detected and total number of samples).

Sampling location	Human (HF183)		Dog		Bird		Ruminant	
	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections
Park Point Sky Harbor	6	4	3	2	3	3	Not analyzed	

During beach surveys, evidence of campfires and dog feces were observed on the beach, many people were observed walking or biking on the road nearby, and geese were noted in the water. No evidence of runoff was noted during the beach surveys (conducted by SSLSWCD on August 1, 2019 and August 12, 2019). In addition, field observations during regular water quality data collection in the 2020 monitoring season noted dogs and dog feces on the shore. Geese and bird feces were also observed. Beach visitors included picnic-goers, paddle-boarders, and a kayaker.

3.6.8.5 Boy Scout Landing Beach

Human, dog, bird, and ruminant genetic markers were detected in samples from Boy Scout Landing Beach during the 2020 MST effort (Table 15). Bird was the predominant genetic marker detected in the samples taken directly at the beach (100%, n=3). While the human marker was detected at the beach as well as along Sargent Creek, the detection rate of human markers was significantly higher in Sargent Creek (83%, n=6) than at the beach (13%, n=8). This suggests that Sargent Creek is contributing human sources of bacteria to Boy Scout Landing Beach.

Table 15. 2020 MST analysis summary for Boy Scout Landing Beach (number of samples with genetic markers detected and total number of samples).

Sampling Location	Human (HF183)		Dog		Bird		Ruminant	
	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections	No. of Samples	No. of Detections
Boy Scout Landing Beach	8	1	3	2	3	3	Not analyzed	
Sargent Creek Outfall	6	5	3	3	3	3	5	1

Goose and dog feces were observed during beach surveys. Runoff from the adjacent parking lot and the outlet of Sargent Creek were noted as potential pollutant sources. Activities noted on the beach included kayaking, swimming, fishing, boating, and dog walking. No erosion along the beach was noted during the beach surveys (conducted by SSLSWCD on August 11, 2019 and August 16, 2019). In addition, field observations during regular water quality data collection in the 2020 monitoring season noted goose feces and traces of geese on the shore parking lot and the lawn next to the beach. Beach visitors included swimmers, anglers, and boaters.

3.6.9 Summary

A summary of *E. coli* sources is provided in Table 16 for each impaired beach direct drainage area. Further information related to each source is provided in the previous sections 3.6.1 through 3.6.8.

Table 16. Summary of *E. coli* sources.

Beach drainage area	Source										
	Stormwater runoff		Human				Pet/ Dog	Wildlife	Nearby waters	Natural background *E. coli*	Naturalized *E. coli*
	Permitted (MS4)	Non-permitted	Leaky wastewater infrastructure	Inadequate bathroom facilities [a]	Illegal sump pump discharges	Unknown septic systems					
Leif Erikson Park Beach	●	●	●	--	--	○	●	●	●	○	unknown
Minnesota Point 15th Street Harbor Side Beach	●	●	●	●	●	○	●	●	●	○	
Park Point 20th Street/ Hearding Island Canal Beach	●	●	●	●	●	--	●	●	●	○	
Park Point Sky Harbor Parking Lot Beach	●	●	--	●	●	--	●	●	●	○	
Boy Scout Landing Beach	●	●	●	--	--	--	●	●	●	○	

●: Potential *E. coli* source that is a priority for targeting
○: Potential *E. coli* source that is a lower priority for targeting
-- : Not likely a source of *E. coli*
a. Includes bathers and transient populations.

4. TMDL development

A waterbody's TMDL represents the loading capacity, or the amount of pollutant that a waterbody can assimilate while still meeting water quality standards. The loading capacity is allocated to the waterbody's pollutant sources. The allocations include WLAs for NPDES-permitted sources, LAs for nonpermitted sources (including natural background), and an MOS, which is implicitly or explicitly defined.

The Duluth Beaches *E. coli* TMDLs overlap with some of the Duluth Urban Area Streams *E. coli* TMDLs and the Nemadji River Watershed *E. coli* TMDLs; refer back to Figure 1 and Figure 3 for maps that include the stream's *E. coli* TMDL subwatersheds. The MPCA developed and EPA approved *E. coli* TMDLs for six streams in the Duluth Urban Area Streams TMDL (MPCA 2020a) and two streams in the Nemadji River Watershed within Minnesota (MPCA 2017b). The stream TMDLs were developed using the same target as the beach TMDLs, which is 126 organisms per 100 mL; therefore, implementation of the stream *E. coli* TMDLs will address the aquatic recreation use of both the streams and beaches. TMDL implementation is discussed in the WRAPSs (MPCA 2017a, 2020b), and best management practices (BMPs) to reduce *E. coli* in the streams will benefit the beaches as well.

4.1 TMDL methodology

Typically, TMDLs are developed using pollutant loads, which are calculated as a pollutant concentration multiplied by a flow and then converted to appropriate units. This approach works well for waterbodies that flow in a linear path in one direction (i.e., downstream), such as streams and rivers.

No flow or water volume data are available for the five impaired beaches; thus, it is not possible to calculate loads. Instead, a concentration-based approach was used to develop TMDLs for the impaired beaches. In concentration-based TMDLs, the loading capacity and all of the allocations are concentrations. Because the allocations are concentrations (mass per volume), they are not additive.

E. coli concentration monitoring data from 2009 through 2018 were used to support TMDL development. Data collected since 2018 was considered as part of the source assessment only. MST data were not used to develop TMDLs or allocations.

4.1.1 Loading capacity

The loading capacity for *E. coli* is based on the monthly geometric mean standard (126 org/100 mL). It is assumed that practices that are implemented to meet the geometric mean standard will also address the individual sample standard (235 org/100 mL). Whereas the TMDLs are based on the geometric mean portion of the water quality standard, attainment of both parts of the water quality standard is required. In a concentration-based TMDL for *E. coli* impairments, the loading capacity equals the numeric value of the standard. The loading capacity is provided in tables for each impaired beach in Section 4.2.

4.1.2 Reductions

Reductions were calculated as the deviation of the observed (monitored) concentration from the standard, during the months that the standard applies. Reductions are calculated as:

$$(\text{monitored} - \text{standard}) / \text{monitored}$$

For the geometric mean standard, the percent reduction is the difference between the geometric mean standard and the highest observed (i.e., monitored) monthly geometric mean, relative to the highest observed monthly geometric mean.

4.1.3 Baseline year

The monitoring data used to support TMDL development are from 2009 through 2018. Because projects undertaken may take a few years to influence water quality, the baseline year for crediting reductions for a given water body is 2011 to be consistent with the Duluth Urban Area Streams TMDL (MPCA 2020a) and the Duluth Urban Area WRAPS (MPCA 2020b). Any activities implemented during or after the baseline year that led to a reduction in pollutant concentrations to the water bodies may be considered as progress towards meeting a WLA or LA. More information on recent and planned projects is provided in Section 6.

4.1.4 Boundary conditions

Boundary conditions are provided for each impaired beach TMDL (Figure 39) to account for upstream sources of *E. coli* that are not explicitly addressed in the TMDL. Boundary conditions were developed using the TMDL target concentration. Two boundary conditions include:

- **St. Louis River at the Fond du Lac dam**: This upstream boundary condition accounts for all *E. coli* sources in the St. Louis River upstream of the dam.

  The Fond du Lac dam was selected for the site of the boundary condition because the dam divides two St. Louis River assessment units and will soon be the division between a stream and lake assessment unit. The Fond du Lac dam is the downstream terminus of assessment unit 04010201-523 (St. Louis River: Thompson Reservoir to Fond du Lac dam) and the upstream terminus of assessment unit 04010201-513 (St. Louis River: Fond du Lac dam to Mission Creek). While -523 is currently a stream segment, MPCA is recategorizing -523 to a lake segment to better align with DNR's approach to managing the St. Louis River and Estuary. Once -523 becomes a lake assessment unit, *E. coli* data will no longer be included in the aquatic recreation use support determination. Additionally, in 2021, the St. Louis River above the dam was assessed and is not impaired due to *E. coli*.

- **State of Wisconsin**: This stateline boundary condition accounts for all *E. coli* sources in Wisconsin that drain to the St. Louis River and Estuary and the Duluth-Superior Harbor.
  - *St. Louis River and Estuary*: The stateline boundary condition follows the St. Louis River and Estuary[7] through the following assessment units:
  - *Duluth-Superior Harbor:* The stateline boundary also bisects the harbor, which is included in the Lake Superior assessment unit (16-0001-00).
  - *Upper Red River and Upper Pokegama River watersheds:* The stateline boundary condition bisects the upper, headwaters areas of the Red River and Pokegama River

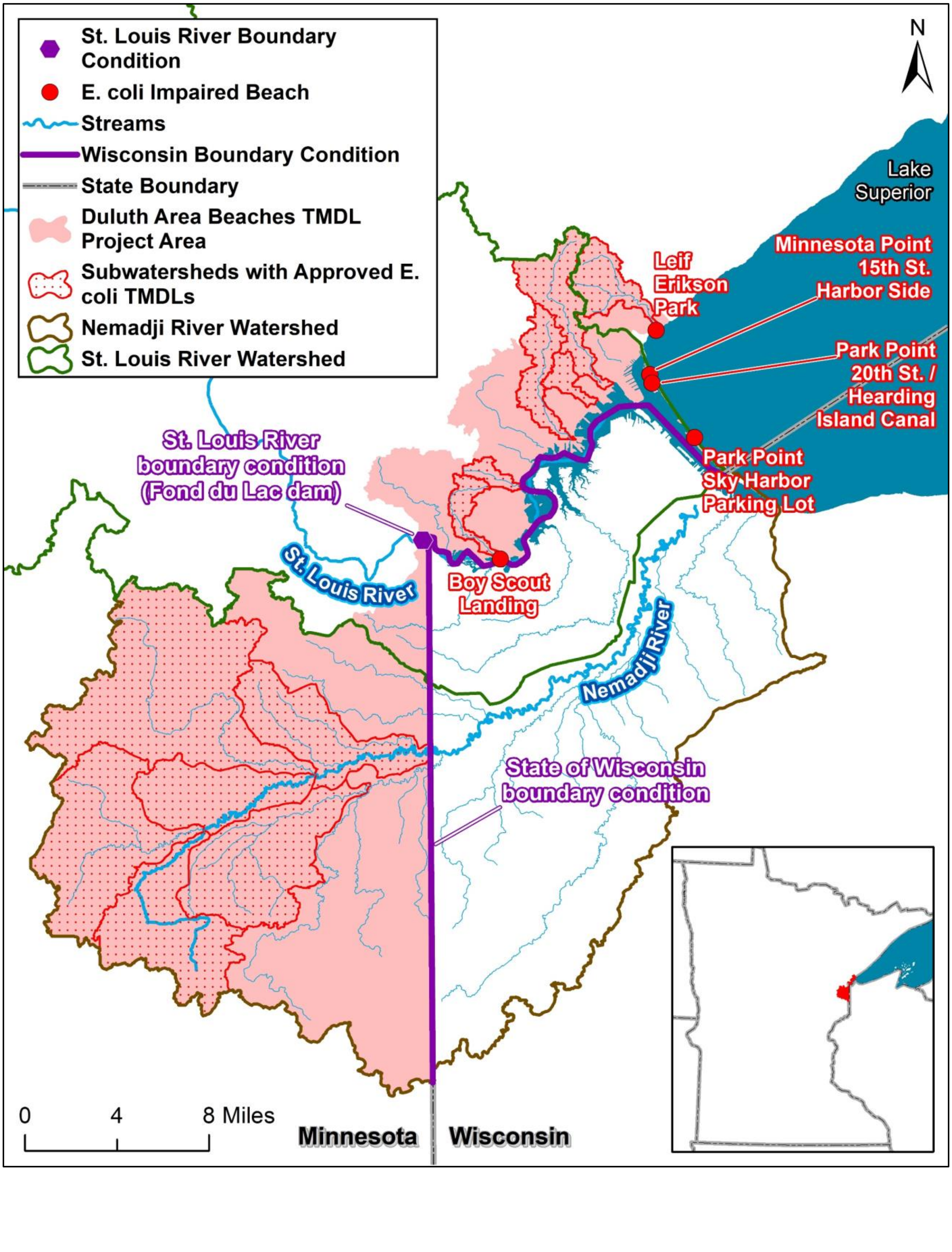
[7] The stateline boundary condition pass through three assessment units: St. Louis River: Mission Creek to Oliver Bridge (04010201-532), St. Louis River: Oliver Bridge to Pokegame River (04010201-533), and St. Louis River (St. Louis Bay): Pokegame River to mouth of St. Louis Bay (04010201-501).

watersheds, which are tributaries to the St. Louis River Estuary. This area also includes unnamed tributaries in Jay Cooke State Park that drain through Wisconsin to the St. Louis River upstream of Boy Scout Beach.

- *Upper Nemadji Watershed:* The stateline boundary condition bisects the Nemadji River Watershed, which includes subwatersheds for the South Fork Nemadji River, Mud Creek, and Clear Creek. The Nemadji River is tributary to the Duluth-Superior Harbor.

The Minnesota-Wisconsin state border was selected as the location for a boundary condition because Minnesota cannot allocate upstream of the state boundary. The EPA regulations prohibit one state from allocating within another state. Additionally, when states share waters, each state is responsible for addressing sources of pollution within their respective borders. Here, the MPCA is responsible for addressing sources of bacteria on the Minnesota side of the St. Louis River and Estuary and the Duluth-Superior Harbor.

Figure 40. Beaches TMDL project area and boundary conditions.



4.1.5 Load allocation methodology

The LA is allocated to existing or future nonpermitted pollutant sources. As the TMDLs are concentration-based, the LA is equal to the water quality standard (i.e., geometric mean standard).

The nonpermitted pollutant sources vary for each impaired beach TMDL. The contributing drainage areas for each beach are discussed in Section 3.1 and summarized herein:

- **Leif Erikson Park Beach**: The impairments are derived from local sources within the direct drainage to the beach, storm sewersheds along the northshore east and west of the impaired beach, and the Chester Creek Watershed. Bacteria loading from the St. Louis River and Nemadji River Watersheds and Lake Superior are not expected to contribute to the impairment at Leif Erikson Park Beach.
- **Boy Scout Landing Beach**: The impairments are derived from sources within the direct drainage to the beach, the Sargent Creek Watershed, and the St. Louis River Watershed between the Fond du Lac Dam and the impaired beach. Sources within Wisconsin are accounted for by the state border boundary condition. Sources in the Nemadji River Watershed or Duluth-Superior Harbor are not expected to contribute to the impairment at Boy Scout Landing Beach.
- **Park Point Beaches**: The impairments are derived from sources within the direct drainage to each beach, the St. Louis River Watershed downstream of Fond du Lac Dam, the Duluth-Superior Harbor, and the Nemadji River Watershed. Sources within Wisconsin are accounted for by the state border boundary condition.

4.1.6 Wasteload allocation methodology

The WLA is allocated to existing or future NPDES-permitted pollutant sources. The only permitted point sources in the impaired beaches' direct drainage subwatersheds that require an *E. coli* WLA are regulated MS4s. In the watersheds draining to the St. Louis River and Estuary downstream of the Fond du Lac dam, Nemadji River (in Minnesota), and Duluth-Superior Harbor, *E. coli* WLAs are required for regulated MS4s and the regional WLSSD. Permitted construction and industrial stormwater sources are not expected to be sources of *E. coli* and are not provided WLAs. There are no permitted CAFOs in the TMDL project area.

There are 10 regulated MS4s in the project area: City of Duluth, Midway Township, City of Hermantown, City of Proctor, City of Rice Lake, Lake Superior College - Duluth, Thomson Township, University of Minnesota – Duluth, St. Louis County, and Minnesota Department of Transportation (MnDOT) Outstate District (see Table 10).

For Boy Scout Landing and the Park Point impaired beaches, MS4 permittees were assigned a WLA if they had regulated area within (1) the subwatershed draining to the impaired beach, or (2) an upstream subwatershed within the study area. Permittees were assigned a WLA for Leif Erickson Beach if they had regulated area within the Chester Creek Watershed. The MS4 regulated area for Proctor, Rice Lake, and Midway Township is only within urban and platted areas within their jurisdictions. The MS4 regulated area for St. Louis County and MnDOT is road right of way within the Census defined urban area. As the TMDLs are concentration-based, the WLA is equal to the water quality standard (i.e., geometric mean standard).

4.1.7 Margin of safety

As the concentration-based TMDLs were set to water quality standards, no explicit MOS was included.

TMDLs did not account for pathogen die-off, which is a conservative assumption that provides implicit MOS. Many source areas (including regulated MS4s, upland deposition from wildlife) are located several miles upstream of the impaired beaches. Likely following precipitation events, pathogens from these sources can be transported by overland flow and runoff to area waterways (e.g., Chester Creek, Sargent Creek, St. Louis River) and then be transported to the impaired beaches. Pathogen die-off during transit from sources to impaired beaches is affected by biological, chemical, and physical factors. For example, pathogen die-off can be increased by microorganism predation of pathogens, low turbidity (high light penetration into the stream), and cold water temperatures. Generally, die-off becomes more significant as the distance of sources from impairments increases. For these five impaired beaches, die-off may be insignificant for pathogens derived from sources within the impaired beaches' direct drainage subwatersheds and pathogens derived from nearby sources directly upstream of the impaired beaches.

Finally, TMDLs were developed at a daily concentration target of 126 org/100mL. This value is equivalent to the value of Minnesota's *E. coli* criterion for the calendar month geometric mean. The TMDL essentially applies a calendar month geometric mean criterion as a daily target, which is a conservative assumption that provides implicit MOS. Also, the daily target of 126 org/100 mL is more conservative than the not to exceed criterion of 235 org/100mL with a 10% exception because 126 is less than 235 and the TMDL target does not have a 10% exception (the TMDL target must be met every day).

4.1.8 Seasonal variation and critical conditions

The CWA requires that TMDLs take into account critical conditions for flow, loading, and water quality parameters as part of the analysis of loading capacity. In concentration-based TMDLs, the loading capacity equals the standard. Seasonal variations and critical conditions are addressed in this TMDL by assessing conditions only during the season when the water quality standard applies (April 1 through October 31). Critical conditions occur during this timeframe as recreation at the beaches typically occurs during the warmer months, especially from Memorial Day through Labor Day. Additionally, summer storms during lower flow conditions, especially in urbanized areas, can rapidly transport pathogens from the watershed to the beaches; after the storm pulse, pathogens can persist in stagnant, nearshore waters.

4.2 TMDL summaries

For each impaired beach, box-and-whisker charts are presented with observed *E. coli* concentrations and the TMDL target (126 org/100 mL), which is set to an equivalent value to that of the calendar month geometric mean criterion (126 org/100 mL). Figure 41, Figure 42, Figure 43, Figure 44, and Figure 45 provide the calendar month geometric means of observed data for the impaired beaches, with the independent axis as the calendar month and the dependent axis as the calendar month geometric mean concentrations. The years (or recreation seasons) are ignored; observed data are plotted using the month. The geometric mean standard is also plotted on the graph. Portions of the boxes-and-whiskers plotting above the line represent deviations from the standard and the allowable concentration, while points plotting below the line represent compliance with the standard and the allowable concentration.

The figure for each beach is followed by an allocation table.

4.2.1 Leif Erikson Park Beach (04010102-C21)

The geometric mean figure (Figure 41) and TMDL allocations (Table 17) for Leif Erikson Park Beach were developed using geometric means of individual samples collected in April through October (the standard window) from 2009 through 2018. Reductions to achieve the geometric mean standard are necessary, especially in July.

Figure 41. Calendar monthly geometric means of *E. coli* concentration, Leif Erikson Park Beach (04010102-C21).
E. coli geometric mean concentrations from 2009 through 2018 are plotted by month.

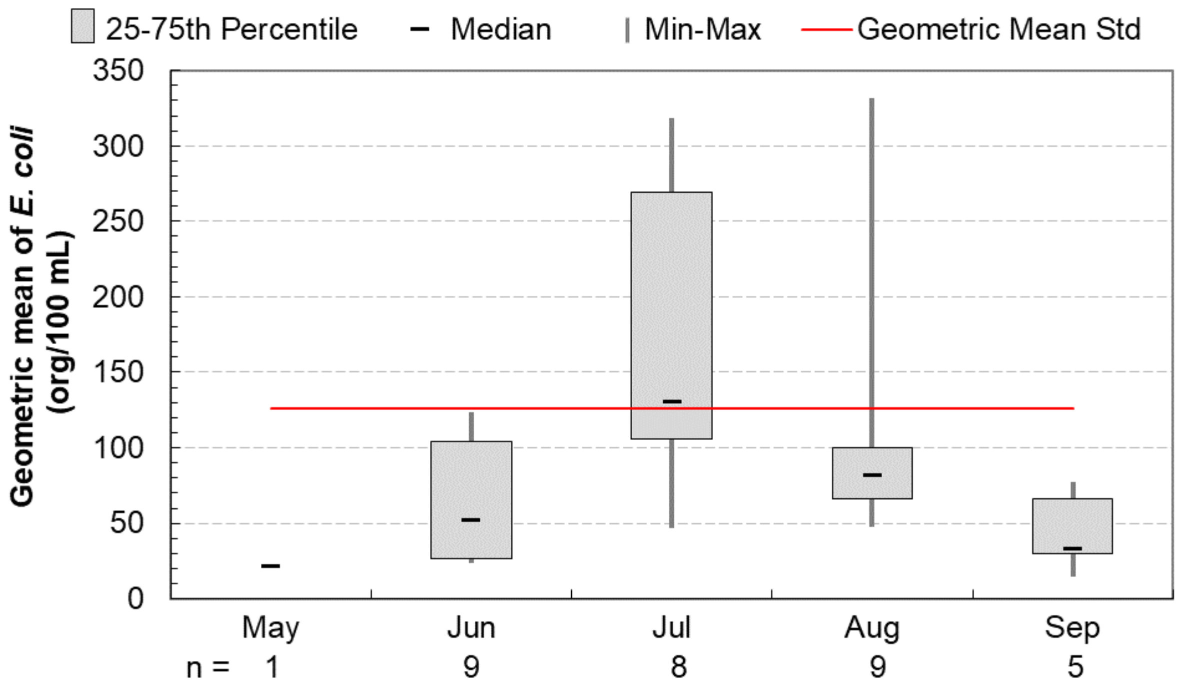


Table 17. *E. coli* TMDL summary, Leif Erikson Park Beach (04010102-C21).

- **303(d) listing year:** 2014
- **Baseline year:** 2011
- **Numeric target used to calculate TMDL:** 126 org/100 mL
- **TMDL and allocations apply Apr 1 –Oct 31**

TMDL Parameter		***E. coli* (org/100 mL)**
WLA	Duluth City MS4 (MS400086)	126
	Rice Lake (MS400151)	
	St. Louis County MS4 (MS400158)	
	MnDOT Outstate District MS4 (MS400180)	
	University of Minnesota Duluth (MS400214)	
	Total WLA	
LA	**Total LA**	
TMDL		
Maximum calendar month geometric mean (org/100 mL)		131
Overall estimated percent reduction [a]		4%

Note – the WLA and LA are not additive, each allocation receives the same concentration (i.e., 126 org/mL). MOS is implicit (see discussion in Section 4.1.7). Attainment of both the geometric mean and single sample parts of the water quality standard is required.

a. Calculated by comparing the highest observed (monitored) calendar month geometric mean concentration from the months that the standard applies to the geometric mean standard, as a concentration, ([monitored – standard]/monitored). Observed *E. coli* data are from 2009 through 2018.

4.2.2 Minnesota Point 15th Street Harbor Side Beach (04010201-A90)

The geometric mean figure (Figure 42) and TMDL allocations (Table 18) for Minnesota Point 15th Street Harbor Side Beach were developed using geometric means of individual samples collected in April through October from 2009 through 2018. Reductions to achieve the geometric mean standard are necessary, especially in July.

Figure 42. Calendar monthly geometric means of *E. coli* concentration, Minnesota Point 15th Street Harbor Side Beach (04010201-A90).

E. coli geometric mean concentrations from 2009 through 2018 are plotted by month.

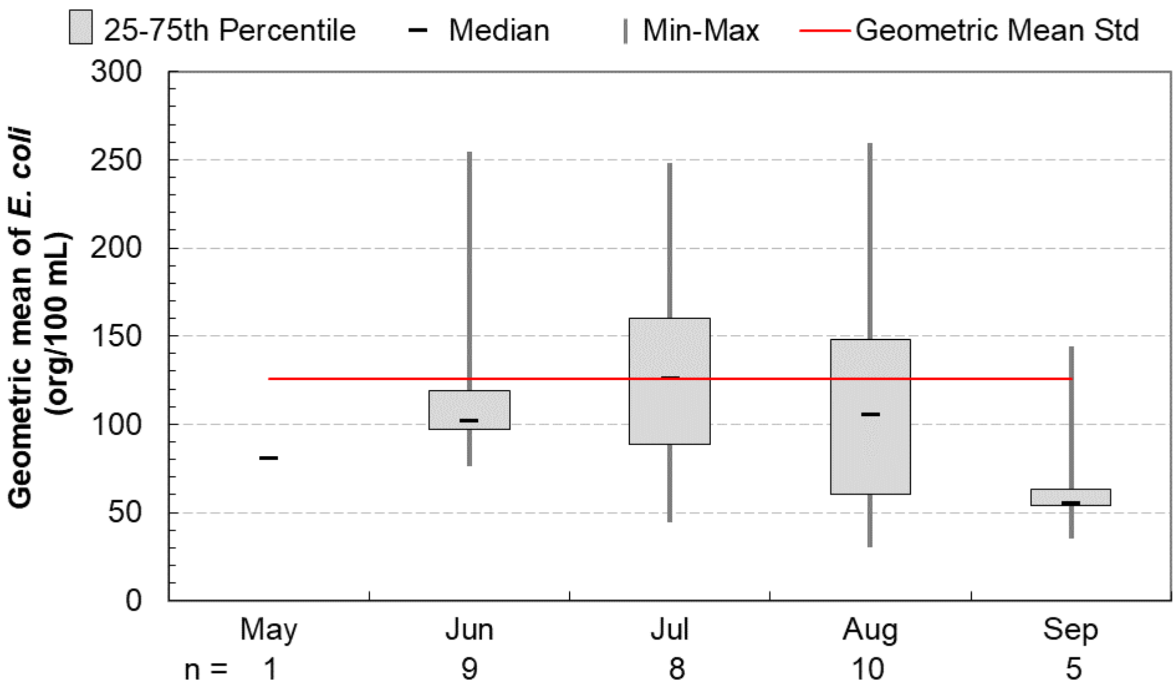


Table 18. *E. coli* TMDL summary, Minnesota Point 15th Street Harbor Side Beach (04010201-A90).

- **303(d) listing year:** 2014
- **Baseline year:** 2011
- **Numeric target used to calculate TMDL:** 126 org/100 mL
- **TMDLs and allocations apply Apr 1 –Oct 31**

TMDL Parameter		*E. coli* (org/100 mL)
Boundary conditions	St. Louis River at Fond du Lac dam	126
	State of Wisconsin	
WLA	WLSSD WWTP (MN0049786)	
	Duluth City MS4 (MS400086)	
	Hermantown (MS400093)	
	Midway Township (MS400146)	
	Proctor (MS400114)	
	Thomson Township (MS400280)	
	University of Minnesota Duluth (MS400214)	
	Lake Superior College (MS400225)	
	St. Louis County (MS400158)	
	MnDOT Outstate District (MS400180)	
	Total WLA	
LA	**Total LA**	
Loading Capacity		
Maximum calendar month geometric mean (org/100 mL)		259
Overall estimated percent reduction [a]		51%

Note – the WLA and LA are not additive, each allocation receives the same concentration (i.e., 126 org/mL). MOS is implicit (see discussion in Section 4.1.7). Attainment of both the geometric mean and single sample parts of the water quality standard is required.

a. Calculated by comparing the highest observed (monitored) calendar month geometric mean concentration from the months that the standard applies to the geometric mean standard, as a concentration, ([monitored – standard]/monitored). Observed *E. coli* data are from 2009 through 2018.

4.2.3 Park Point 20th Street/Hearding Island Canal Beach (04010201-A89)

The geometric mean figure (Figure 43) and TMDL allocations (Table 19) for Park Point 20th Street/Hearding Island Canal Beach were developed using geometric means of individual samples collected in April through October from 2009 through 2014. Reductions to achieve the geometric mean standard are necessary from June through September.

Figure 43. Calendar monthly geometric means of *E. coli* concentration, Park Point 20th Street/Hearding Island Canal Beach (04010201-A89).

E. coli geometric mean concentrations from 2009 through 2018 are plotted by month.

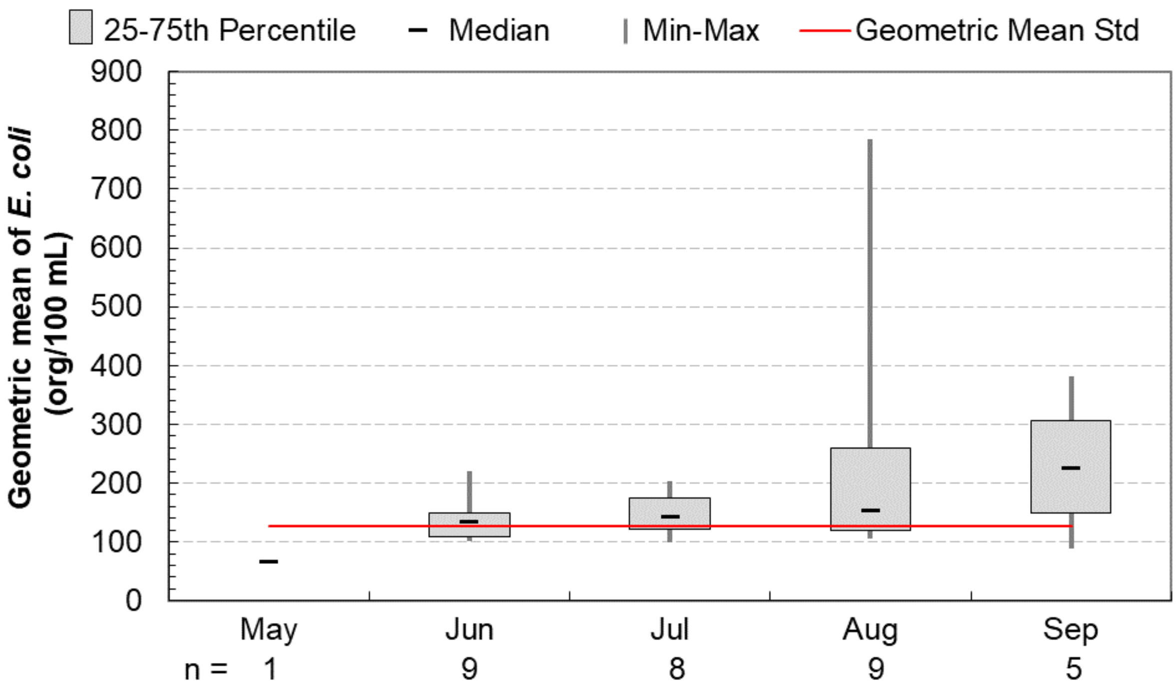


Table 19. ***E. coli*** **TMDL summary, Park Point 20th Street/Hearding Island Canal Beach (04010201-A89).**

- **303(d) listing year:** 2014
- **Baseline year:** 2011
- **Numeric target used to calculate TMDL:** 126 org/100 mL
- **TMDL and allocations apply Apr 1 –Oct 31**

<table>
<tr><th colspan="2">TMDL Parameter</th><th>E. coli (org/100 mL)</th></tr>
<tr><td rowspan="2">Boundary conditions</td><td>St. Louis River at Fond du Lac dam</td><td rowspan="15">126</td></tr>
<tr><td>State of Wisconsin</td></tr>
<tr><td rowspan="11">WLA</td><td>WLSSD WWTP (MN0049786)</td></tr>
<tr><td>Duluth City MS4 (MS400086)</td></tr>
<tr><td>Hermantown (MS400093)</td></tr>
<tr><td>Midway Township (MS400146)</td></tr>
<tr><td>Proctor (MS400114)</td></tr>
<tr><td>Thomson Township (MS400280)</td></tr>
<tr><td>University of Minnesota Duluth (MS400214)</td></tr>
<tr><td>Lake Superior College (MS400225)</td></tr>
<tr><td>St. Louis County (MS400158)</td></tr>
<tr><td>MnDOT Outstate District (MS400180)</td></tr>
<tr><td>Total WLA</td></tr>
<tr><td>LA</td><td>Total LA</td></tr>
<tr><td colspan="2">Loading Capacity</td></tr>
<tr><td colspan="2">Maximum calendar month geometric mean (org/100 mL)</td><td>784</td></tr>
<tr><td colspan="2">Overall estimated percent reduction [a]</td><td>84%</td></tr>
</table>

Note – the WLA and LA are not additive, each allocation receives the same concentration (i.e., 126 org/mL). MOS is implicit (see discussion in Section 4.1.7). Attainment of both the geometric mean and single sample parts of the water quality standard is required.

a. Calculated by comparing the highest observed (monitored) calendar month geometric mean concentration from the months that the standard applies to the geometric mean standard, as a concentration, ([monitored – standard]/monitored). Observed *E. coli* data are from 2009 through 2014.

4.2.4 Park Point Sky Harbor Parking Lot Beach (04010201-A87)

The geometric mean figure (Figure 44) and TMDL allocations (Table 20) for Park Point Sky Harbor Parking Lot Beach were developed using geometric means of individual samples collected in April through October from 2009 through 2018. Reductions to achieve the geometric mean are necessary especially in July.

Figure 44. Calendar monthly geometric means of *E. coli* concentration, Park Point Sky Harbor Parking Lot Beach (04010201-A87).
E. coli geometric mean concentrations from 2009 through 2018 are plotted by month.

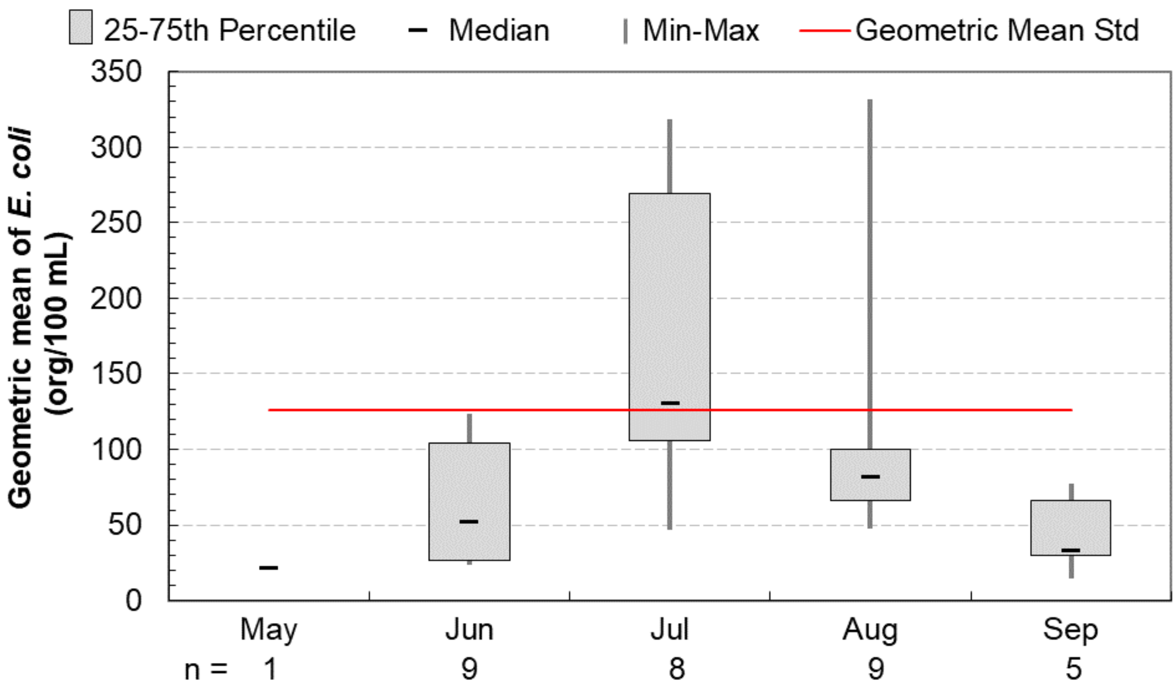


Table 20. *E. coli* TMDL summary, Park Point Sky Harbor Parking Lot Beach (04010201-A87).

- **303(d) listing year:** 2016
- **Baseline year:** 2011
- **Numeric target used to calculate TMDL:** 126 org/100 mL
- **TMDL and allocations apply Apr 1 –Oct 31**

<table>
<tr><th colspan="2">TMDL Parameter</th><th>E. coli (org/100 mL)</th></tr>
<tr><td rowspan="2">Boundary conditions</td><td>St. Louis River at Fond du Lac dam</td><td rowspan="15">126</td></tr>
<tr><td>State of Wisconsin</td></tr>
<tr><td rowspan="11">WLA</td><td>WLSSD WWTP (MN0049786)</td></tr>
<tr><td>Duluth City MS4 (MS400086)</td></tr>
<tr><td>Hermantown (MS400093)</td></tr>
<tr><td>Midway Township (MS400146)</td></tr>
<tr><td>Proctor (MS400114)</td></tr>
<tr><td>Thomson Township (MS400280)</td></tr>
<tr><td>University of Minnesota Duluth (MS400214)</td></tr>
<tr><td>Lake Superior College (MS400225)</td></tr>
<tr><td>St. Louis County (MS400158)</td></tr>
<tr><td>MnDOT Outstate District (MS400180)</td></tr>
<tr><td>Total WLA</td></tr>
<tr><td>LA</td><td>Total LA</td></tr>
<tr><td colspan="2">Loading Capacity</td></tr>
<tr><td colspan="2">Maximum calendar month geometric mean (org/100 mL)</td><td>331</td></tr>
<tr><td colspan="2">Overall estimated percent reduction [a]</td><td>62%</td></tr>
</table>

Note – the WLA and LA are not additive, each allocation receives the same concentration (i.e., 126 org/mL). MOS is implicit (see discussion in Section 4.1.7). Attainment of both the geometric mean and single sample parts of the water quality standard is required.

a. Calculated by comparing the highest observed (monitored) calendar month geometric mean concentration from the months that the standard applies to the geometric mean standard, as a concentration, ([monitored – standard]/monitored). Observed *E. coli* data are from 2009 through 2018.

4.2.5 Boy Scout Landing Beach (04010201-A92)

The geometric mean figure (Figure 45) and TMDL allocations (Table 21) for Boy Scout Landing Beach were developed using geometric means of individual samples collected in April through October from 2009 through 2018. Reductions to achieve the geometric mean standard are necessary in August.

Figure 45. Calendar monthly geometric means of *E. coli* concentration, Boy Scout Landing Beach (04010201-A92).
E. coli geometric mean concentrations from 2009 through 2018 are plotted by month.

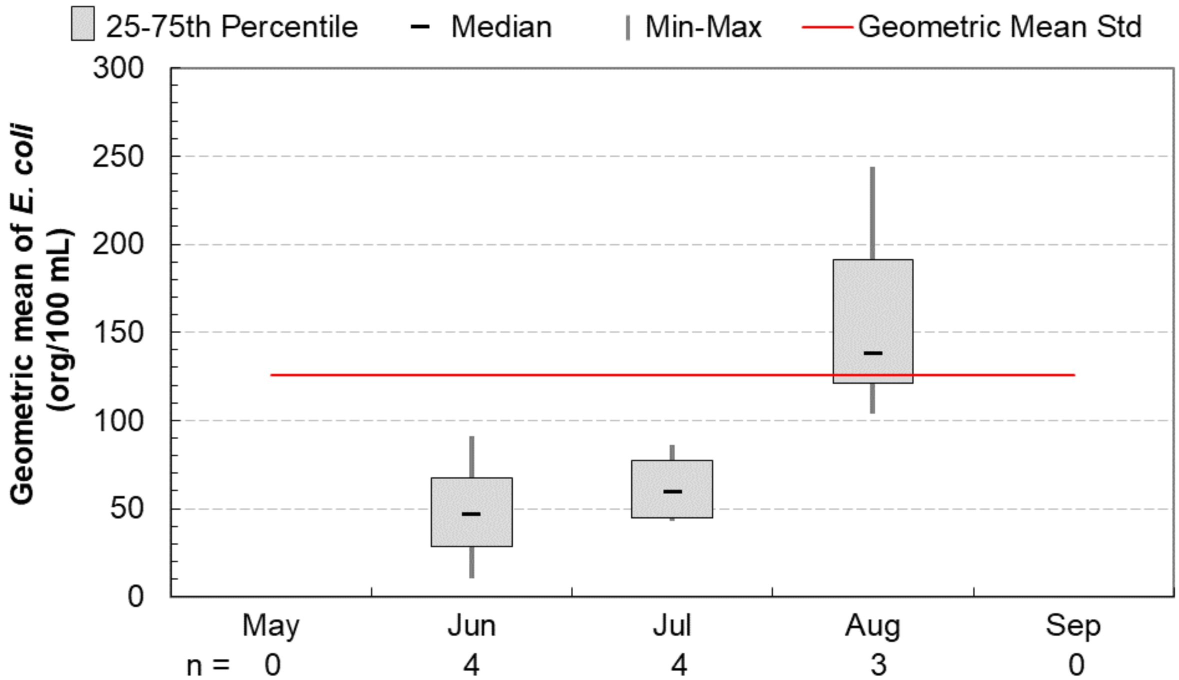


Table 21. *E. coli* TMDL summary, Boy Scout Landing Beach (04010201-A92).

- **303(d) listing year:** 2020
- **Baseline year:** 2011
- **Numeric target used to calculate TMDL:** 126 org/100 mL
- **TMDL and allocations apply Apr 1 –Oct 31**

TMDL Parameter		***E. coli* (org/100 mL)**
Boundary conditions	St. Louis River at Fond du Lac dam	126
	State of Wisconsin	
WLA	Duluth City MS4 (MS400086)	
	Midway Township MS4 (MS400146)	
	Thomson Township (MS400280)	
	MnDOT Outstate District MS4 (MS400180)	
	Total WLA	
LA	**Total LA**	
Loading Capacity		
Maximum calendar month geometric mean (org/100 mL)		244
Overall estimated percent reduction [a]		48%

Note – the WLA and LA are not additive, each allocation receives the same concentration (i.e., 126 org/mL). MOS is implicit (see discussion in Section 4.1.7). Attainment of both the geometric mean and single sample parts of the water quality standard is required.

a. Calculated by comparing the highest observed (monitored) calendar month geometric mean concentration from the months that the standard applies to the geometric mean standard, as a concentration, ([monitored – standard]/monitored). Observed *E. coli* data are from 2009 through 2018.

5. Future growth considerations

5.1 New or expanding permitted MS4 WLA transfer process

Future modifications of allocations in this TMDL may be necessary if any of the following scenarios occur within the project watershed boundaries.

- One regulated MS4 acquires land from another regulated MS4. Examples include annexation or highway expansions.
- One or more nonregulated MS4s become regulated.
- Expansion of a U.S. Census Bureau Urban Area encompasses new regulated areas for existing permittees. An example is existing state highways that were outside an urban area at the time the TMDL was completed, but are now inside a newly expanded urban area.
- A new MS4 or other stormwater-related point source is identified and is covered under a NPDES Permit.

Since these TMDLs are not load-based, all sources receive the same allocation equal to the water quality standard. In cases where new MS4 WLAs need to be added to the TMDL, the permittees will be notified of the requirements and have an opportunity to comment.

5.2 New or expanding wastewater

The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to water bodies with an EPA approved TMDL for total suspended solids or *E. coli* (described in MPCA 2012). This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are at or below the instream target and will ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs will be handled by the MPCA, with input and involvement by the EPA, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and EPA to comment on the permit changes based on the proposed WLA modification(s). Once any comments or concerns are addressed and the MPCA determines that the new or expanded wastewater discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made.

6. Reasonable assurance

The EPA requires reasonable assurance that TMDLs will be achieved and water quality standards will be met. “Reasonable assurance” shows that elements are in place, for both permitted and nonpermitted sources, that are making and will continue to make progress toward needed pollutant reductions. Reasonable assurance that the practices implemented to control sources of bacteria will meet both the geometric mean standard and the individual sample standard are provided in the following sections.

6.1 Permitted sources

Permitted stormwater and the WLSSD wastewater treatment facility are the only permitted sources discharging *E. coli* in the project area. WLSSD already includes a permit limit equal to the water quality standard. A WLA is assigned to the WLSSD in conformance with this TMDL.

The MPCA is responsible for applying federal and state regulations to protect and enhance water quality in Minnesota. The MPCA oversees stormwater management accounting activities for all MS4 entities listed in this TMDL report. The Small MS4 General Permit requires regulated municipalities to implement BMPs that reduce pollutants in stormwater to the maximum extent practicable. A critical component of permit compliance is the requirement for the owners or operators of a regulated MS4 conveyance to develop a Stormwater Pollution Prevention Program (SWPPP). The SWPPP addresses all permit requirements, including the following six measures:

- Public education and outreach
- Public participation
- Illicit discharge detection and elimination program
- Construction site runoff controls
- Post-construction runoff controls
- Pollution prevention and municipal good housekeeping measures

A SWPPP is a management program that captures the MS4 permittee’s activities for managing stormwater within their regulated area. In the event of a completed TMDL study, MS4 permittees must document the WLA in their future NPDES/SDS permit application and provide an outline of the BMPs to be implemented that address needed reductions. The MPCA requires MS4 owners or operators to submit their application and corresponding SWPPP document to the MPCA for review. Once the application and SWPPP are deemed adequate by the MPCA, all application materials are placed on 30-day public notice, allowing the public an opportunity to review and comment on the prospective program. Once NPDES/SDS permit coverage is granted, permittees must implement the activities described within their SWPPP and submit an annual report to the MPCA documenting the implementation activities completed within the previous year, along with an estimate of the cumulative pollutant reduction achieved by those activities. For information on all requirements for annual reporting, please see the *Minnesota Stormwater Manual* (Minnesota Stormwater Manual Contributors 2020): *Guidance for completing the TMDL reporting form*.

This TMDL report assigns *E. coli* WLAs to permitted MS4s in the project area. The Small MS4 General Permit requires permittees to provide a description of bacteria BMPs that have been developed and implemented to satisfy permit requirements.

Specifically, the 2020 Small MS4 General Permit states:

> *22.3 If the permittee has an applicable WLA where a reduction in pollutant loading is required for bacteria, the permittee must maintain a written or mapped inventory of potential areas and sources of bacteria (e.g., dense populations of waterfowl or other bird, dog parks). [Minn. R. 7090]*
>
> *22.4 If the permittee has an applicable WLA where a reduction in pollutant loading is required for bacteria, the permittee must maintain a written plan to prioritize reduction activities to address the areas and sources identified in the inventory in item 22.3. The written plan must include BMPs the permittee will implement over the permit term, which may include, but is not limited to: a. water quality monitoring to determine areas of high bacteria loading; b. installation of pet waste pick-up bags in parks and open spaces; c. elimination of over-spray irrigation that may occur at permittee owned areas; d. removal of organic matter via street sweeping; e. implementation of infiltration structural stormwater BMPs; or f. management of areas that attract dense populations of waterfowl (e.g., riparian plantings). [Minn. R. 7090]*

The MPCA's stormwater program and its NPDES permit program are regulatory activities providing reasonable assurance that implementation activities are initiated, maintained, and consistent with WLAs assigned in this study. The Minnesota Stormwater Manual provides guidance for meeting bacteria TMDL MS4 requirements.

Finally, the City of Duluth has proposed to conduct a comprehensive evaluation of sanitary sewer infrastructure within the impaired reaches of Chester Creek and in locations of past sanitary sewer overflows. If additional sanitary sewer overflows, which are prohibited, are identified, the city can mitigate them. This evaluation will help ensure that additional point source bacteria loads do not contribute to the impairments in Chester Creek and Leif Erikson Park Beach.

6.2 Nonpermitted sources

Reasonable assurance that nonpoint sources of *E. coli* will be reduced for the impaired beaches is given below by the following points.

- Reliable means of addressing pollutant loading;
- A means of prioritizing and focusing management;
- Development of a strategy for implementation;
- Availability of funding to execute projects;
- A system of tracking progress and monitoring water quality response; and
- Existing nonpoint source pollution reduction examples.

There are several **reliable means of addressing nonpermitted bacteria loading** to the Duluth area impaired beaches, as seen through the many partners and collaborations working to improve water quality in the project area. Restoration of the Duluth area impaired beaches will occur as part of local, regional, state, and federal efforts and will be supported by MDH, the SSLSWCD, St. Louis County, state agencies, the City of Duluth, and residents. In addition, watershed groups such as the Regional Stormwater Protection Team, the Duluth Urban Watershed Advisory Committee (DUWAC), Minnesota Sea Grant, the Natural Resources Research Institute, and the University of Minnesota Duluth are active partners in watershed protection and restoration in the watershed.

DUWAC is a voluntary group of stakeholders that provides the opportunity for collaboration, information sharing, and education related to watershed implementation. The committee was formed in 2015. The DUWAC's primary purpose is to serve as an information exchange and coordinating mechanism for a wide variety of projects currently underway, as well as proposed future projects, with consequences for the region's water resources.

In addition, many groups are working together at this time in varying capacities to address the BUIs in the St. Louis River AOC including, but not limited to, the following organizations:

- City of Duluth, Minnesota
- City of Superior, Wisconsin
- Duluth Seaway Port Authority
- Fond du Lac Band of Lake Superior Chippewa
- MPCA
- Harbor Technical Advisory Committee of the Duluth-Superior Metropolitan Interstate Council
- Lake Superior National Estuarine Research Reserve
- MDH
- Minnesota DNR
- Minnesota Land Trust
- NOAA
- St. Louis River Alliance
- University of Minnesota-Duluth
- University of Minnesota - Minnesota Sea Grant
- University of Minnesota Natural Resources Research Institute
- University of Wisconsin-Superior
- University of Wisconsin-Wisconsin Sea Grant
- U.S. Army Corps of Engineers - Detroit District
- U.S. EPA Great Lakes National Program Office
- U.S. EPA Great Lakes Toxicology and Ecology Division
- U.S. Fish and Wildlife Service
- Wisconsin Department of Natural Resources
- Wisconsin Landmark Conservancy

Results of the MST analysis, the ongoing St. Louis River One Watershed, One Plan (1W1P) planning effort, and the MS4 SWPPPs provide the means for **prioritizing and focusing management activities** to address impaired beaches in this TMDL. Management activities to address bacteria loading to beaches are many; however, sources that were detectable in the MST analysis for this TMDL should be prioritized for management and control.

Minnesota has a long history of water management by local government, which included developing water management plans along county boundaries since the 1980s. The Board of Water and Soil Resources (BWSR)-led 1W1P program is rooted in work initiated by the Local Government Water Roundtable (Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of Soil and Water Conservation Districts). The Roundtable recommended that local governments organize to develop focused implementation plans based on watershed boundaries. That recommendation was followed by legislation in 2015 (Minn. Stat. § 103B.801) that would establish the 1W1P program, which provides policy, guidance, and support for developing comprehensive watershed management plans that:

- Align local water planning purposes and procedures on watershed boundaries to create a systematic, watershed-wide, science-based approach to watershed management.
- Acknowledge and build off existing local government structure, water plan services, and local capacity.
- Incorporate and make use of data and information, including WRAPS.
- Solicit input and engage experts from agencies, citizens, and stakeholder groups; focus on implementation of prioritized and targeted actions capable of achieving measurable progress.
- Serve as a substitute for a comprehensive plan, local water management plan, or watershed management plan developed or amended, approved, and adopted.

A 1W1P is currently in development for the St. Louis River 1W1P Planning Area that includes the St. Louis River Watershed, Cloquet River Watershed, and the southern portion of Lake Superior South Watershed, which encompasses the entire Duluth Urban Area. BWSR is committed to completing all 1W1Ps by 2025 and the St. Louis River 1W1P is expected to be completed in 2022. Implementation of the St. Louis River 1W1P through dedicated funding for completed 1W1P plans will have positive impacts on water quality.

The **development of a strategy for implementation** is expanded upon in the implementation strategy summary (Section 8).

Several **funding sources are available to execute projects** outlined in the implementation strategy to restore impaired beaches in the Duluth area. Funding sources to implement TMDLs can come from local, state, federal, and/or private sources. Examples of available funding include:

- BWSR’s Watershed-based Implementation Funding
- Clean Water Fund Competitive Grants, part of the Clean Water, Land, and Legacy Amendment
- Minnesota’s Lake Superior Coastal Program grants
- Local government cost-share and loan programs

- Federal grants and technical assistance programs (e.g., National Fish and Wildlife Foundation, U.S. Forest Service)
- Federal Section 319 program for watershed improvements
- Great Lakes Restoration Initiative (GLRI)
- Outdoor Heritage Fund, part of the Clean Water, Land, and Legacy Amendment
- Great Lakes Commission grants
- Great Lakes Areas of Concern Land Acquisition Program grants (these are GLRI funds administered by NOAA's Office of Coastal Management)
- BEACH Act grant program
- MS4 capital and operational budgets

Watershed-based implementation funding is a noncompetitive process to fund water quality improvement and protection projects for lakes, rivers/streams, and groundwater. This funding allows collaborating local governments to pursue timely solutions based on a watershed's highest priority needs. The approach depends on the completion of a comprehensive watershed management plan developed under the 1W1P program framework to provide assurance that actions are prioritized, targeted, and measurable.

BWSR has begun the transition of moving toward watershed-based implementation funding to accelerate water management outcomes, enhance accountability, and improve consistency and efficiency across the state. This approach allows more clean water projects to be implemented and helps local governments spend limited resources where they are most needed.

Watershed-based implementation funding assurance measures are based on fiscal integrity and accountability for achieving measurable progress towards water quality elements of comprehensive watershed management plans. Assurance measures will be used as a means to help grantees meaningfully assess, track, and describe use of these grant funds to achieve clean water goals through prioritized, targeted, and measurable implementation. The following assurance measures are supplemental to existing reporting and on-going grant monitoring efforts:

- Understand contributions of prioritized, targeted, and measurable work in achieving clean water goals.
- Review progress of programs, projects, and practices implemented in identified priority areas.
- Complete Clean Water Fund grant work on schedule and on budget.
- Leverage funds beyond the state grant.

The Healthier Watersheds tracking system (Healthier watersheds: Tracking the actions taken | Minnesota Pollution Control Agency (state.mn.us)) is used to **track the progress** of implementation efforts throughout Minnesota, and the monitoring plan outlined in Section 7 will **monitor the water quality response** of implementation efforts in the Duluth area beaches. In addition, the City of Duluth and other government entities maintain permit compliance records related to project and program activities that can be used to track implementation progress.

Lastly, the numerous **examples of existing nonpoint source pollution reduction examples** within the project area provide further reasonable assurance for the Duluth Area Beaches TMDL. Agencies, organizations, and landowners in the Duluth Urban Area Watershed have been implementing water quality projects in an effort to reduce pollutant loading to impaired waters and are expected to continue this effort into the future. For example, SSLSWCD implements watershed projects such as large-scale stream restorations in impaired watersheds. The SWCD also offers technical and financial assistance for conservation efforts in the watershed. Other examples include:

Education and outreach efforts throughout the area aims to reduce bacteria loading from dog waste. A popular public service announcement and education campaign through the Regional Stormwater Protection Team, There is no such thing as “the Poop Fairy” and PFU - Poop Fairy University use humor to encourage residents to pick up after their dogs to prevent excess *E. coli* levels in local waterways. The City of Duluth also has an animal litter ordinance in place that requires “cleaning up any feces of the animal and disposing of such feces in a sanitary manner”. “Keep Duluth Clean” is an initiative in the City of Duluth that strives to promote community-motivated clean-up events and works to minimize illegal dumping, littering, and mishandling of Duluth's ecosystem services. In addition to the community-motivated litter campaign, the City of Duluth Parks and Recreation Department regularly hosts beach clean-up days along the Lake Superior shoreline. These clean up days provide the opportunity to educate the public on beach closings while removing potential sources of *E. coli* to the impaired beaches.

- The City of Duluth has been addressing leaky wastewater infrastructure through their annual capital improvement plan. Most recently, the City of Duluth has begun to address and reduce I&I in the sanitary system on Park Point to reduce the occurrences of sewer overflows. In 2017, 2018, and 2020, the City of Duluth invested approximately $1.5 million dollars into lining the public sanitary sewers on Park Point. This effort is expected to continue for another two to four years. The City of Duluth is also working on an aggressive plan to eliminate I&I from private lateral sanitary sewer lines (personal correspondence with City of Duluth Utility Programs Coordinator on 12/14/2020). The City of Duluth set aside approximately $300,000 to help homeowners offset the cost of lining or replacing private sewer lines that have been identified as contributing I&I to the sanitary sewer system in 2019-2020. There are plans to continue offering funds for lining private sewer lines on Park Point. A portable bathroom facility was also recently added to the Boy Scout Landing Beach.
- Two previous MST efforts have been conducted: the Duluth Stream Bacterial Source Identification Study (Burns & McDonnell Engineering Company, Inc. 2020) and the Bacterial Source Tracking at Impaired Beaches in the St. Louis River AOC (Prihoda et al. 2017). These

efforts help to better understand sources of *E. coli* in the area and therefore determine the appropriate implementation activities to reduce them.

In summary, significant time and resources have been devoted to identifying the best practices, providing means of focusing them in the Duluth area, and supporting their implementation via state initiatives and dedicated funding. The Duluth Urban Area WRAPS and TMDLs processes engaged partners to arrive at reasonable examples of BMP combinations that attain pollutant reduction goals. Minnesota is a leader in watershed planning as well as monitoring and tracking progress toward water quality goals and pollutant load reductions.

7. Monitoring plan

Future monitoring is important for several reasons including:

- Evaluating water bodies to determine if they are meeting water quality standards and tracking trends;
- Assessing potential sources of pollutants;
- Determining the effectiveness of implementation activities in the watershed; and
- De-listing waters that are no longer impaired.

Monitoring is also a critical component of an adaptive management approach and can be used to help determine when a change in management is needed. This section describes existing monitoring efforts and recommended monitoring activities in the watershed, subject to availability of resources and other priorities.

The MDH will continue to monitor beaches for excess levels of bacteria through their Minnesota Lake Superior Beach Monitoring Program. Sampling is conducted at least once a week at the impaired beaches in this TMDL, with the exception of Park Point 20th Street/Hearding Island Canal Beach, from May through the first week of September as described in Section 3.4.

MDH maintains a user-friendly website for information related to Lake Superior Beach Monitoring Program https://www.mnbeaches.org/. There, website visitors can view information on each beach, look at past water quality data, learn about potential beach advisories or closings, and read tips on how to keep themselves and the beach healthy when swimming or recreating there. Beach goers can sign up for Beach-alert emails and the MDH also maintains a 24-hour hotline for information.

The Minnesota Lake Superior Beach Monitoring Program has also developed nowcast models that predict current water quality conditions at Lake Superior beaches. The nowcast models are calibrated for each beach and were developed based on historical climate and water quality measures. Models use readily available information such as rainfall, cloud cover, wave height, water clarity, and temperature to estimate the probability that *E. coli* counts will exceed the acceptable standard. Nowcast models allow MDH staff to make timely beach advisory decisions and issue same-day notifications instead of waiting a day for laboratory results to become available.

In addition to MDH's routine beach monitoring, to better evaluate sources and the effectiveness of implementation activities, the following monitoring recommendations are provided:

- **Leif Erikson Park Beach**
    - Conduct longitudinal *E. coli* sampling from mouth of Chester Creek to the beach to understand potential impacts of *E. coli* levels from Chester Creek on beach closures.
    - Conduct comprehensive sanitary survey within the Leif Erikson Park Beach drainage area, including synoptic sampling within the watershed to help identify local sources of *E. coli* and hotspots.

- Conduct comprehensive MST study in the project area influencing Leif Erikson Park Beach and Chester Creek.

- **Boy Scout Landing Beach**
    - Consider increasing sampling events to twice a week either by re-classifying the beach as a Tier I beach or supplementing the MDH routine monitoring.
    - Conduct longitudinal *E. coli* sampling along Sargent Creek, specifically upstream and downstream of Highway 23 to better identify the location of *E. coli* hotspots.
    - Monitor *E. coli* levels within sediment in Sargent Creek and at the outlet of Sargent Creek. Evaluate cost effectiveness and conduct sediment removal to eliminate this potential source of bacteria to Boy Scout Landing Beach, if needed.
    - Recommendations for monitoring along Sargent Creek from the Duluth Urban Area Streams TMDL (MPCA 2020a):
        - Increase sampling of Sargent Creek under very high and very low flow conditions; there is currently no sampling under very high flows and only one sample under very low flows.
        - Monitor upstream of the impaired segment of Sargent Creek to determine potential source areas (currently only one station at downstream end).
- **Park Point Harbor Side Beaches (MN Point 15th Street Harbor Side Beach, Park Point 20th St/ Hearding Island Canal Beach, and Park Point Sky Harbor Parking Lot Beach)**
    - Additional *E. coli* monitoring within the Duluth-Superior Harbor during the recreational season and during the nonrecreational season is needed.
- **All beaches**
    - Additional transect monitoring (from the beach into the harbor and along the shoreline outside of the beach delineation) of *E. coli* to better understand interactions between these potential areas of influence, particularly during high winds and seiche events. Transect monitoring should be paired (i.e., collected concurrently) with beach sampling.
    - Synoptic monitoring of *E. coli* at regular intervals along the St. Louis River and Estuary and within the Duluth-Superior Harbor during a variant of flow conditions to determine how far bacteria migrate downstream and to evaluate die-off.
    - Reference sampling of *E. coli* throughout St. Louis River and Estuary and Duluth-Superior Harbor.

8. Implementation strategy summary

The Duluth Urban Areas WRAPS (MPCA 2020b) and Nemadji River WRAPS (MPCA 2017a) provide an overview of implementation strategies for *E. coli*-impaired waters in the project area. Continued implementation of these WRAPS will address the various sources of *E. coli* throughout the project area. The Duluth Urban Area WRAPS specifically includes implementation strategies that address four of the five impaired beaches (excepting Boy Scout Landing Beach). Boy Scout Landing Beach was not yet listed on Minnesota's 303(d) list at the time of WRAPS development and was therefore not included in the Duluth Urban Area WRAPS. Many of the recommended practices for impaired beaches in the WRAPS are also applicable to Boy Scout Landing Beach.

In addition to the strategies included in the Duluth Urban Areas WRAPS and Nemadji River WRAPS, more detailed implementation strategies were developed for both permitted and nonpermitted sources based on information included in this TMDL report and are included in the following sections. Implementation activities do not have to be restricted to within the specific beach delineated drainage area, but rather would be beneficial to occur anywhere within the expanded project area including the drainage area to the entire St. Louis River and Estuary, Duluth-Superior Harbor, Nemadji River, and tributaries and Leif Erikson Park Beach project area.

8.1 Strategies to address permitted sources of *E. coli*

There are 10 regulated MS4s in the project area for which NPDES/SDS MS4 General Permit (MNR040000) coverage is required. MS4 permittees are required to document progress towards meeting the WLA(s) as part of their MS4 SWPPP.

The MPCA Phase 2 MS4 permit utilizes a performance-based approach to bacteria impairments, focusing on an inventory of potential bacteria sources. The MPCA worked with a diverse stakeholder group to better understand sources of bacteria in urban settings and develop appropriate guidance and tools for addressing bacteria impairments. These tools are available on the Minnesota Stormwater Manual to assist permittees in meeting requirements found in the 2020 MS4 general permit reissued in November 2020. The manual will be updated as more research is conducted and as this stakeholder group proceeds with recommendations.

If current MS4 permit requirements for bacteria WLAs remain similar in the next MS4 general permit (expected to be issued in 2025), MS4s would be required to maintain a written or mapped inventory of bacteria sources, as well as a prioritization plan to reduce those bacteria sources.

In addition, permit implementation shall be continued for WLSSD.

8.2 Beach specific strategies to address sources of *E. coli*

In addition to the recommended practices provided in the Duluth Urban Area WRAPS (MPCA 2020b) and in Section 8.1, the following beach-specific strategies are recommended. Recommendations are based on results of the source assessment and Core Team input.

8.2.1 Leif Erikson Park Beach

- Implement recommended strategies in the Duluth Urban Area Streams TMDL and Duluth Urban Area WRAPS for Chester Creek with additional practices, as needed, specifically focusing on human-derived sources.
- Comprehensive sanitary survey throughout drainage area, including synoptic sampling to identify hot spots.
- Stormwater management plan development and implementation targeted in priority areas identified during sanitary survey.
- Continued infrastructure upgrades of public and private sanitary sewers. Consider potential to do so simultaneously with road replacement projects.
- Survey to ensure no failing septic systems from existing or previous dwellings.
- Wildlife management within storm sewer system to discourage potential raccoon activity (e.g., maintenance and inspection, nest removal, etc.).
- Continued maintenance of bathroom facilities and other existing amenities, such as trash and dog waste stations at beach and park.

8.2.2 Minnesota Point 15th Street Harbor Side Beach

- Survey to ensure no failing septic systems from existing or previous dwellings.
- Continued enforcement of sump pump ordinances to ensure no illegal discharges.
- Continued infrastructure upgrades of public and private sanitary lines. Consider potential to do so simultaneously with road replacement projects. It is estimated there are less than 15 private laterals within the drainage area.
- Increased signage targeting beachgoers on proper beach care and maintenance while visiting.
- Stormwater management to treat parking lot runoff from the U.S. Army Reserve Center. Practices could include permeable pavement and bioretention. Small scale stormwater management practices could also be used to store and infiltrate runoff from the contributing drainage area consisting of roads (Minnesota Avenue) and residential areas.
- Addition of restroom at or near beach.
- Revegetation of the slope leading to the beach.
- Increase the number of trash cans in surrounding areas. Consider adopt-a-road programs to encourage trash pick-up along roadways. Implement the “Keep Duluth Clean” campaign.
- Coordination with Wisconsin and Wisconsin municipalities and agencies to address potential sources of *E. coli* to the Nemadji River, St. Louis River and Estuary, and Duluth-Superior Harbor from Wisconsin and the possibility of a Wisconsin-side TMDL.

8.2.3 Park Point 20th Street/Hearding Island Canal Beach

- Future discussions with multiple agencies, city, and stakeholders to have future discussions about the viability of this beach.

- Increased signage targeting beachgoers at the actual beach location on proper beach care and maintenance while visiting, including pet waste disposal stations.
- Small scale stormwater management practices, including planting a shoreline buffer, installing permeable pavement and bioretention areas to treat runoff from the multi-family residential apartment complex parking lot.
- Assess the condition of the private sanitary sewer lateral (assume one serving the residential apartment complex) and replace or repair it if it is deteriorated. Consider potential to do so simultaneously with road replacement projects.
- Remove debris along the shoreline that traps litter; add a trash can at the beach; consider an adopt-a-street program for the neighborhood to encourage trash pick-up along roadways; implement the "Keep Duluth Clean" campaign.
- Addition of restroom or portable toilet at the beach.
- Provide outreach to marina users about proper wastewater and ballast water management.
- Coordination with Wisconsin and Wisconsin municipalities and agencies to address potential sources of *E. coli* to the Nemadji River, St. Louis River and Estuary, and Duluth-Superior Harbor from Wisconsin and the possibility of a Wisconsin-side TMDL.

8.2.4 Park Point Sky Harbor Parking Lot Beach

- Increased signage targeting beachgoers on proper beach care and maintenance while visiting, including pet waste disposal stations.
- Small scale stormwater management practices, as space allows, treating runoff from the road and parking areas.
- Wildlife deterrence (e.g., areas of higher vegetation, ropes, dogs or drone agitation, etc.) to keep birds and geese from accessing fields across Minnesota Avenue.
- Replacement of private lateral (assumes one lateral). Consider potential to do so simultaneously with road replacement projects.
- Increase the number of trash cans in surrounding areas. Consider adopt-a-road programs to encourage trash pick-up along roadways. Implement the "Keep Duluth Clean" campaign.
- Addition of more permanent restrooms at or near beach.
- Coordination with Wisconsin and Wisconsin municipalities and agencies to address potential sources of *E. coli* to the Nemadji River, St. Louis River and Estuary, and Duluth-Superior Harbor from Wisconsin and the possibility of a Wisconsin-side TMDL.

8.2.5 Boy Scout Landing Beach

- Implement recommended strategies in the Duluth Urban Area Streams TMDL and Duluth Urban Area WRAPS for Sargent Creek with additional practices, as needed, specifically focusing on human-derived sources such as septic systems. While ruminant genetic markers were detected in the MST analysis, the subwatershed to Sargent Creek is largely forested and this source is not a focus for implementation.

- Continued maintenance of bathroom facilities, stormwater management practices, and other existing amenities at beach.
- Increased signage targeting beachgoers on proper beach care and maintenance while visiting, including pet waste disposal stations.
- Coordination with Wisconsin and Wisconsin municipalities and agencies to address potential sources of *E. coli* to the St. Louis River from Wisconsin and the possibility of a Wisconsin-side TMDL.

8.3 St. Louis River AOC BUI removal strategy

The BUI for Beach Closings and Body Contact Restrictions focuses on human sources of bacteria to impaired beaches. According to the St. Louis River AOC RAP (MPCA et al. 2020), the remaining strategies to be completed in Minnesota to address the Beach Closings and Body Contact Restrictions BUI in the St. Louis River AOC include:

- Document compliance status of municipal wastewater treatment and MS4 discharge permits within the AOC (management action 7.01 in the RAP), and
- Tracking the cleanup projects at the U.S. Steel/Spirit Lake and Munger Landing remediation sites (management actions 7.04 and 7.06).

8.4 Cost

TMDLs are required to include an overall approximation of implementation costs (Minn. Stat. 2007, § 114D.25). The costs to implement the activities outlined in the strategy are approximately $3 to $4 million dollars over the next 15 years. This includes the cost of planning, maintenance, and capital costs. Assumptions that support the cost estimate are provided below:

- Line/replace lateral sanitary sewer lines – City of Duluth provides between $2,000 and $4,000 per lateral replacement, and the remaining portion is covered by the property owner. A conservative cost of $4,000 per private lateral was used in cost estimates for this TMDL, however, lateral line replacement costs are typically greater than that. The City has subsequently set aside approximately $300,000 total, or $4,000 per lateral, to help owners offset the cost of lining or repairing private sewer services that have been identified as contributing to the sanitary system on Park Point. In 2017, 2018, and 2020, the City of Duluth invested approximately $1.5 million dollars into lining the public sanitary sewers on Park Point. This effort is expected to continue for another two to four years.
- Portable bathroom installation/upgrade and maintenance – Installation of portable bathrooms including concrete pad and proper grading is estimated at approximately $100,000 per install with an annual maintenance costs of approximately $2,500 for each facility.
- Plan design, and construct small scale stormwater management practices – $400,000 is set aside for Park Point and Leif Erikson Park beaches. Total annual maintenance costs are estimated to be $10,000.
- Extensive sanitary survey and longitudinal sampling – approximately $200,000 for the Leif Erikson Park Beach drainage area. An additional $1 million is set aside for resulting projects.

- Increased signage, trash receptacles, and pet waste stations – a total of $15,000 for all beaches, annually.
- Vegetative management for wildlife control/installation of vegetated shoreline buffers – approximately $10,000 per beach for planning and implementation.
- Continued education campaigns – the original cost of video production for the "There is No Poop Fairy" campaign video was approximately $4,000. The proposed ramp up to production including more video and photo production is estimated at an additional $6,500 (communication with RSPT Co-Chair on January 6, 2021). This cost is assumed to be annual.

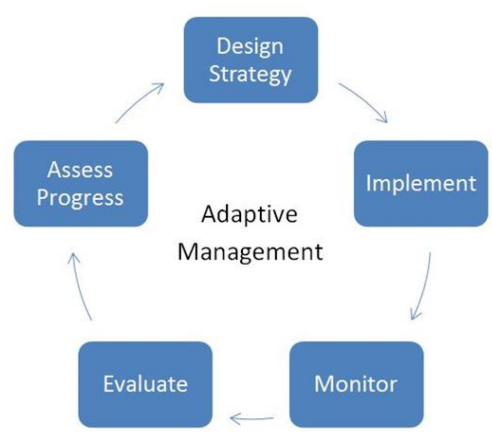
In addition, costs associated with activities in the implementation of the Duluth Urban Streams TMDL and Nemadji River TMDL will have positive impacts of water quality in impaired beaches; however, these costs are not included in this estimate. According to MPCA (2020a):

- Increased frequency of street sweeping to monthly or semi-monthly, with use of a regenerative air vacuum sweeper, is estimated at $1 million capital costs every 10 years and $250,000 annually over the 30-year plan. Current street sweeping costs were provided by the City of Duluth during development of this beach TMDL and are estimated at approximately $750,000 per year for the entire city. The actual cost of street sweeping can fluctuate due to factors such as equipment maintenance needs, material handling, etc. (communication with City of Duluth on January 12, 2021).
- The removal, upgrade, or replacement of all septic systems deemed an imminent threat to public health and safety is estimated at approximately $15,000 per system.
- Increased staffing levels for TMDL implementation are estimated to be $200,000 to $300,000 per year. Roles and responsibilities of staffing could include developing and implementing programs aimed largely at pet waste, education and outreach, wildlife management, and septic systems.

8.5 Adaptive management

The approach to implementation focuses on adaptive management. An adaptive management approach is an overall system of continuous improvements and feedback loops that allows for changes in the management strategy if environmental indicators suggest that the strategy is inadequate or ineffective. Continued monitoring and course corrections responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL.

Figure 46. Adaptive management process.



Natural resource management involves a series of actions and associated feedback loops that help to inform next steps to achieve overarching goals. In the simplest of terms, adaptive management is a cyclical process or loop in which actions are implemented, monitored, evaluated, compared to anticipated progress, and redesigned if needed (Figure 46.). In actuality, adaptive management in natural resource management consists of many of these feedback loops, all of which can occur at different speeds and durations. These loops or cycles can be large and programmatic in nature such as Minnesota's watershed approach, while others can be small and on a scale such as an individual field (Nelson et al. 2017). As a structured, iterative implementation process, adaptive management offers the flexibility for responsible parties to monitor implementation actions, determine the success of such actions, and ultimately, base management decisions upon the measured results of completed implementation actions and the current state of the system. This process enhances the understanding and estimation of predicted outcomes and ensures refinement of necessary activities to better guarantee desirable results. In this way, understanding of the resource can be enhanced over time and management can be improved (Williams et al. 2009).

9. Public participation

A virtual Core Team meeting for the Duluth Area Beaches TMDL was held on December 21, 2020. Subsequently, Core Team members were able to review and provide input on the results of the *E. coli* source assessment, the concentration-based TMDL approach, and recommended implementation activities. Following this input substantial revisions were made. A key revision to the TMDL approach included expanding the number of regulated MS4s with WLAs for the impaired beaches to include those with an upstream subwatershed within the study area (i.e., streams impaired for *E. coli* that discharge near the impaired beach) in addition to the subwatershed draining directly to the impaired beach.

Public notice

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from January 31, 2022 through March 2, 2022. There were two official comment letters received and responded to as a result of the public comment period.

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Appendix A. *E. coli* sampling results and MST selection

Table 22. *E. coli* sampling results (2020) and MST selection.

[shaded box] = sample selected for MST analysis

Note: The observations provided in this table represent a point in time and are not necessarily reflective of long term or average conditions.

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Boy Scout Landing	16-0001-B001	MDH	6/2/2020	8:40	Clear/Sunny	76.8	0	66.7	4	W	0	0	0	4.1	0.08	Y	1 bird in water
Boy Scout Landing	16-0001-B001	MDH	6/9/2020	8:31	Clear/Sunny	58.7	0	63.3	13	NE	0	0	0	45.7	0.13	Y	goose feces on shore
Boy Scout Landing	16-0001-242	SSL SWCD	6/15/2020	13:05	Cloudy, breezy	66	1	66.5	5	E	0	0	0	27.9	0	N	7 people, none swimming. Goose feces in parking lot.
Boy Scout Landing	16-0001-B001	MDH	6/16/2020	8:37	Partly Sunny/Partly Cloudy	67	0	58.4	4	SE	0	0	0	14.6	0	Y	bird feces on shore
Boy Scout Landing	16-0001-242	SSL SWCD	6/19/2020	11:02	Mostly sunny, breezy	74	1	72.5	9	W	0.1	0	0	90.6	0.39	Y	4 people, none swimming. Goose feces @ parking lot edges. Lots of boating activity.
Boy Scout Landing	16-0001-B001	MDH	6/23/2020	8:29	Partly Sunny/Partly Cloudy	68.2	0	70.5	7.7	N	0	0	0	8.5	0	Y	2 anglers
Boy Scout Landing	16-0001-B001	MDH	7/1/2020	8:39	Partly Sunny/Partly Cloudy	68.4	0	71.6	2.2	NE	0	0	0	56.5	0.59	Y	1 adult on shore, 2 children on shore
Boy Scout Landing	16-0001-B001	MDH	7/7/2020	8:36	Clear/Sunny	77.7	1	80	3.7	SW	0	0	0	41	0.33	Y	tadpoles in water, high turbidity
Boy Scout Landing	16-0001-242	SSL SWCD	7/9/2020	14:45	Overcast	79.3	1	78.8	8	SE	0.2	0	0	74.9	2.52	Y	People fishing and swimming at the landing.

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Boy Scout Landing	16-0001-B001	MDH	7/22/2020	14:33	Mostly Sunny	67.3	0	72.1	12	E	0.25	0	0	46.4	0.95	Y	
Boy Scout Landing	16-0001-B001	MDH	7/28/2020	8:28	Clear/Sunny	76	0	75.4	5	W	0.25	0	0	38.8	2.28	Y	2 anglers
Boy Scout Landing	16-0001-242	SSL SWCD	7/31/2020	10:45	Sunny, calm	84	1	80.6	0	N/A	0	0	18	1986.3	0	Y	Lots of goose feces on beach and on lawn next to beach
Boy Scout Landing	16-0001-B001	MDH	8/4/2020	8:36	Clear/Sunny	65.4	0	73.2	8.4	E	0.25	0	60	45	0.04	Y	
Boy Scout Landing	16-0001-B001	MDH	8/11/2020	8:33	Clear/Sunny	77.1	0	73.2	18.3	W	0.5	0	6	88.4	2.08	Y	
Boy Scout Landing	16-0001-B001	MDH	8/26/2020	12:56	Mostly Sunny	81.9	0	73.2	11.5	W	0.5	0	0	51.2	0.02	Y	goose poop on shore
Boy Scout Landing	16-0001-242	SSL SWCD	8/31/2020	12:50	Mostly sunny, breezy	68.7	1	72.9	3	W	0.5	0	0	456.9	0.11	Y	Goose feces on beach, parking lot and on lawn next to beach
Boy Scout Landing	16-0001-B001	MDH	9/2/2020	14:54	Clear/Sunny	75.1	0	69.6	13.4	SW	1	0	0	46.5	0.71	Y	
Boy Scout Landing	16-0001-242 (Dup)	SSL SWCD	9/14/2020	11:13										73.8	0.08	N	
Boy Scout Landing	16-0001-242	SSL SWCD	9/14/2020	11:12	Partly sunny, windy	61.7	1	61.7	1	E	0.1	2	0	70.3	0.08	Y	Goose feces on beach, parking lot and on lawn next to beach
Boy Scout Landing	16-0001-B001	MDH	7/14/2020	8:31	Cloudy	71.5	0	75.4	2	E	0	35	0	67.7	0.61	Y	
Boy Scout Landing	16-0001-B001	MDH	7/21/2020	8:29	Rain	61	1	72.5	5.8	E	0	0	0	261.3	0.07	Y	goose poop and feathers on shore

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Boy Scout Landing	16-0001-B001	MDH	8/18/2020	8:29	Clear/Sunny	68.0	0	68.9	1.4	S	0.25	0	0	65.1	0	Y	goose poop and feathers on shore
Boy Scout Landing	16-0001-B001	MDH	8/25/2020	8:38	Clear/Sunny	74.5	0	69.1	2.6	E	0.25	0	0	1732.9	0.14	Y	goose poop, feathers, tracks on shore
Chester Creek Outfall	S007-185	SSL SWCD	6/15/2020	11:21	Partly sunny, breezy					E				328.2	0	N	
Chester Creek Outfall	S007-185	SSL SWCD	6/19/2020	9:05	Mostly sunny, calm									>2419.6	0.39	Y	
Chester Creek Outfall	S007-185	SSL SWCD	9/14/2020	9:00	Cloudy, windy									1203.3	0.08	Y	
Hearding Island	16-0001-B037	SSL SWCD	6/15/2020	12:06	Cloudy, breezy	58	1	59	7	E	0.1	2	0	21.1	0	N	Goose feces on grass between beach and parking lot.
Hearding Island	16-0001-B037	SSL SWCD	6/19/2020	10:04	Mostly sunny, breezy	69	1	66	9	W	0.5	0	0	66.9	0.39	Y	0 people, some goose feces on grass between beach and parking lot.
Hearding Island	16-0001-B037	SSL SWCD	7/9/2020	13:15	Overcast, windy	80.2	2	75.2	10	SSE	0.8	0	0	770.1	2.52	Y	Gusty wind.
Hearding Island	16-0001-B037	SSL SWCD	7/31/2020	9:40	Sunny, calm	77.5	1	76.6	1	E	0.1	0	30	69.3	0	Y	Lots of goose feces on lawn next to beach
Hearding Island	16-0001-B037	SSL SWCD	8/31/2020	11:50	Partly sunny, breezy	64.8	2	67.8	15	W	1	0	0	35.9	0.11	Y	Goose feces on lawn next to beach
Hearding Island	16-0001-B037	SSL SWCD	9/14/2020	10:09	Cloudy, windy	56.5	1	56.5	4	E	0.1	0	0	30.9	0.08	Y	Goose feces on lawn next to beach

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Hearding Island	16-0001-B037 (Dup)	SSL SWCD	9/14/2020	10:10										35.5	0.08	N	
Leif Erikson	16-0001-B009	MDH	5/27/2020	13:24	Clear/Sunny	69.9	1	62.3	4.5	E	0.25	0	0	222.4	1.49	Y	9 adults at station, 2 children at station
Leif Erikson	16-0001-B009	MDH	6/2/2020	10:42	Mostly Sunny	81.1	0	49.3	7.2	W	0.25	0	0	6.3	0.08	Y	2 adults on shore, 2 children in water
Leif Erikson	16-0001-B009	MDH	6/3/2020	14:49	Clear/Sunny	80	0	49.8	3.4	NW	0.5	0	0	2	0.08	Y	4 adults on shore, 2 children on shore
Leif Erikson	16-0001-B009	MDH	6/9/2020	13:01	Mostly Sunny	51.5	1	54.3	15.5	NE	2	0	0	4.1	0.13	Y	2 adults on shore, 2 children on shore
Leif Erikson	16-0001-B009	MDH	6/11/2020	14:31	Mostly Sunny	68.7	0	48.9	3.2	W	0.5	0	0	15.8	0.02	Y	
Leif Erikson	16-0001-B009	SSL SWCD	6/15/2020	11:01	Partly sunny, breezy	59.2	0	53.5	7	E	1	0	0	9.7	0	N	9 people, 0 swimmers, 1 dog on a leash. Homeless shelter @ Chester Creek, between I35 and Lakewalk. Dog waste bag @ Chester Creek outfall.
Leif Erikson	16-0001-B009	MDH	6/16/2020	11:30	Mostly Sunny	61.7	0	53.3	3.3	E	3.3	0	0	8.4	0	Y	5 adults on shore
Leif Erikson	16-0001-B009	MDH	6/17/2020	14:07	Clear/Sunny	73.4	0	58.1	14.4	E	0.5	0	0	1	0	Y	10 adults on shore, 25 children on shore, 2 children in water
Leif Erikson	16-0001-B009	SSL SWCD	6/19/2020	8:43	Mostly sunny, calm	72	0	56.5	1	E	0	0	0	160.7	0.39	Y	6 people, none swimming.
Leif Erikson	16-0001-B009	MDH	6/23/2020	11:40	Mostly Sunny	74.3	0	59.4	2.5	NE	0.5	0	0	9.8	0	Y	7 adults on shore, 1 dog on shore
Leif Erikson	16-0001-B009	MDH	6/24/2020	12:09	Partly Sunny/Partly Cloudy	72.1	0	57	1.7	N	0.5	0	0	7.5	0.13	Y	6 adults on shore, 5 children in water

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Leif Erikson	16-0001-B009	MDH	6/30/2020	14:25	Fog	64	0	61	8	E	1	0	0	7.4	0.51	Y	7 adults on shore, 15 children on shore
Leif Erikson	16-0001-B009	SSL SWCD	7/9/2020	11:40	Sunny, hazy	81.4	1	69.4	3	SSE	0.51	0	0	920.8	2.52	Y	Dogs & people wading. Gusty wind. ~5 people in water
Leif Erikson	16-0001-B009	MDH	7/9/2020	10:11	Cloudy	81	2	66.7	12.2	SE	1	0	0	686.7	2.52	Y	1 adult in water, 2 children in water, 10 adults on shore, 5 children on shore
Leif Erikson	16-0001-B009	MDH	7/13/2020	14:25	Mostly Sunny	74	0	69.5	13.6	E	2	0	0	56.3	0	Y	20 adults on shore, 3 children on shore, 4 children in water
Leif Erikson	16-0001-B009	MDH	7/14/2020	11:22	Rain	70	0	68.4	0.7	NE	1	0	0	127.4	0.61	Y	trash on station
Leif Erikson	16-0001-B009	MDH	7/15/2020	12:16	Clear/Sunny	85.3	1	69.1	12.6	S	1	0	0	108.1	0.64	Y	16 adults on shore, 12 children in water
Leif Erikson	16-0001-B009	MDH	7/21/2020	14:22	Rain	60	2	65.2	4.3	E	2	0	0	261.3	0.07	Y	trash on shore
Leif Erikson	16-0001-B009	MDH	7/22/2020	10:35	Rain	59.8	2	64.8	8	N	4	0	0	770.1	0.95	Y	
Leif Erikson	16-0001-B009	MDH	7/23/2020	11:22	Clear/Sunny	73.9	0	63.5	7.1	NE	1	0	0	8.6	0.96	Y	5 adults on shore
Leif Erikson	16-0001-B009	MDH	7/28/2020	11:50	Clear/Sunny	81.1	0	63.1	7.4	SW	1	0	0	18.5	2.28	Y	10 adults on shore, 2 children in water
Leif Erikson	16-0001-B009	MDH	7/29/2020	11:36	Clear/Sunny	77.4	0	66.6	0.2	NE	0.5	0	0	7.5	0.03	Y	2 dogs in water, 2 children on shore, 6 adults on shore
Leif Erikson	16-0001-B009	SSL SWCD	7/31/2020	8:45	Sunny, calm	77	0	71.6	0.3	E	0	0	0	16.1	0	Y	3 people on beach, none swimming.
Leif Erikson	16-0001-B009	MDH	8/4/2020	11:51	Clear/Sunny	73.4	0	67.9	7.8	NE	1	0	0	3.1	0.04	Y	8 adults on shore, 6 children on shore
Leif Erikson	16-0001-B009	MDH	8/13/2020	12:52	Cloudy	68.3	1	64.6	9.9	NE	2	0	0	119.8	0.16	Y	1 adult in water

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Leif Erikson	16-0001-B009	MDH	8/18/2020	14:00	Clear/Sunny	72.4	0	59.9	5.2	E	0.75	0	0	151.5	0	Y	5 adults on shore, 3 children and 1 dog in water
Leif Erikson	16-0001-B009	MDH	8/19/2020	10:42	Mostly Cloudy	78.1	1	66	23.3	S	1	0	0	22.8	0	Y	7 adults and 2 children on shore
Leif Erikson	16-0001-B009	MDH	8/25/2020	10:19	Clear/Sunny	75.1	1	71	6.1	NE	1	0	0	3.1	0.14	Y	5 adults on shore, 2 adults in water, 4 children in water
Leif Erikson	16-0001-B009	MDH	8/26/2020	11:09	Clear/Sunny	78.2	0	66.5	6	N	1.5	0	0	8.6	0.02	Y	5 adults on shore, 1 child in water
Leif Erikson	16-0001-B009	SSL SWCD	8/31/2020	11:07	Partly sunny, slight breeze	65.3	2	64.8	2	SW	0.1	0	0	770.1	0.11	Y	7 people on beach, none swimming
Leif Erikson	16-0001-B009	SSL SWCD	9/14/2020	9:16	Cloudy, windy	53.6	2	54.1	9	E	1.5	0	0	19.9	0.08	Y	No people, no obvious sources of contamination
Leif Erikson	16-0001-B009	MDH	5/26/2020	14:20	Fog	51.3	1	53.5	6	NE	0.5	0	0	2	0.01	Y	3 adults on shore
Leif Erikson	16-0001-B009	MDH	9/2/2020	13:15	Clear/Sunny	76.5	0	62.4	16.3	SW	1	0	0	44.8	0.71	Y	4 adults on shore, 6 children on shore, 1 dog on shore
Leif Erikson - North	16-0001-240	SSL SWCD	6/15/2020	10:58	Partly sunny, breezy					E				6.3	0	N	
Leif Erikson - North	16-0001-240	SSL SWCD	6/19/2020	8:39	Mostly sunny, calm									35	0.39	Y	
Leif Erikson - North	16-0001-240	SSL SWCD	7/9/2020	11:35	Sunny, hazy									298.7	2.52	Y	
Leif Erikson - North	16-0001-240	SSL SWCD	7/31/2020	8:35	Sunny, calm									6.3	0	Y	
Leif Erikson - North	16-0001-240	SSL SWCD	8/31/2020	10:56	Partly sunny, slight breeze									1203.3	0.11	Y	

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Leif Erikson - North	16-0001-240	SSL SWCD	9/14/2020	9:25	Cloudy, windy									75.4	0.08	Y	
Leif Erikson - South	16-0001-241	SSL SWCD	6/15/2020	11:09	Partly sunny, breezy					E				15.8	0	N	
Leif Erikson - South	16-0001-241	SSL SWCD	6/19/2020	8:52	Mostly sunny, calm									36.8	0.39	Y	
Leif Erikson - South	16-0001-241	SSL SWCD	7/9/2020	11:42	Sunny, hazy									>2419.6	2.52	Y	
Leif Erikson - South	16-0001-241	SSL SWCD	7/31/2020	8:40	Sunny, calm									42.6	0	Y	
Leif Erikson - South	16-0001-241	SSL SWCD	8/31/2020	11:02	Partly sunny, slight breeze									1046.2	0.11	Y	
Leif Erikson - South	16-0001-241	SSL SWCD	9/14/2020	9:10	Cloudy, windy									16.3	0.08	Y	
MN Point 15th Street	16-0001-B007	MDH	5/26/2020	13:29	Fog	55.9	0	54.7	1.6	NE	0	0	0	52	0.01	Y	
MN Point 15th Street	16-0001-B007	MDH	5/27/2020	12:43	Clear/Sunny	77.3	0	62.4	0.2	E	0	0	0	14.2	1.49	Y	
MN Point 15th Street	16-0001-B007	MDH	6/2/2020	10:01	Clear/Sunny	78.6	0	68.4	7	W	0.25	0	0	42.8	0.08	Y	
MN Point 15th Street	16-0001-B007	MDH	6/3/2020	14:17	Clear/Sunny	75	0	62.2	3.4	NW	0	0	0	49.6	0.08	Y	
MN Point 15th Street	16-0001-B007	MDH	6/9/2020	9:50	Cloudy	56.5	0	57.2	2.4	NE	0.5	0	0	48.9	0.13	Y	1 duck in water, dog feces on shore
MN Point 15th Street	16-0001-B007	MDH	6/10/2020	13:52	Cloudy	66.7	0	58.9	18.1	NW	1	0	0	27.5	0.13	Y	
MN Point 15th Street	16-0001-B007	SSL SWCD	6/15/2020	11:51	Cloudy, breezy	61	1	59.5	2	E	0.25	0	0	27.9	0	N	0 people, no obvious contamination sources.

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
MN Point 15th Street	16-0001-B007	MDH	6/16/2020	10:32	Mostly Sunny	62.1	0	59.9	2.3	E	0	0	0	34.1	0	Y	1 kayaker
MN Point 15th Street	16-0001-B007	MDH	6/17/2020	9:34	Clear/Sunny	67.8	1	60.5	3.6	E	0	0	0	24.9	0	Y	2 adults on shore
MN Point 15th Street	16-0001-B007	SSL SWCD	6/19/2020	9:47	Mostly sunny, breezy	70	1	66	6	W	0.25	2	0	82.6	0.39	Y	0 people, no obvious contamination sources.
MN Point 15th Street	16-0001-B007	MDH	6/23/2020	10:36	Mostly Sunny	70.6	1	62.5	3.6	NE	0.25	0	0	27.2	0	Y	beach sand is starting to have more small stones on it; similar to years other than 2019, where substrate was mainly pebbles
MN Point 15th Street	16-0001-B007	MDH	6/24/2020	10:53	Partly Sunny/Partly Cloudy	74.3	0	68.7	0.9	N	0.25	0	0	105	0.13	Y	
MN Point 15th Street	16-0001-B007	MDH	6/24/2020	10:53	Partly Sunny/Partly Cloudy	74.3	0	68.7	0.9	N	0.25	0	0	105	0.13	Y	
MN Point 15th Street	16-0001-B007	MDH	6/30/2020	13:48	Fog	64.7	1	63.5	3.3	NE	0	0	0	65	0.51	Y	
MN Point 15th Street	16-0001-B007	MDH	7/1/2020	10:33	Cloudy	69.2	0	64.2	4.9	NE	0	0	0	28.2	0.59	Y	
MN Point 15th Street	16-0001-B007	MDH	7/7/2020	10:13	Mostly Sunny	79.6	1	73	0.2	E	0	0	0	93.3	0.33	Y	2 adults in water, 2 children in water
MN Point 15th Street	16-0001-B007	SSL SWCD	7/9/2020	12:50	Overcast, windy	81.3	2	76.1	8	SSE	0.5	0	0	547.5	2.52	Y	Gusty wind.
MN Point 15th Street	16-0001-B007	MDH	7/14/2020	10:19	Rain	66.6	0	70.2	3.4	E	0	0	0	196.8	0.61	Y	

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
MN Point 15th Street	16-0001-B007	MDH	7/15/2020	10:42	Clear/Sunny	83	0	71.8	12.5	S	0.5	0	0	83.9	0.64	Y	1 adult on shore, 1 dog in water
MN Point 15th Street	16-0001-B007	MDH	7/21/2020	10:01	Rain	59.7	1	64.8	5	E	1	0	0	83.6	0.07	Y	
MN Point 15th Street	16-0001-B007	MDH	7/22/2020	8:52	Rain	61.9	2	63.5	5.5	NE	2	0	0	93.2	0.95	Y	topography changed - more gradual slope and water more shallow
MN Point 15th Street	16-0001-B007	MDH	7/28/2020	10:32	Clear/Sunny	81.7	0	75.4	8.8	SW	0.75	0	0	52.8	2.28	Y	
MN Point 15th Street	16-0001-B007	MDH	7/29/2020	10:18	Clear/Sunny	78.5	1	73.4	1.1	NE	0	0	30	25.9	0.03	Y	geese about 500 yards away
MN Point 15th Street	16-0001-B007	SSL SWCD	7/31/2020	9:55	Sunny, calm	77	1	77.9	3	E	0.1	0	0	8.6	0	Y	No people. 1 dog waste bag on beach.
MN Point 15th Street	16-0001-B007	MDH	8/4/2020	10:12	Clear/Sunny	71	0	70.2	2.4	NE	0.25	0	0	83.3	0.04	Y	1 adult on shore, 1 dog on shore, 2 children in water
MN Point 15th Street	16-0001-B007	MDH	8/11/2020	10:38	Clear/Sunny	80.6	0	72.4	20.2	W	1	0	0	104.3	2.08	Y	
MN Point 15th Street	16-0001-B007	MDH	8/13/2020	14:01	Cloudy	69.7	2	69.9	1.7	NE	0.5	0	0	770.1	0.16	Y	
MN Point 15th Street	16-0001-B007	MDH	8/18/2020	10:19	Clear/Sunny	73.2	0	69.9	1.9	E	0.25	0	0	22.6	0	Y	
MN Point 15th Street	16-0001-B007	MDH	8/19/2020	9:37	Partly Sunny/Partly Cloudy	77	0	69.6	13.9	S	0.75	0	0	68.3	0	Y	dredging happening about 500 yards away in the shipping channel
MN Point 15th Street	16-0001-B007	MDH	8/25/2020	9:47	Clear/Sunny	72	0	69.8	1.6	NE	0.25	0	0	10.8	0.14	Y	

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
MN Point 15th Street	16-0001-B007	MDH	8/26/2020	9:59	Mostly Sunny	73.5	0	67.9	2	N	0.25	0	0	201.4	0.02	Y	1 dog in water, 1 adult on shore
MN Point 15th Street	16-0001-B007	SSL SWCD	8/31/2020	11:30	Partly sunny, breezy	63.5	1	67.6	10	W	0.75	0	0	34.1	0.11	Y	1 pile of dog feces
MN Point 15th Street	16-0001-B007	MDH	9/2/2020	14:14	Clear/Sunny	73.4	1	67.8	12.8	SW	1	0	0	34.5	0.71	Y	
MN Point 15th Street	16-0001-B007	SSL SWCD	9/14/2020	9:54	Cloudy, windy	58.1	1	56.1	2	W	0.25	0	0	648.8	0.08	Y	No people, no obvious sources of contamination
MN Point 15th Street	16-0001-B007 (Dup)	SSL SWCD	9/14/2020	9:55										579.4	0.08	N	
Park Point Sky Harbor	16-0001-B004	MDH	5/26/2020	12:27	Fog	57.8	0	54.3	4.4	E	0	0	0	4.1	0.01	Y	
Park Point Sky Harbor	16-0001-B004	MDH	5/27/2020	11:31	Clear/Sunny	67	0	60.1	3	E	0	0	0	7.3	1.49	Y	2 water sport recreators nonmotorized - stand up paddleboarders
Park Point Sky Harbor	16-0001-B004	MDH	6/2/2020	9:10	Clear/Sunny	86.4	1	68.7	1.6	E	0	0	6	6.3	0.08	Y	
Park Point Sky Harbor	16-0001-B004	MDH	6/3/2020	13:47	Clear/Sunny	78.6	1	62.4	6	NW	0	0	0	36.9	0.08	Y	2 adults on shore, 2 dogs on shore
Park Point Sky Harbor	16-0001-B004	MDH	6/9/2020	9:03	Mostly Sunny	56.1	1	58.8	5.4	NE	0	0	0	11	0.13	Y	
Park Point Sky Harbor	16-0001-B004	MDH	6/10/2020	13:01	Cloudy	64.5	2	59.8	12.2	N	0.75	2	0	816.4	0.13	Y	
Park Point Sky Harbor	16-0001-B004	SSL SWCD	6/15/2020	12:25	Cloudy, breezy	60.6	1	60.5	0.5	E	0	1	0	14.5	0	N	Dog feces on dunes.

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Park Point Sky Harbor	16-0001-B004	MDH	6/16/2020	9:09	Partly Sunny/Partly Cloudy	64.2	1	60.3	5.4	E	0	1	0	16	0	Y	
Park Point Sky Harbor	16-0001-B004	MDH	6/17/2020	8:57	Clear/Sunny	64.2	2	62.1	5.6	E	0.25	0	0	62.2	0	Y	bird feces on shore, picnicking family on shore
Park Point Sky Harbor	16-0001-B004	SSL SWCD	6/19/2020	10:19	Mostly sunny, breezy	70	2	67	6	W	0.1	8	0	98.7	0.39	Y	0 people, no obvious contamination sources.
Park Point Sky Harbor	16-0001-B004	MDH	6/23/2020	9:17	Mostly Sunny	69.4	1	64.8	3.3	NE	0.25	0	0	59.1	0	Y	bird feces on shore
Park Point Sky Harbor	16-0001-B004	MDH	6/24/2020	9:31	Mostly Sunny	71.6	1	67.8	0.8	N	0.25	0	0	101.2	0.13	Y	
Park Point Sky Harbor	16-0001-B004	MDH	6/24/2020	9:31	Mostly Sunny	71.6	1	67.8	0.8	N	0.25	0	0	101.2	0.13	Y	
Park Point Sky Harbor	16-0001-B004	MDH	6/30/2020	13:11	Fog	64.3	2	66.9	2.4	NE	0	10	0	42.2	0.51	Y	goose feces on shore, goose tracks on shore
Park Point Sky Harbor	16-0001-B004	MDH	7/1/2020	9:26	Cloudy	64.3	2	65.2	8.1	E	0	0	0	35.9	0.59	Y	
Park Point Sky Harbor	16-0001-B004	MDH	7/7/2020	9:14	Clear/Sunny	80.2	1	79.6	5	E	0	0	45	1203.3	0.33	Y	
Park Point Sky Harbor	16-0001-B004	SSL SWCD	7/9/2020	13:35	Overcast, windy	79.1	2	76.6	6	SSE	0.25	0	0	1986.3	2.52	Y	Gusty wind. Gulls on airport dock but not on beach.
Park Point Sky Harbor	16-0001-B004	MDH	7/14/2020	9:06	Rain	67.7	1	71.8	4.5	E	0.25	0	0	34.1	0.61	Y	8 ducks in water (a mama and 7 babies!)
Park Point Sky Harbor	16-0001-B004	MDH	7/15/2020	9:02	Clear/Sunny	76.5	1	72.7	12	SW	0.5	0	0	47.1	0.64	Y	

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Park Point Sky Harbor	16-0001-B004	MDH	7/21/2020	9:23	Rain	61.3	1	66	7	E	0.25	0	0	67.6	0.07	Y	1 mama 7 baby ducks in water
Park Point Sky Harbor	16-0001-B004	MDH	7/22/2020	8:19	Rain	59.2	2	65.4	15.9	NE	0.5	0	0	104.6	0.95	Y	
Park Point Sky Harbor	16-0001-B004	MDH	7/28/2020	9:15	Clear/Sunny	79	2	73.2	10	W	0.5	0	0	135.4	2.28	Y	
Park Point Sky Harbor	16-0001-B004	MDH	7/29/2020	8:49	Clear/Sunny	78.1	2	75	1.9	NE	0.25	0	40	30.1	0.03	Y	
Park Point Sky Harbor	16-0001-B004	SSL SWCD	7/31/2020	9:25	Sunny, calm	73.6	2	76.3	3	E	0	0	0	16.1	0	Y	No obvious sources of contamination. No people.
Park Point Sky Harbor	16-0001-B004	MDH	8/4/2020	9:11	Clear/Sunny	70.9	0	69.8	8.8	E	0.25	0	0	11	0.04	Y	
Park Point Sky Harbor	16-0001-B004	MDH	8/11/2020	9:20	Clear/Sunny	78.5	2	72.3	14.4	W	0.75	0	0	85.7	2.08	Y	
Park Point Sky Harbor	16-0001-B004	MDH	8/13/2020	13:29	Cloudy	70.3	3	68.7	6.5	NE	0.5	1	0	76.3	0.16	Y	
Park Point Sky Harbor	16-0001-B004	MDH	8/18/2020	9:03	Clear/Sunny	69.4	2	67.8	3.4	E	0	0	0	29.2	0	Y	1 kayaker
Park Point Sky Harbor	16-0001-B004	MDH	8/19/2020	8:31	Mostly Sunny	73	1	69.8	11.9	SW	1	0	0	10.8	0	Y	
Park Point Sky Harbor	16-0001-B004	MDH	8/25/2020	9:21	Clear/Sunny	69.5	1	71.4	5.3	NE	0.25	0	10	17.3	0.14	Y	
Park Point Sky Harbor	16-0001-B004	MDH	8/26/2020	8:39	Rain	67.2	1	66.7	6.4	NE	0.5	0	8	17.1	0.02	Y	
Park Point Sky Harbor	16-0001-B004	SSL SWCD	8/31/2020	12:05	Partly sunny, breezy	64.8	2	69.4	14	W	1	0	0	14.6	0.11	Y	Some goose and dog feces on dunes next to beach

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Park Point Sky Harbor	16-0001-B004	MDH	9/2/2020	13:53	Clear/Sunny	72.3	2	66.4	21.3	SW	1	0	0	50.4	0.71	Y	
Park Point Sky Harbor	16-0001-B004 (Dup)	SSL SWCD	9/14/2020	10:26										22.8	0.08	N	
Park Point Sky Harbor	16-0001-B004	SSL SWCD	9/14/2020	10:25	Cloudy, windy	59.7	2	58.8	4	E	0.1	0	0	13.4	0.08	Y	No people, no obvious sources of contamination
Sargent Creek Outfall	S004-972	SSL SWCD	6/15/2020	13:13	Cloudy, breezy					E				62	0	N	
Sargent Creek Outfall	S004-972	SSL SWCD	6/19/2020	11:12	Mostly sunny, breezy									613.1	0.39	Y	
Sargent Creek Outfall	S004-972	SSL SWCD	7/9/2020	14:40	Overcast									1986.3	2.52	Y	
Sargent Creek Outfall	S004-972	SSL SWCD	7/31/2020	10:35	Sunny, calm									104.3	0	Y	
Sargent Creek Outfall	S004-972	SSL SWCD	8/31/2020	12:45	Mostly sunny, breezy									2419.6	0.11	Y	
Sargent Creek Outfall	S004-972	SSL SWCD	9/14/2020	11:04	Partly sunny, windy									124.6	0.08	Y	
Sargent Creek Outfall	S004-972 (Dup)	SSL SWCD	9/14/2020	11:05										113.7	0.08	N	
Stormwater Outfall	SS00086	SSL SWCD	6/15/2020	11:06	Partly sunny, breezy					E				139.6	0	N	

Beach	Site ID	Entity	Date	Time (DST)	Weather	Air Temp (F)	Turbidity	Water Temp (F)	Wind Speed (MPH)	Wind Direction	Wave Height (Ft)	# Gulls	# Geese	*E. coli* results	Two-day precip.	Filtered?	Observations
Stormwater Outfall	SS00086	SSL SWCD	6/19/2020	8:48	Mostly sunny, calm									1119.9	0.39	Y	
Stormwater Outfall	SS00086	SSL SWCD	9/14/2020	9:12	Cloudy, windy									1553.1	0.08	Y	

Appendix B. Lab Methods

Detection of source-specific DNA sequences in Fecal Indicator Bacteria by quantitative polymerase chain reaction (qPCR)

1.0 Scope and application

This Standard Operating Procedure is to be followed for concentrating and extracting DNA from uncultured bacteria in water samples followed by qPCR analysis to detect specific gene sequences within the microbial community for microbial source tracking.

2.0 Summary of method

See procedure

3.0 Definitions

3.4.1 May: This action, activity, or procedural step is neither required nor prohibited.
3.4.2 May not: This action, activity, or procedural step is prohibited.
3.4.3 Must: This action, activity, or procedural step is required.
3.4.4 Shall: This action, activity, or procedural step is required.
3.4.5 Should: This action, activity, or procedural step is suggested but not required.

4.0 **Interferences**

Polymerase chain reaction can be inhibited by several factors, most of which are defined simply as “PCR inhibitors” present in the sample matrix. High concentrations of DNA are the only inhibitor that has been observed with this method as described. It is recommended that several volumes of DNA be used over several PCR reactions until optimization is achieved.

5.0 **Safety**

If the technician has any doubts about how to proceed, contact the laboratory director before beginning the preparation.

6.0 Equipment and supplies

Autoclave/sterilizer
Sterile forceps
Flame source
Sterile, polycarbonate 0.45µm pore size, 47mm diameter filter membranes
Sterile filter funnel units with polycarbonate 0.45µm pore size, 47mm diameter membrane filters attached, 100-300mL capacity
Side armed flask 1L
Vacuum source with hose
Vacuum filter manifold to hold a number of filter bases
2ml sterile screw cap bead tubes with 212 - 300 µm glass beads
Vortex
Sterile 50ml centrifuge tubes
10ml sterile glass pipette with bulb
Ultracentrifuge capable of spinning 50ml centrifuge tubes
Sterile 50ml centrifuge tubes
Waterbath or incubator
Micropipettes capable of measuring 10-1000µL
Sterile, filtered pipette tips
2.0mL sterile, nuclease free, low retention microcentrifuge tubes
Microcentrifuge
Benchtop homogenizer able to hold 2ml bead tubes and capable of speeds 4-6.5 m/s
Applied Biosystems StepOne or StepOnePlus Real-Time PCR System
Applied Biosystems StepOne Software v2.3
Microcentrifuge tube racks
48-Well or 96-Well Reaction Plates
48-Well or 96-Well Optical Adhesive Films
Sharpie

7.0 Reagents and standards

GeneRite DNA Purification Kit
PCR Master Mix 2X (Applied Biosystems®)
Forward and reverse primers and probe
10% bleach solution
70% ethanol
Absolute ethanol
di H20
Absolute ethanol for flame sterilization
Sterile PBS solution, pH 7.4
Influent sewage DNA extract (positive control)
Nuclease-free PCR-grade water

8.0 Sample collection, preservation, and storage

Samples should be collected, stored at 4˚C and filtered within 3 hours of receipt.

9.0 Quality Control

General

Ensure work surfaces are sterilized by wiping down with a 10% bleach solution followed by 70% ethanol. All beakers, pipette tips, forceps and all other tools that come into contact must also be sterile (done either by autoclaving or immersing in 10% bleach solution). Gloves and lab coat must be worn at all times. Gloves must be changed between samples to prevent cross-contamination.

qPCR

The reaction plate for each client qPCR run must include at least one positive control to monitor the success of the reaction and 3 negative control (no template control) reactions per assay to monitor the for contaminated reagents. Client samples must always be run in at least duplicate qPCR reactions for each assay to increase precision of the measurements and obtain confidence in the results. The test methods have been optimized to reduce inhibitor affects on qPCR reactions. However, depending on the nature of the sample, inhibition may still be encountered. Therefore, each sample must be monitored for inhibition by running a third qPCR reaction containing a 1:10 dilution of the sample in addition to the un-diluted duplicate reaction.

Assay-specific limits of detection (LOD) and limits of quantification (LOQ) have been pre-determined and are documented.

Standard curves used for quantification are generated from either plasmid constructs containing the target (Integrated DNA Technologies or equivalent) of interest or bacterial genomic DNA. To maintain integrity of the DNA, aliquots are made at concentrations of $1x10^5$copies/µl or greater and stored at -80˚C. The dynamic range of the standard curve, as determined during the method validation process, is the range of concentrations over which the target can be accurately quantified. Observations higher and lower than the standard curve cannot be treated as reliable quantitative data.

10.0 Calibration and standardization

All support equipment shall be verified or calibrated annually and pipettors biannually.

11.0 **Procedure**

Sample Filtration

1. Remove sample from sample refrigerator and record information on electronic sample data sheet.
2. Obtain sterile filtration funnel and remove from packaging
3. Position funnel with polycarbonate membrane onto the vacuum manifold attached to a vacuum source
4. Turn on vacuum to ensure that there are no air leaks in the system
5. Shake water sample to obtain a homogenous mixture. If the water appears to be very turbid, shake and let sit for 10 minutes for the debris to settle
6. Add 100 mL water sample to funnel and allow to filter through. If the filter becomes clogged before the entire sample can be filtered through, remove the membrane (step 8), place in a sterile bead tube (label “1 of 2” and the volume filtered) and continue filtering using a second membrane positioned onto the same funnel in order to get a combined volume of 250ml or more. Use a maximum of 2 membranes, even if a total volume of 250ml is not obtained. Place the second membrane in a separate bead tube and label “2 of 2”
7. When sample is completely filtered, rinse the sides of the filter funnel with 20-30ml sterile buffer solution with the vacuum still on
8. Turn off vacuum, remove the top portion of the filter funnel and remove membrane with flame-sterilized forceps
9. Carefully lift filter membrane from plate at opposite edges using flame-sterilized forceps and roll into a cylinder with the top side facing inward

10. Place the membrane into a sterile 2ml Bead Tube
11. Store at 20˚C or proceed to DNA extraction

DNA Extraction

1. Proceed with DNA extraction using the GeneRite DNA Purification Kit according to manufacturer's protocol.
2. Store labeled, purified DNA at -20˚C for future analysis

Quantitative Polymerase Chain Reaction

Reagents and DNA are stored at -20˚C and in separate freezers
*PCR master mix is stored at 4*ºC
All PCR reactions are prepared at room temperature in an enclosed PCR work station to prevent contamination

1. Wipe down the PCR work area with 10% bleach followed with 70% ethanol and turn on the UV light for 10 min
2. For each assay, prepare a fresh qPCR master mix containing the assay-specific forward and reverse primers, probe, PCR Master Mix 2X and nuclease-free PCR-grade water at the appropriate, optimized concentrations in a labeled 1.5ml tube. Prepare a separate master mix for each assay. Prepare enough master mix for all of the samples including positive and negative controls and the standard curve. The master mix must be prepared daily
3. For each assay include:
   - Three no template negative control reactions, use nuclease-free PCR-grade water as the template
   - One positive control reaction (not required if doing a standard curve)
   - A 5 point assay-specific standard curve (for quantification only)
   - Duplicate reactions of all samples
   - One inhibition monitoring reaction for all samples
4. Prepare the 5 point standard curve by making five 1:10 serial dilutions of the appropriate plasmid construct containing the target or gDNA to make 100000, 10000, 1000, 100, and 1 target copy dilutions. Use nuclease-free PCR-grade water to make the dilutions
5. Use the 48-well or 96-well plate depending on the amount of samples in total. For every sample, load 18µL of master mix to the reaction plate with. Load 2µL of template DNA for all samples, standard dilutions, positive and negative controls
6. Seal the plate with optical adhesive film and pulse centrifuge
7. Place reaction plate into the real-time thermocycler and run the appropriate assay-specific program.

12.0 Data analysis and calculations

Refer to the Quality Policy Manual for corrective actions whenever quality control criteria are not met

1. Analyze the resulting amplification curves ensuring there are no curves for the No Template Control wells and that a curve is present for the positive control. If the No Template Control is detected it must be detected at a minimum of 3 C_T units greater than the unknown sample C_T values
2. For quantification reactions, the standard deviation between replicate reactions must not exceed 1.0 (or 1.4 C_T units). For low concentration samples with amplification curves greater than 35 C_Ts, a standard deviation of ≤ 1.4 units is permitted
3. Ensure that the inhibition monitoring sample amplifies at a C_T greater than the corresponding undiluted template. If it amplifies at a lower C_T, the sample is inhibited and appropriate measures must be taken (see the Quality Policy Manual)
4. Examine the averaged sample C_T values. A sample that amplifies at a greater C_T value than the limit of detection (LOD) is considered negative. A sample that amplifies at a lower C_T value than the LOD but outside the dynamic linear range of the standard curve is considered positive but not quantifiable (or trace). A sample that amplifies at

a lower C_T value than the LOD but within the dynamic linear range of the standard curve is considered positive and quantifiable

5. Normalize quantification values to copies per 100µl of DNA extract and 100ml of sample water and
6. Record result in the sample data sheet

13.0 Method performance

All positive and negative controls should be 100% in agreement with anticipated results. All assay-specific qPCR quality performance criteria must also be met. Any deviations or contaminations must be recorded and results should be considered suspect. See Quality Policy Manual for further details.

14.0 Pollution prevention

1. The solutions and reagents used in this method pose little threat to the environment when used and recycled appropriately
2. Solutions and reagents should be prepared in volumes consistent with the number of samples being processed to avoid the necessity for disposing of excess expired materials

15.0 Waste management

Sterilized liquids and solids can be disposed of down the sink or in the garbage

16.0 **References**

Bernhard, AE, and KG Field. A PCR assay to distinguish human and ruminant feces on the basis of differences in *Bacteroides-Prevotella* genes encoding 16S rDNA. Appl. Environ. Microbiol. 2000 66: 4571-4574.

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Scott, T., Rose, J., Jenkins, T., Farrah, S., Lukasik, J. Microbial Source Tracking: Current Methodology and Future Directions. Appl. Environ. Microbiol. 2002 68: 5796-5803

17.0 Tables, diagrams, flowcharts, and validation data

None

Appendix C. MST sampling results (2020)

Table 23. MST results for Park Point Sky Harbor Parking Lot Beach.

DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).

ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).

a = The detection and quantification limits for the Bird_GFD marker were 1,500 and 5,000 copies per 100 mL, respectively.

Marker was detected in sample.

* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*			
	Human HF183	**Bird_GFD**	**Dog_BacCan_UCD**	**Human_HumM2**
6/10/2020	ND	DNQ	DNQ	ND
6/19/2020	DNQ	Did not analyze	Did not analyze	Did not analyze
6/24/2020	DNQ	Did not analyze	Did not analyze	Did not analyze
7/7/2020	DNQ	8,450 [a]	DNQ	Did not analyze
7/9/2020	1,430	Did not analyze	Did not analyze	Did not analyze
7/28/2020	ND	5,500 [a]	ND	ND

Table 24. MST results for Minnesota Point 15th Street Harbor Side Beach.

DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).

ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).

a = The detection and quantification limits for the Bird_GFD marker were 1,500 and 5,000 copies per 100 mL, respectively.

Marker was detected in sample.

* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*			
	Human HF183	**Bird_GFD**	**Dog_BacCan_UCD**	**Human_HumM2**
7/9/2020	ND	7,300 [a]	DNQ	ND
7/14/2020	DNQ	Did not analyze	Did not analyze	Did not analyze
8/11/2020	1,220	Did not analyze	Did not analyze	Did not analyze
8/13/2020	DNQ	DNQ [a]	DNQ	Did not analyze
8/26/2020	ND	DNQ [a]	ND	ND
9/14/2020	DNQ	Did not analyze	Did not analyze	Did not analyze

Table 25. MST results for Park Point 20th Street/Hearding Island.

DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).

ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).

a = The detection and quantification limits for the Bird_GFD marker were 1,500 and 5,000 copies per 100 mL, respectively.

Marker was detected in sample.

* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*			
	Human HF183	Bird_GFD	Dog_BacCan_UCD	Human_HumM2
6/19/2020	DNQ	DNQ	ND	Did not analyze
7/9/2020	DNQ	6,800 [a]	ND	Did not analyze
7/31/2020	ND	5,550 [a]	DNQ	ND

Table 26. MST results for Boy Scout Landing Beach – Sargent Creek Outfall.

DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).

ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).

a = The detection and quantification limits for the Bird_GFD marker were 1,500 and 5,000 copies per 100 mL, respectively.

Marker was detected in sample.

* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*				
	Human HF183	Bird_GFD	Dog_BacCan_UCD	Human_HumM2	Ruminant_Rum2Bac
6/19/2020	DNQ	8,050	DNQ	Did not analyze	ND
7/9/2020	DNQ	DNQ [a]	629	Did not analyze	DNQ
7/31/2020	ND	1,100 [a]	DNQ	ND	ND
8/31/2020	511	Did not analyze	Did not analyze	Did not analyze	Did not analyze
8/31/2020	1,720	Did not analyze	Did not analyze	Did not analyze	ND
9/14/2020	DNQ	Did not analyze	Did not analyze	Did not analyze	ND

Table 27. MST results for Boy Scout Landing Beach.

DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).

ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).

a = The detection and quantification limits for the Bird_GFD marker were 1,500 and 5,000 copies per 100 mL, respectively.

Marker was detected in sample.

* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*			
	Human HF183	Bird_GFD	Dog_BacCan_UCD	Human_HumM2
6/19/2020	ND	DNQ [a]	DNQ	ND
7/9/2020	ND	Did not analyze	Did not analyze	ND
7/14/2020	ND	Did not analyze	Did not analyze	ND
7/21/2020	DNQ	Did not analyze	Did not analyze	Did not analyze
7/31/2020	ND	1,080	DNQ	ND
8/11/2020	ND	DNQ	ND	ND
8/25/2020	ND	Did not analyze	Did not analyze	ND
9/14/2020	ND	Did not analyze	Did not analyze	ND

Table 28. MST results for Leif Erikson Park Beach.
DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).
ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).
a = The detection and quantification limits for the Bird_GFD marker were 1,500 and 5,000 copies per 100 mL, respectively.
Marker was detected in sample.
* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*			
	Human HF183	Bird_GFD	Dog_BacCan_UCD	Human_HumM2
6/19/2020	ND	ND	ND	ND
7/9/2020	28,400	DNQ [a]	742	Did not analyze
7/9/2020	16,700	DNQ [a]	1,060	Did not analyze
7/14/2020	1,460	DNQ [a]	DNQ	Did not analyze
7/21/2020	DNQ	DNQ [a]	DNQ	Did not analyze
7/22/2020	DNQ	ND	DNQ	Did not analyze
8/31/2020	8,480	DNQ	DNQ	Did not analyze
9/14/2020	ND	DNQ [a]	ND	ND

Table 29. MST results for Leif Erikson Park Beach – North.
DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).
ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).
Marker was detected in sample.
* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*		
	Human HF183	Bird_GFD	Dog_BacCan_UCD
6/19/2020	DNQ	DNQ [a]	ND
7/9/2020	2,460	DNQ [a]	DNQ
8/31/2020	872	DNQ	DNQ

Table 30. MST results for Leif Erikson Park Beach – South.

DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).

ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).

a = The detection and quantification limits for the Bird_GFD marker were 1,500 and 5,000 copies per 100 mL, respectively.

Marker was detected in sample.

* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*		
	Human HF183	Bird_GFD	Dog_BacCan_UCD
6/19/2020	1,240	DNQ [a]	ND
7/9/2020	32,300	DNQ [a]	1,820
8/31/2020	22,200	DNQ [a]	595

Table 31. MST results for Leif Erikson Park Beach – Chester Creek Outlet.

DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).

ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).

Marker was detected in sample.

* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*				
	Human HF183	Bird_GFD	Dog_BacCan_UCD	Human_HumM2	Ruminant_Rum2Bac
6/19/2020	11,700	DNQ	664	Did not analyze	ND
9/14/2020	1,690	DNQ	DNQ	Did not analyze	ND

Table 32. MST results for Leif Erikson Park Beach – Stormwater Outfall.

DNQ = Detected Not Quantified. Detection below quantification limit (500 copies per 100 mL) but above detection limit (100 copies per 100 mL).

ND= Non detect. Marker not detected in sample (<100 copies per 100 mL).

a = The detection and quantification limits for the Bird_GFD marker were 1,500 and 5,000 copies per 100 mL, respectively.

Marker was detected in sample.

* Note, the quantification of genetic markers is unique to each sample. Comparisons should only be conducted within individual samples and dates and are not possible between samples and/or dates.

Sample Date	Copies per 100mL*		
	Human HF183	Bird_GFD	Dog_BacCan_UCD
6/19/2020	907	DNQ [a]	ND
9/14/2020	ND	DNQ	ND