REGION 7
LENEXA, KS 66219

November 20, 2023

Ms. Kayla Lyon
Director
Iowa Department of Natural
Resources
Wallace Building
502 E. 9th Street
Des Moines, Iowa 50319-0034

RE: Approval of the Total Maximum Daily Load document for Statewide Beach Bacteria Addendum #2

Dear Ms. Lyon:

This letter responds to the *Escherichia coli* Total Maximum Daily Load submission from the Iowa Department of Natural Resources for Prairie Rose Lake, Lake Keomah, and North Twin Lake. This TMDL document was originally received by the U.S. Environmental Protection Agency, Region 7 on October 16, 2023.

Prairie Rose Lake and North Twin Lake were identified on the 2012 Iowa Clean Water Act Section 303(d) List, while Lake Keomah was identified in the 2008 list, as not supporting their primary contact recreation uses due to bacteria. Prairie Rose Lake and Lake Keomah remain impaired for the 2022 Iowa Clean Water Act Section 303(d) List, but North Twin Lake was removed from the list in 2020 due to improved water quality. This submission fulfills the statutory requirement to develop TMDLs for impairments listed on a state's CWA Section 303(d) List for Prairie Rose Lake and Lake Keomah. As North Twin Lake is not impaired at the time of this action, it is accepted as a protection TMDL. The specific impairments are:

Water Body Name	WBIDs	Causes
Prairie Rose Lake	IA 05-NSH-1462	*E. coli*
Lake Keomah	IA 03-SSK-930	*E. coli*
North Twin Lake*	IA 04-RAC-1167	*E. coli*

*Protection TMDL

The EPA has completed its review of the TMDL document with supporting documentation and information. By this letter, the EPA approves the TMDL document submitted October 16, 2023, for *E. coli* impairments for Prairie Rose Lake and Lake Keomah. Enclosed with this letter is the Region 7 TMDL decision document which summarizes the rationale for the EPA's approval of the TMDL document. The EPA believes the separate elements of the TMDLs described in the enclosed document adequately address the pollutants of concern, taking into consideration seasonal variation and a margin of safety.

Although the EPA does not review the monitoring or implementation plans submitted by the state for approval, the EPA acknowledges the state's efforts. The EPA understands that the state may use the monitoring plan to gauge the effectiveness of the TMDL and determine if future revisions are necessary or appropriate to meet applicable water quality standards. The EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in these TMDLs. Therefore, the Statewide Beach Bacteria Addendum #2 should reference the implementation plan provided in the original Statewide Beach Bacteria TMDL document regarding implementation efforts to achieve the loading reductions identified.

The EPA appreciates the thoughtful effort that the Iowa DNR has put into this TMDL. We will continue to cooperate with and assist in future efforts by the Iowa DNR to develop TMDLs. If you have any questions, please contact Chelsea Paxson, of my staff, at (913) 551-7609.

Sincerely,

DANA SKELLEY

Digitally signed by DANA SKELLEY
Date: 2023.11.21 08:26:48 -06'00'

Dana Skelley
Acting Director

Enclosure

cc: Lori McDaniel
Noah Poppelreiter
Alex Martin
James Hallmark

United States Environmental Protection Agency
Region 7
Total Maximum Daily Load Approval

Statewide Beach Bacteria TMDL: Addendum #2
Iowa

Escherichia coli

DANA SKELLEY

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Date: 2023.11.21 08:26:04 -06'00'

Dana Skelley
Acting Director
Water Division

Date

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EPA Region 7 TMDL Review

Submittal Date || Initial: October 16, 2023 **Approved: Yes**

Statewide Beach Bacteria TMDL: Addendum #2

ATTAINs Action Identifier	IA 05-NSH-1462
State	Iowa
Document Name	Prairie Rose Lake TMDL
Basin(s)	Middle East Branch West Nishnabotna River
HUC(s)	102400020104
Water body(ies)	Prairie Rose Lake
Tributary(ies)	Unnamed tributaries
Number of Segments	1 Lake Beach
Number of Segments for Protection	0
Causes	Recreational Use Impairment for *Escherichia coli*

ATTAINs Action Identifier	IA 03-SSK-930
State	Iowa
Document Name	Lake Keomah TMDL
Basin(s)	Snyder Creek-South Skunk River
HUC(s)	070801051204
Water body(ies)	Lake Keomah
Tributary(ies)	Unnamed tributaries
Number of Segments	1 Lake Beach
Number of Segments for Protection	0
Causes	Recreational Use Impairment for *Escherichia coli*

ATTAINs Action Identifier	IA 04-RAC-1167
State	Iowa
Document Name	North Twin Lake TMDL
Basin(s)	Drainage Ditch 13-Lake Creek
HUC(s)	071000060603
Water body(ies)	North Twin Lake
Tributary(ies)	Unnamed tributary
Number of Segments	1 Lake Beach
Number of Segments for Protection	1
Causes	Previous Recreational Use Impairment for *Escherichia coli* (Protection TMDL)

Submittal Letter and Total Maximum Daily Load Revisions

The state submittal letter indicates final TMDL(s) for specific pollutant(s) and water(s) were adopted by the state and submitted to the EPA for approval under Section 303(d) of the Clean Water Act [40 CFR § 130.7(c)(1)]. Include date submitted letter was received by the EPA, date of receipt of any revisions and the date of original approval if submittal is a revised TMDL document.

The Total Maximum Daily Load document was initially submitted by the Iowa Department of Natural Resources to Region 7 of the U.S. Environmental Protection Agency on October 16, 2023. The EPA approves this version of the TMDL document.

Water Quality Standards Attainment

The targeted pollutant is validated and identified through assessment and data. The water body's loading capacity for the applicable pollutant is identified and the rationale for the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources is described. The TMDL(s) and associated allocations are set at levels adequate to result in attainment of applicable water quality standards [40 CFR § 130.7(c)(1)]. A statement that the WQS will be attained is made.

The target pollutant, *Escherichia coli*, was verified through assessment and data. For this TMDL document, the Iowa DNR used the approach established in the Statewide Beach Bacteria TMDL document approved by the EPA on August 6, 2020. The approach focused on the near shore beach environment (NSBE) as the impaired portion of the lake in need of water quality improvement. This TMDL document is the second in a series of addendums to the originally approved TMDL document and was reviewed for completeness separately by the EPA.

The TMDL addendum document focuses on three state lake beaches. The submitted lakes are Prairie Rose Lake (IA 05-NSH-1462), Lake Keomah (IA 03-SSK-930), and North Twin Lake (IA 04-RAC-1167). Prairie Rose Lake and Lake Keomah are listed on the Iowa 2022 list of impaired waters for E. coli impairment of the primary contact recreation use. North Twin Lake is not listed on the Iowa 2022 list of impaired waters for E. coli impairment. Rather, North Twin Lake is submitted as a protection TMDL due to previous bacteria impairment of the primary contact recreation use. These uses are designated through Iowa's Surface Water Classification (2019) as Prairie Rose Lake (number 548), Lake Keomah (number 391), and North Twin Lake (number 81).

Data presented in the TMDL addendum document demonstrate the *E. coli* impairment for each lake is associated with bacteria loadings from the NSBE possibly due to waterfowl deposition and bacteria regeneration in the beach sand. Although the Water Quality Standards (WQS) apply throughout the lakes, the NSBE and near shore beach volume (NSBV) were targeted as the critical condition in this TMDL and all other nonpoint sources are considered insignificant for attaining WQS.

The single sample maximum (SSM) of 235 organisms per 100 milliliters (org/100mL) concentration was targeted as protective of both the SSM and geometric mean WQS. The NSBV and SSM of 235 org/100 mL were used to calculate the water bodies' loading capacities. The WQS in the water bodies will be attained when less than 10% of samples exceed the SSM and the geometric mean is not exceeded during the designated recreational season. This document shows the TMDL concentrations for E. coli (Table 1) followed by an explanation of the daily maximum TMDL load for each water body. The targets in this TMDL document are established at a level necessary to attain and maintain WQS.

Table 1. TMDL allocations by concentration (orgs/100 mL).

TMDL	235
WLA	0
LA	211.5
MOS	23.5

The formula to calculate the TMDL is:

Equation 1. TMDL = LC = ΣWLA + ΣLA + MOS

Where: TMDL = total maximum daily load; LC = loading capacity; ΣWLA = sum of wasteload allocations (point sources); ΣLA = sum of load allocations (nonpoint sources); MOS = margin of safety (to account for uncertainty).

Therefore, the daily maximum TMDL for Prairie Rose Lake is:

Equation 2. TMDL = LC (1.9x109 orgs/day) = ΣWLA (0 orgs/day) + ΣLA (1.71x109 orgs/day) + MOS (1.9x108 orgs/day)

Therefore, the daily maximum TMDL for Lake Keomah is:

Equation 3. TMDL = LC (2.96x109 orgs/day) = ΣWLA (0 orgs/day) + ΣLA (2.66x109 orgs/day) + MOS (2.96x108 orgs/day)

Therefore, the protection daily maximum capacity for North Twin Lake is:

Equation 4. TMDL = LC (4.43x109 orgs/day) = ΣWLA (0 orgs/day) + ΣLA (3.99x109 orgs/day) + MOS (4.43x108 orgs/day)

The existing loads must be reduced by 78.6% at Prairie Rose Lake and 67.7% at Lake Keomah. The targets in this TMDL document are established at a level necessary to attain and maintain WQS.

Designated Use(s), Applicable Water Quality Standard(s) and Numeric Target(s)
The submittal describes applicable WQS, including beneficial uses, applicable numeric and/or narrative criteria, and a numeric target. If the TMDL(s) is based on a target other than a numeric water quality criterion, then a numeric expression, site specific if possible, was developed from a narrative criterion and a description of the process used to derive the target is included in the submittal.

Prairie Rose Lake, Lake Keomah, and North Twin Lake all have designated uses for primary contact recreation, aquatic life, and human health:

Primary Contact Recreational Use – Class A1: Waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, water skiing, and water contact recreational canoeing (Iowa Administrative Code 567-61.3(1)(b)(1).

Aquatic Life – Class B(LW): Artificial and natural impoundments with hydraulic retention times and other physical and chemical characteristics suitable to maintain a balanced community normally associated with lake-like conditions (Iowa Administrative Code 567-61.3(1)(b)(9)).

Human Health – Class HH: Waters in which fish are routinely harvested for human consumption or waters both designated as a drinking water supply and in which fish are routinely harvested for human consumption (Iowa Administrative Code 567-61.3(1)(b)(10)).

Additionally, Prairie Rose Lake and Lake Keomah are designated for drinking water:

Drinking water supply – Class C: Waters which are used as a raw water source of potable water supply (Iowa Administrative Code 567-61.3(1)(b)(11)).

For each water body, the primary contact recreation use is or was impaired by bacteria and the targeted pollutant is identified as E. coli. Iowa's WQS for the primary contact recreation use require E. coli concentrations not to exceed a geometric mean of 126 org/100 mL and a SSM of 235 org/100 mL during the recreational season of March 15 to November 15 (Iowa Administrative Code 567-61.3(3)(a)(1)).

For antidegradation, the 303(d) listed water bodies are all considered Tier 1 waters which indicates that "Existing surface water uses and the level of water quality necessary to protect the existing uses will be maintained and protected" (Iowa Administrative Code 567-61.2(2)(a)). Regarding North Twin Lake, any antidegradation review should be conducted consistent with Iowa's Antidegradation Policy and Antidegradation Implementation Procedures, including the assignment of a Tier designation.

The applicable numeric criteria and their application are discussed in detail in the section explaining Water Quality Standards Attainment.

Pollutant(s) of Concern

A statement that the relationship is either directly related to a numeric WQS or established using surrogates and translations to a narrative WQS is included. An explanation and analytical basis is provided for expressing the TMDL(s) through surrogate measures or by translating a narrative WQS to a numeric target (e.g., parameters for sediment impairments, such as percent fines and turbidity, or excess algae impairments, such as chlorophyll-a and phosphorus). For each identified pollutant, the submittal describes the analytical basis for conclusions, allocations, and a margin of safety that do not exceed the loading capacity. If the submittal is a revised TMDL document, there are refined relationships linking the load to WQS attainment. If there is an increase in the TMDL(s), there is a refined relationship specified to validate that increase (either load allocation or wasteload allocation). This section will compare and validate the change in targeted load between the versions.

There is a direct link between the numeric WQS and the targeted E. coli pollutant. The TMDL document targets fully supporting the primary contact recreation WQS for E. coli by basing the TMDL allocations upon the SSM, which can be no greater than 235 orgs/100 mL during the recreational season. Because the SSM established in Iowa WQS is based upon the 75th percentile, compliance with the SSM is protective of the geometric mean WQS1.

As explained in the Water Quality Standards Attainment Section, the submittal describes an analytical basis for conclusions and provides allocations, including a margin of safety, that do not exceed the load capacity. As such, the targets in the TMDL document are established at a level necessary to attain and maintain WQS.

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[1] An Approach for Using Load Duration Curves in the Development of TMDLs, EPA 841-B-07-006, 2007.

Source Analysis

Important assumptions made in developing the TMDL document, such as assumed distribution of land use in the watershed, population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources, are described. Point, nonpoint, and background sources of pollutants of concern are described, including magnitude and location of the sources. The submittal demonstrates all significant sources have been considered. If this is a revised TMDL document any new sources or removed sources will be specified and explained.

In the absence of a national pollutant discharge elimination system permit, the discharges associated with sources were applied to the LA, as opposed to the WLA for purposes of this TMDL document. The decision to allocate these sources to the LA does not reflect any determination by the EPA as to whether these discharges are, in fact, unpermitted point source discharges within this watershed. In addition, by establishing these TMDL(s) with some sources treated as LAs, the EPA is not determining that these discharges are exempt from NPDES permitting requirements. If sources of the allocated pollutant in this TMDL document are found to be, or become, NPDES-regulated discharges, their loads must be considered as part of the calculated sum of the WLAs in this TMDL document. Any WLA in addition to that allocated here is not available.

The characterization of the pollutant of concern and its allocation to sources are described. The TMDL document explains important assumptions regarding the distribution of *E. coli* in the lakes and attributes sources of *E. coli* to waterfowl loafing in the NSBE and bacteria regeneration in the beach sand.

The nonpoint and background sources of pollutants of concern for the NSBE are described. The original TMDL document attributes fecal deposits from waterfowl, shoreline temperature, and sand moisture as unique to the NSBE area and demonstrates through data that this environment fosters a continual bacteria population at the NSBE. Transect sampling demonstrates that *E. coli* concentrations decline with distance from the beaches, and open lake sampling indicates *E. coli* concentrations are below the impairment threshold in the main body of each lake. Therefore, this TMDL document addresses the bacteria loading from the NSBE and considers all other nonpoint sources within the watershed insignificant for impairment purposes.

There are no known point sources within the NSBE; therefore, there are no wasteload allocations for all three lakes. Additionally, the state has determined there are no animal feeding operations meeting criteria to require a federal NPDES permit in the NSBE. Should future development of concentrated animal feeding operations occur, they will have WLAs of zero. Any new source or new discharge that will cause or contribute to the violation of WQS must comply with 40 CFR 122.4(i) and demonstrate there are sufficient allocations to allow for the discharge. For unpermitted large CAFOs, a precipitation-related discharge of manure, litter, or process wastewater from land application areas under the control of the CAFO shall be considered an agricultural stormwater discharge only where land application has been in accordance with site-specific management practices that ensure appropriate agricultural utilization of the nutrients and recordkeeping requirements have been met. See 40 CFR 122.23(e).

Any CAFO that does not obtain an NPDES permit must operate as a no-discharge facility. A discharge from an unpermitted CAFO is a violation of Section 301 of the Clean Water Act. It is the EPA's position that all CAFOs should obtain an NPDES permit because it provides clarity of compliance requirements. This TMDL document does not reflect a determination by the EPA that such facilities do not meet the definition of a CAFO nor that the facility does not need to obtain a permit. To the contrary, a CAFO that discharges has a duty to obtain a permit. Moreover, the EPA recommends that the state use its CWA inspection, permitting, CAFO designation, and enforcement authorities to ensure that all AFOs that should be regulated are required to have NPDES permits. If it is determined that any such operation is a CAFO that discharges, any future WLA assigned to the facility must not result in an exceedance of the sum of the WLAs in the TMDL document as approved.

Allocation - Loading Capacity

The submittal identifies appropriate loading capacities, including WLAs for point sources and LAs for nonpoint sources. If no point sources are present, the WLA is stated as zero. If no nonpoint sources are present, the LA is stated as zero [40 CFR § 130.2(i)]. If this is a revised TMDL document, the change in loading capacity will be documented in this section. All TMDLs must give a daily number, establishing TMDL "daily" loads consistent with the U.S. Court of Appeals for the D.C. circuit decision in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006).

The LC is identified for each lake at the NSBE as a concentration and mass, as presented in the Water Quality Standards Attainment Section. The concentration is based on the SSM WQS criterion. The mass is based on the SSM WQS criterion and the NSBV, which is defined as the volume of water within the swimming zone of the lake. The resulting LC for each lake beach applies throughout the recreation season.

The EPA agrees that the LC will attain and maintain WQS.

Wasteload Allocation Comment

The submittal lists individual WLAs for each identified point source [40 CFR § 130.2(h)]. If a WLA is not assigned it must be shown that the discharge does not cause or contribute to a WQS excursion, the source is contained in a general permit addressed by the TMDL, or extenuating circumstances exist which prevent assignment of an individual WLA. Any such exceptions must be explained to a

satisfactory degree. If a WLA of zero is assigned to any facility, it must be stated as such [40 CFR § 130.2(i)]. If this is a revised TMDL document, any differences between the original TMDL(s) WLA and the revised WLA will be documented in this section.

There are no permitted WLAs in the NSBE for the lakes. The WLA is zero.

Load Allocation Comment
All nonpoint source loads, natural background, and potential for future growth are included. If no nonpoint sources are identified, the LA must be given as zero [40 CFR §130.2(g)]. If this is a revised TMDL document, any differences between the original TMDL(s) LA and the revised LA will be documented in this section.

The LA is the amount of the pollutant load that is assigned to nonpoint sources and includes all existing and future nonpoint sources, as well as natural background contributions. As presented in the Water Quality Standards Attainment Section, the LAs are calculated as the remainder of the LC after the allocations to the WLA and the MOS.

Based on the land uses and watersheds of the three lakes, nonpoint sources can result from livestock, wildlife, pets, and humans. Iowa DNR has determined the impairment source is from the NSBE and is attributed to waterfowl loafing on the beaches and *E. coli* regenerating in the sand. The EPA maintains that all aforementioned nonpoint sources may contribute to the bacteria impairment.

These TMDLs are specific to the NSBEs and concentrate on addressing the impairment of the beaches and their beachsheds. The TMDL document has identified all known nonpoint sources of *E. coli* in the NSBEs.

Margin of Safety
The submittal describes explicit and/or implicit margins of safety for each pollutant [40 CFR § 130.7(c)(1)]. If the MOS is implicit, the conservative assumptions in the analysis for the MOS are described. If the MOS is explicit, the loadings set aside for the MOS are identified and a rationale for selecting the value for the MOS is provided. If this is a revised TMDL document, any differences in the MOS will be documented in this section.

The MOS for these TMDLs are explicit. Each TMDL applies a MOS of 10% of the LC to account for uncertainties in the TMDL analyses.

The EPA concludes that the TMDL incorporates an adequate MOS because available data used to analyze the current condition targets the 90^{th} percentile under critical conditions. The state's WQS conservatively establish a SSM at the 75^{th} percentile, which is used to calculate the LC, and the state evaluates a waterbody impairment based upon a 10% excursion of the SSM. Pathogen excursions above the 90^{th} percentile are considered extreme, short-duration events.

The EPA agrees that the state has provided adequate MOS to support the TMDLs.

Seasonal Variation and Critical Conditions

The submittal describes the method for accounting for seasonal variation and critical conditions in the TMDL(s) [40 CFR § 130.7(c)(1)]. Critical conditions are factors such as flow or temperature which may lead to the excursion of the WQS. If this is a revised TMDL document, any differences in conditions will be documented in this section.

The TMDL document accounts for seasonal variation and critical conditions. The critical condition for season is defined as the recreation season from March 15 to November 15, with particular emphasis on the summer months from May 23 to September 7 when bacteria concentrations are typically at their highest and require the greatest load reductions. The critical condition for flow is defined as the NSBV, which is considered constant for each lake. Overall, the NSBEs and NSBVs represent critical conditions for each lake due to the high *E. coli* concentrations that are specific to the beaches.

The EPA agrees that the state considered seasonal variation and critical conditions during the analysis of this TMDL document and the setting of TMDL allocations.

Public Participation

The submittal describes required public notice and public comment opportunities and explains how the public comments were considered in the final TMDL(s) [40 CFR § 130.7(c)(1)(ii)].

The public was given an opportunity to provide feedback during the TMDL process through website postings and a virtual presentation. The TMDL document was posted for public review from July 20, 2023, to August 21, 2023. No comments were received.

The EPA agrees that the public has had a meaningful opportunity to comment on the TMDL document.

Monitoring Plan for TMDL(s) Under a Phased Approach

The TMDL identifies a monitoring plan that describes the additional data to be collected to determine if the load reductions required by the TMDL lead to attainment of WQS and a schedule for considering revisions to the TMDL(s) (where a phased approach is used) [40 CFR § 130.7]. If this is a revised TMDL document, monitoring to support the revision will be documented in this section. Although the EPA does not approve the monitoring plan submitted by the state, the EPA acknowledges the state's efforts. The EPA understands that the state may use the monitoring plan to gauge the effectiveness of the TMDL(s) and determine if future revisions are necessary or appropriate to meet applicable WQS.

The original Statewide Beach Bacteria TMDL document identified future monitoring goals for (1) regular weekly monitoring during the recreation season, (2) trend analysis, and (3) evaluation of implemented best management practice effectiveness. In addition to weekly sampling, the document proposed sample collection for microbial source tracking and brief continuous sampling to evaluate precipitation and wind impacts.

Reasonable Assurance

Reasonable assurance only applies when less stringent WLA are assigned based on the assumption that nonpoint source reductions in the LA will be met [40 CFR § 130.2(i)]. This section can also contain statements made by the state concerning the state's authority to control pollutant loads. States are not required under Section 303(d) of the Clean Water Act to develop TMDL implementation plans and the EPA does not approve or disapprove them. However, this TMDL document provides information regarding how point and nonpoint sources can or should be controlled to ensure implementation efforts achieve the loading reductions identified in this TMDL document. The EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in this TMDL document. Therefore, the discussion of reduction efforts relating to point and nonpoint sources can be found in the implementation section of the TMDL document and are briefly described below.

The states have the authority to issue and enforce state operating permits. Inclusion of effluent limits into a state operating permit and requiring that effluent and instream monitoring be reported to the state should provide reasonable assurance that instream WQS will be met. Section 301(b)(1)(C) requires that point source permits have effluent limits as stringent as necessary to meet WQS. However, for WLA to serve that purpose, they must be stringent enough to meet WQS in conjunction with the water body's other loadings. This generally occurs when a TMDL's combined nonpoint source LAs and point source WLAs do not exceed the WQS-based LC and there is reasonable assurance that a TMDL's allocations can be achieved. Discussion of reduction efforts relating to nonpoint sources can be found in the implementation section of the TMDL document.

There are no known point sources located in the NSBE. However, management and structural BMPs are identified in the Implementation and Management Plan of the original Statewide Beach Bacteria TMDL document. This section discusses a general approach for planning and implementation which could lead to *E. coli* reductions and the attainment of applicable WQS for identified nonpoint sources.

October 4, 2023

Dana Skelley
U.S. EPA, Region VII
11201 Renner Blvd.
Lenexa, KS 66219

Subject: Submittal of Statewide Beach Bacteria TMDL, Addendum #2 for EPA approval

Dear Ms. Skelley:

Enclosed is the Final Statewide Beach Bacteria Total Maximum Daily Load, Addendum #2 document. This document amends the original Statewide Beach Bacteria TMDL, which was approved by the EPA on August 6, 2020, by addressing tables; figures; table of contents; list of figures; list of tables; appendices that required updating to reflect the new TMDL's included with this submittal. The new lake beach TMDL's included with this submittal are:

- Prairie Rose Lake
- Lake Keomah
- North Twin Lake (Protective TMDL)

Iowa DNR posted the draft TMDL to the DNR's website coincident with a press release announcing the start of the 30-day public comment period, which ran from July 20, 2023 until August 21, 2023. Iowa DNR made available a video recording of a standard public meeting presentation posted to the DNR website coincident with the Public Notice period. The Iowa DNR received no public comments on the draft.

Please note that North Twin Lake was delisted during the 2020 assessment cycle. However, since sampling and analysis for this lake was already in process, the analysis was completed and the lake is being submitted as a protective TMDL.

Please accept this document for approval as the completed TMDL for these three (3) lake beaches.

Sincerely,

Kayla Lyon
Digitally signed by Kayla Lyon
Date: 2023.10.04 13:50:32 -05'00'

Kayla Lyon, Director
Department of Natural Resources

Enclosure

Addendum #2 Statewide Beach Bacteria TMDL
Summary of Updates

This addendum to the Statewide Beach Bacteria TMDL addresses bacteria TMDLs at three lakes: Prairie Rose Lake, Lake Keomah, and North Twin Lake.

This document addresses tables, figures, table of contents, list of figures, list of tables, and appendices that require updating to reflect the TMDLs addressed in this addendum. In addition, this document includes new TMDL chapters for Prairie Rose Lake (Chapter 10), Lake Keomah (Chapter 11), and North Twin Lake (Chapter 12). Please note that North Twin Lake was delisted as part of the 2020 assessment cycle. Consequently, it is being submitted as a protective TMDL. Below is a summary of updates and new chapters.

- Update the Table of Contents by inserting the attached information into the Table of Contents.
- Update the List of Figures by inserting the attached information into the List of Figures.
- Update the List of Tables by inserting the attached information into the List of Tables.
- Replace Figure 1 with the attached Figure 1 identified with Addendum #2 in the header. This figure was updated from the 2022 303(d) impaired waters list. Updates include identifying beach bacteria TMDLs that have been approved, current listing of lakes impaired for *E. coli* (potential future projects), and beach bacteria TMDLs that are included with the current addendum.
- Replace Table 1 with the attached Table 1 identified with Addendum #2 in the header. This table was updated from the 2022 Integrated Report. Updates include identifying beach bacteria TMDLs that have been approved, current listing of lakes impaired for *E. coli*, and beach bacteria TMDLs that are included with the current addendum.
- Insert Chapter 10, Prairie Rose TMDL.
- Insert Chapter 11, Lake Keomah TMDL.
- Insert Chapter 12, North Twin Lake TMDL (Protective TMDL).
- Replace Appendix E. Public Participation with the attached Appendix E. Public Participation identified with Addendum #2 in the header. This appendix has been updated to indicate past public meetings and beach bacteria included with this addendum.

Water Quality Improvement Plan
for the

Statewide Beach Bacteria

Addendum #2

Shelby, Mahaska, and Calhoun Counties

Total Maximum Daily Loads for:
Pathogen Indicators (*E. coli*)

Prepared by:
James Hallmark, P.E. and
Jason Palmer

Iowa Department of Natural Resources
Water Quality Monitoring and Assessment Section
2023

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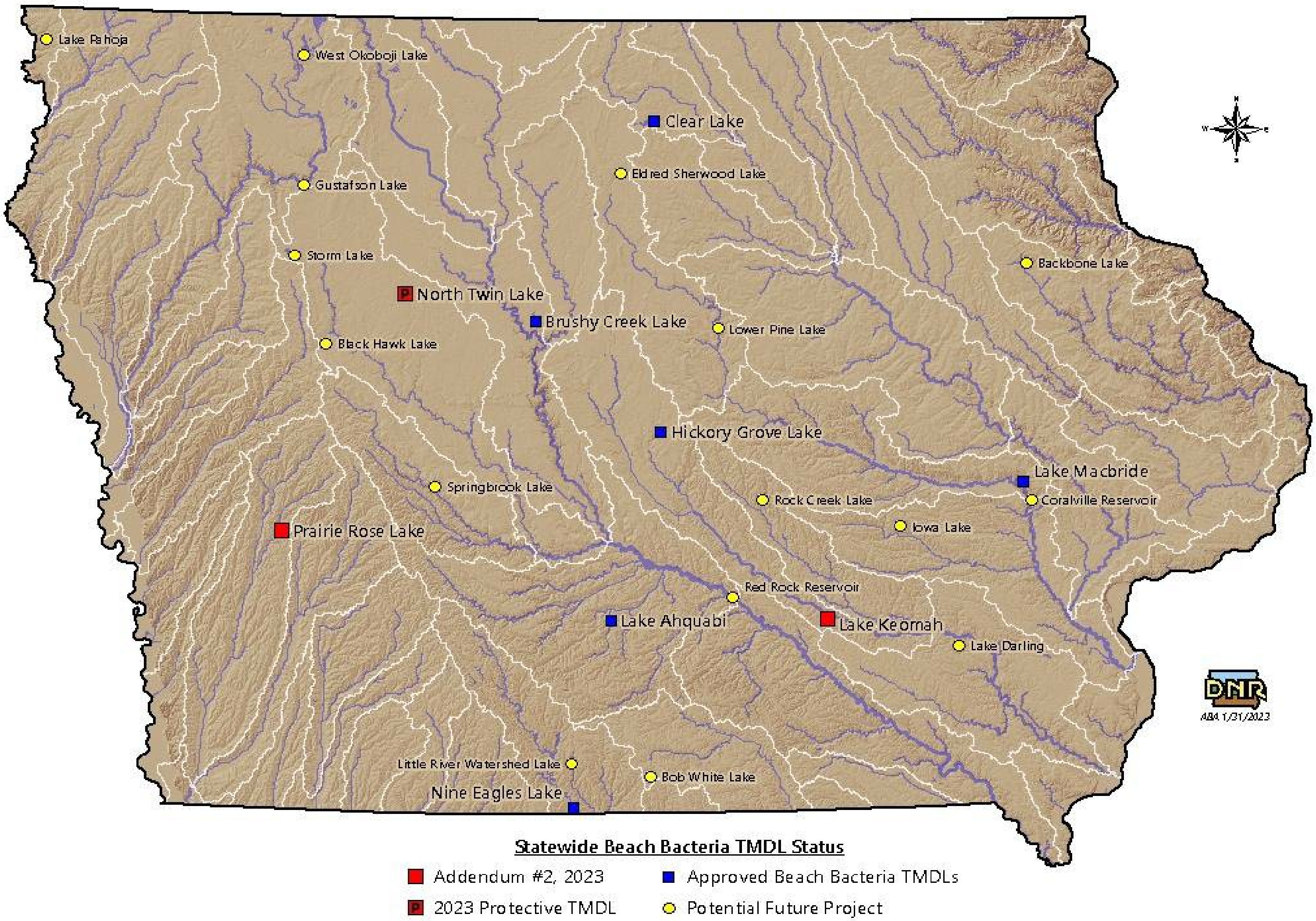

Figure 1. Location Map of Lakes Impaired for *E. coli*.

Table 1. Impaired Lakes for *E. coli*[(1)].

Lake Name	Chapter[(4)]	TMDL Approved Date [(5)]	ADB Code	HUC-8 Subbasin	County	Cycle Listed
Hickory Grove Lake	4	2020	03-SSK-950	South Skunk	Story	2008
Clear Lake[(2)] Clear Lake St Park McIntosh Woods	5	2020	02-WIN-841	Winnebago	Cerro Gordo	2004 2010
Nine Eagles Lake	6	2020	05-GRA-1361	Thompson	Decatur	2006
Brushy Creek Lake	7	2022[(3)]	04-UDM-1276	Middle Des Moines	Webster	2012
Lake Ahquabi[(7)]	8	2022[(3)]	04-LDM-1080	Lake Red Rock	Warren	2012
Lake Macbride	9	2022[(3)]	02-IOW-629	Middle Iowa	Johnson	2006
Prairie Rose Lake	10	Pending[(6)]	05-NSH-1462	West Nishnabotna	Shelby	2012
Lake Keomah	11	Pending[(6)]	03-SSK-930	South Skunk	Mahaska	2008
North Twin Lake[(8)]	12	2020[(6)]	04-RAC-1167	North Raccoon	Calhoun	2012
Backbone Lake	---	---	01-MAQ-20	Maquoketa	Delaware	2004
Black Hawk Lake	---	---	04-RAC-1134	North Raccoon	Sac	2016
Bob White Lake	---	---	05-CHA-1338	Upper Chariton	Wayne	2004
Coralville Reservoir	---	---	02-IOW-630	Middle Iowa	Johnson	2020
Eldred Sherwood Lake	---	---	02-IOW-773	Upper Iowa	Hancock	2008
Gustafson Lake	---	---	06-LSR-1625	Little Sioux	Buena Vista	2014
Iowa Lake	---	---	02-IOW-677	Lower Iowa	Iowa	2012
Lake Darling	---	---	03-SKU-924	Skunk	Washington	2018
Lake Pahoja	---	---	06-BSR-1532	Lower Big Sioux	Lyon	2016
Little River Watershed Lake	---	---	05-GRA-1358	Thompson	Decatur	2014
Lower Pine Lake	---	---	02-IOW-758	Upper Iowa	Hardin	2006
Red Rock Reservoir	---	---	04-LDM-1017	Lake Red Rock	Marion	2014
Rock Creek Lake	---	---	03-NSK-865	North Skunk	Jasper	2006
Springbrook Lake	---	---	04-RAC-1196	South Raccoon	Guthrie	2012
Storm Lake	---	---	04-RAC-1143	North Raccoon	Buena Vista	2010
West Okoboji Lake	---	---	06-LSR-2066	Little Sioux	Dickinson	2006

(1) Table includes impaired lakes based on the 2022 303(d) impaired waters list, lakes that have previously been approved, and bacteria TMDLs that are included with the current submittal.
(2) Clear Lake is impaired due to water quality at two beaches Clear Lake State Park and McIntosh Woods State Park. Clear Lake was initially impaired for bacteria during the 2004 cycle due to water samples from Clear Lake State Park. Water quality samples from McIntosh Woods State Park showed an impairment for bacteria in the 2010 cycle.
(3) Addendum #1
(4) This column lists the associated chapter of the lake TMDL or if the lake has been delisted it will have the designation “Delisted”.
(5) This column indicates the year the TMDL was approved by the EPA or if the lake has been delisted it is the year of the assessment cycle in which it was delisted.
(6) Addendum #2
(7) The TMDL for Lake Ahquabi was submitted in calendar year 2021 as part of Addendum #1. Subsequent to and independent of this submittal, Lake Ahquabi was delisted as part of the 2022 assessment cycle.
(8) North Twin Lake was delisted in the 2020 assessment cycle. However, analysis for the lake was in process before the delisting occurred. Consequently, the analysis was completed and the TMDL is submitted as a protective TMDL.

10. Prairie Rose Lake TMDL

10.1 Description and History of Prairie Rose Lake

Prairie Rose Lake, IA 05-NSH-1462, is located in Monroe Township, Shelby County, Iowa approximately six (6) miles southeast of Harlan. Prairie Rose Lake and Prairie Rose State Park received their names from a small town called Village of Prairie Rose, which was located near the present park location. Plans for Prairie Rose State Park were initiated in the 1930's. However, actual construction of the dam started in 1958 with the park dedication taking place in 1962. The lake and state park provide fishing, camping, hiking, and other outdoor recreational activities for the public.

The lake is located within the 442-acre Prairie Rose State Recreation Area, which is owned and operated by the Iowa Department of Natural Resources (DNR). The lake has a watershed area of 4,640-acres, a maximum depth of 25 feet, a shore length of approximately six (6) miles, and an approximate volume of 1,653 acre-feet. Table 10-1 is a summary of the lake and watershed properties. Figure 10-1 is an aerial photograph with the boundaries of the watershed.

Table 10-1. Prairie Rose Lake Watershed and Lake Information.

Waterbody Name	Prairie Rose Lake
Waterbody ID	IA 05-NSH-1462
12 Digit Hydrologic Unit Code (HUC)	102400020104
HUC-12 Name	Middle East Branch West Nishnabotna River
Location (Ambient Monitoring Site)	Section 36, T79N, R38W, Shelby County Iowa
Water Quality Standard Designated Uses	Class A1 Primary Contact Recreation Class B(LW) Aquatic Life Class C Drinking Water Supply Class HH Human Health
Antidegradation Protection Level	Tier 1
Tributaries	Unnamed Tributaries
Receiving Waterbody	Unnamed Tributary to East Branch West Nishnabotna River
Watershed Area	4,640 acres
Lake Surface Area	196.1 acres(1)
Maximum Depth	25.0 feet(1)
Volume	1,653.0 acre-feet(1)
Length of Shoreline	6.0 miles
Watershed/Lake Area Ratio	23.7:1

(1) Data obtained from October 2015 DNR Bathymetric Survey.

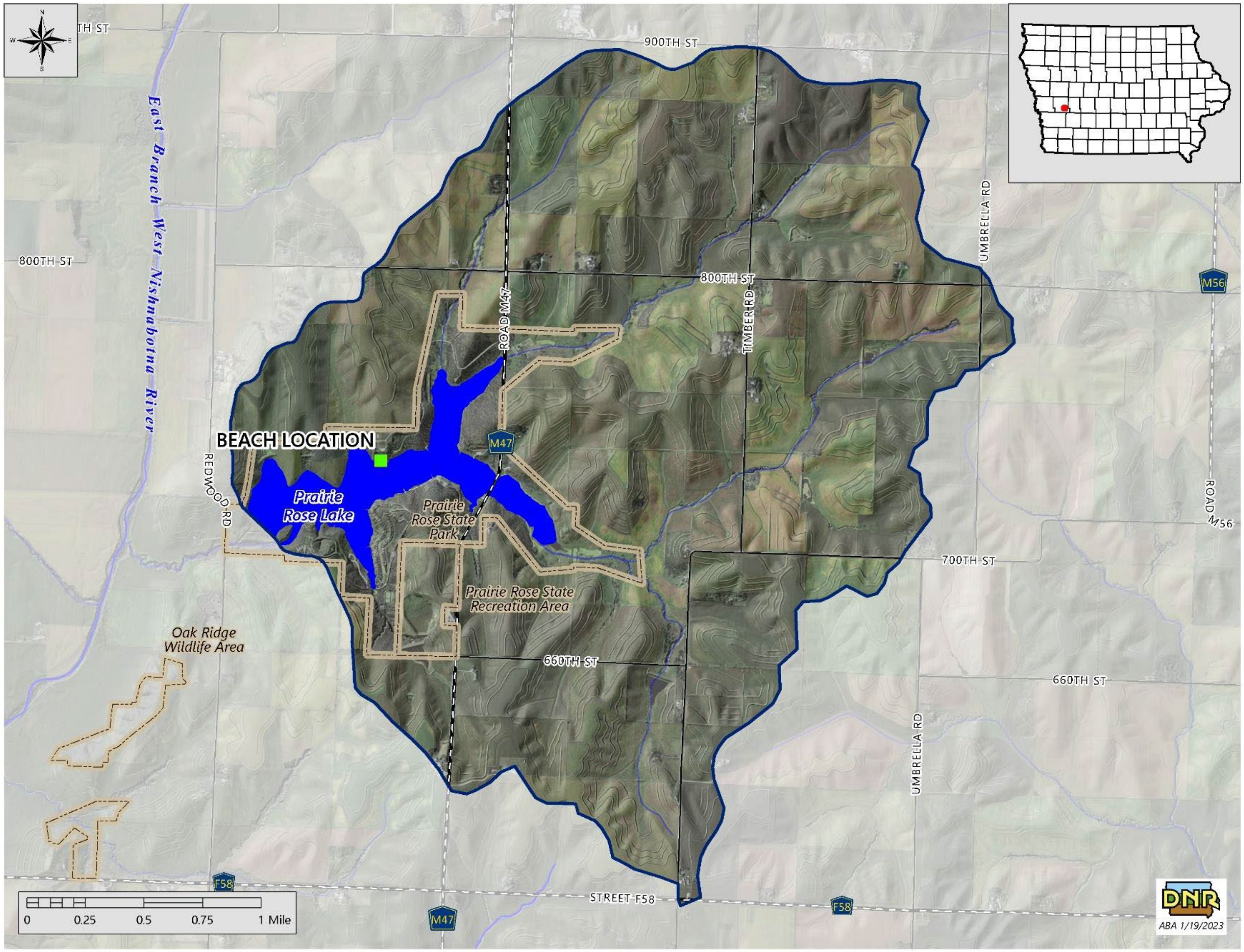

Figure 10-1. Prairie Rose Lake Watershed.

Land Use

A Geographic Information System (GIS) coverage of land use information was developed using the 2021 USDA Cropland Data Layer (USDA, National Agricultural Statistics Service). The dominant land use is row crops (corn and soybeans rotations) making up approximately 60% of the land use (Table 10-2). The eight land uses shown in Table 10-2 were aggregated from the fourteen land uses in the cropland data layer as shown in the description column. Figure 10-2 shows the distribution of the various land uses throughout the Prairie Rose Lake watershed in a pie-chart.

Table 10-2. Prairie Rose Lake Watershed Land Uses.

Land Use	Description	Area (AC)	Percent of total
Water/Wetland	Water and Wetlands	234	5.0%
Forested	Bottomland, Coniferous, Deciduous	124	2.7%
Grassland	Ungrazed, Grazed, & CRP-	1,212	26.1%
Alfalfa/Hay	Perennial Hay Crop-	34	0.7%
Row Crop	Corn, Soybeans, & other	2,774	59.8%
Roads	Roads Lightly Developed Urban	134	2.9%
Urban	Intensively Developed Urban	128	2.8%
Barren	Barren Land	<1	<0.1%
Total		**4,640**	**100.0%**

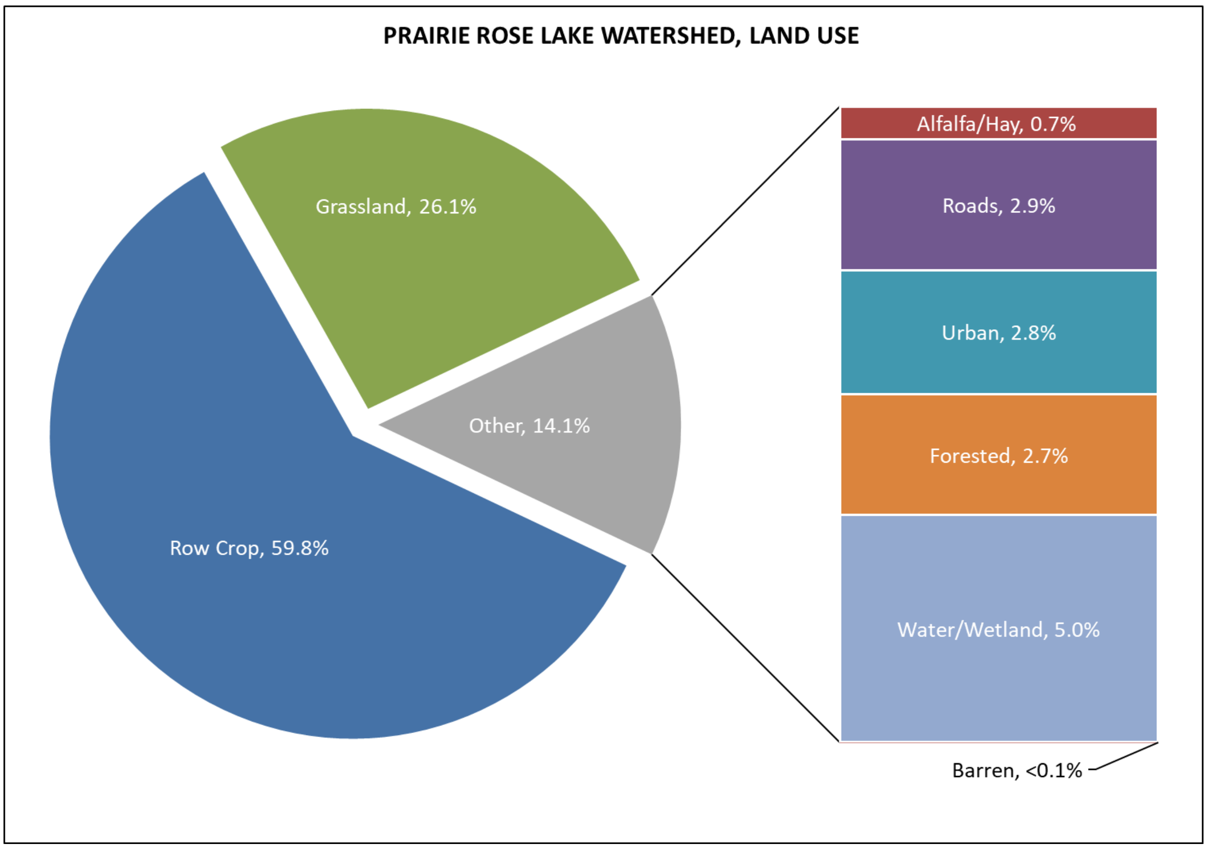

Figure 10-2. Land Use Composition of the Prairie Rose Lake Watershed.

Hydrology, Soils, Climate, Topography

From data obtained from the NRCS, there are three dominant soil series in this watershed. The three soils, the Marshall, Judson-Ackmore-Colo complex, and Exira make up 84% of the soils in the watershed. Each soil series has been grouped into one of four hydrologic soil group (HSG). HSGs are based on estimates of runoff potential. HSG-C makes up 99% of the watershed. The Prairie Rose Lake watershed is in the Steeply Rolling Loess Prairies ecoregion. This landscape is distinguished with thick loess deposits and underlying glacial till along with peaked hills and narrow ridges with steep diverging side slopes.

The average rainfall for the Prairie Rose Lake watershed from 2008 through 2022 was 35.6 inches with the majority (74%) falling between April 1st and September 30th. Lake evapotranspiration averaged 49.0 inches per year with more typically occurring in dryer years. Figure 10-3 shows the annual rainfall and lake evapotranspiration from 2008 to 2022. Figure 10-4 shows the monthly average relationship between watershed evapotranspiration and rainfall. In some drier summer months, evapotranspiration may exceed rainfall, leading to a deficit in the water budget for the watershed.

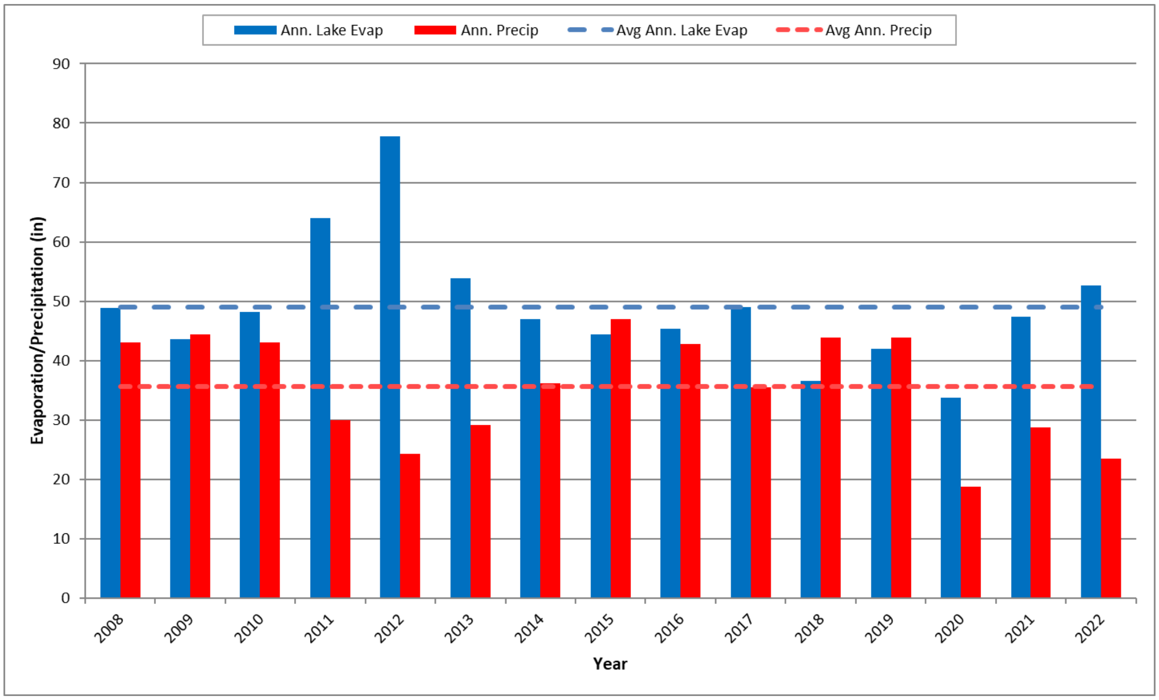

Figure 10-3. Annual Rainfall and Estimated Evapotranspiration Totals, Prairie Rose Watershed.

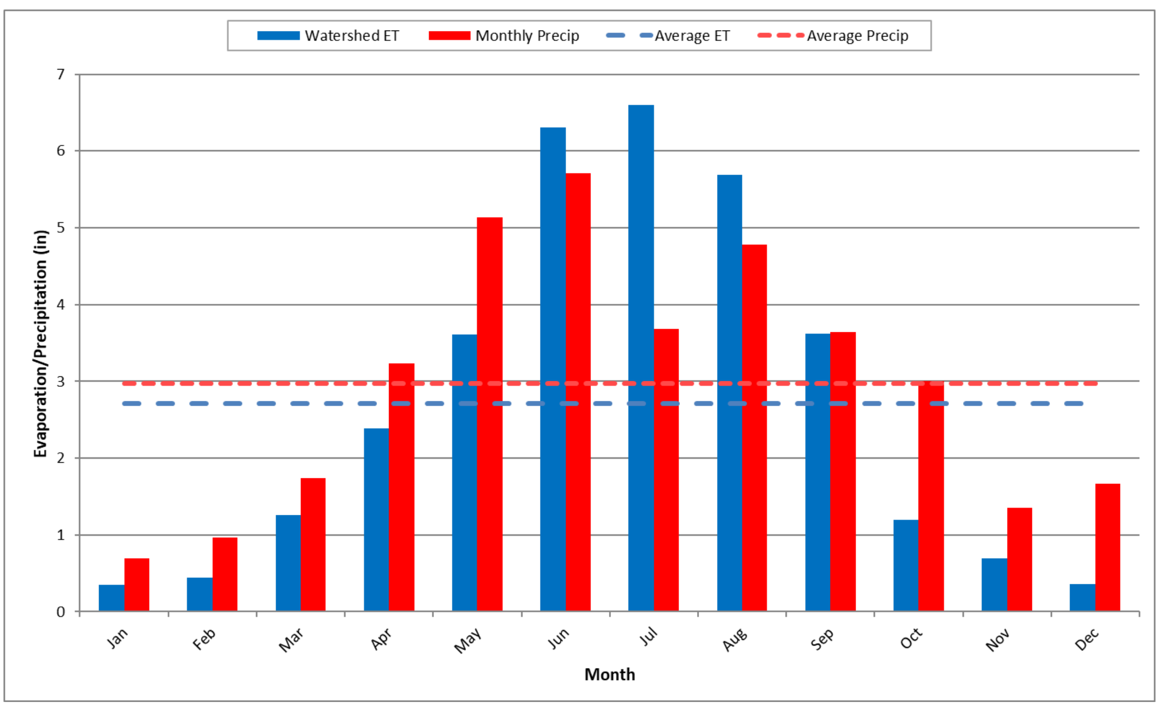

Figure 10-4. Monthly Rainfall and Estimated Evapotranspiration Totals, Prairie Rose Watershed.

10.2 Beach Investigation Sampling and Analysis

Swimming advisories are commonly posted at public beaches across Iowa every season. Weekly monitoring of public swimming zones at state and county beaches have resulted in the impairment of numerous lakes for Fecal Indicator Bacteria (FIB) contamination, a violation of the State of Iowa's water quality standards. These swimming beach impairments result in whole lake waterbodies being listed as impaired on the state's biennial 303(d) list. These impairment listings do not accurately reflect the condition(s) of the larger lake environment outside the swimming zone and fail to account for beach proximate conditions in the assessment process.

Traditionally, management of these systems has assumed that the larger watershed serves as the primary source of FIB to the recreational areas. However, sampling at numerous beach systems across Iowa have shown a disconnect between the open lake environment and FIB contamination in the swimming zone, which is driven by conditions in the foreshore sand environment. An extensive study conducted in 2015-2016 assessed the relationships between the nearshore beach environment, open lake conditions and watershed delivery of FIB (*E. coli*) in three representative beach / lake systems currently impaired for FIB contamination across Iowa (Chapter 2). The results of this study and subsequent TMDL development provided an assessment framework for other beach systems in the region. Following are the results of this assessment for Prairie Rose Beach on Prairie Rose Lake (IA 05-NSH-1462).

Sampling and Data Collection

Samples were collected from the beach swimming zone, the open lake transect zone, the alternate transect, and the open lake sampling points seasonally and in response to wet weather events from spring 2017 through the fall of 2017 and again from the spring of 2021 through the fall of 2021 (Figure 10-5). All water and sand sample collections and laboratory analyses were conducted following protocols highlighted in Chapter 2.3.

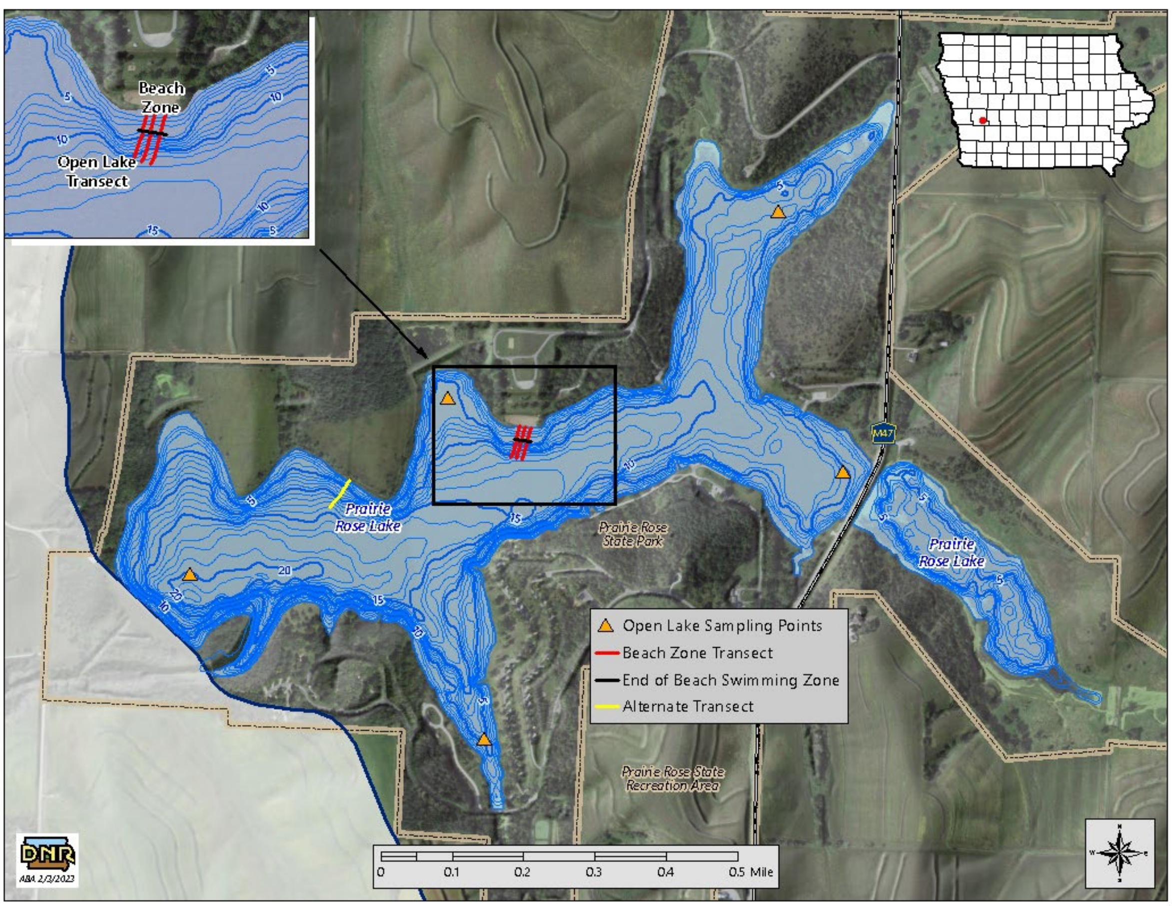

Figure 10-5. Overview of Monitoring Locations on Prairie Rose Lake.

Sampling Results and Analysis
Water sample collection in the nearshore swimming zone showed a high degree of variability. Sample results commonly varied by thousands of MPN/100 ml, indicating that this environment was highly sensitive to changes in *E. coli* loading. While these data showed that intermittent spikes in concentrations could be quite high, the bulk of data collected showed overall low *E. coli* concentrations. The observed median concentration was below the detection limit of 10 MPN/100 ml (Table 10-3), indicating the majority of samples had non-detectable *E. coli* concentrations. This information suggests that conditions in the recreational swimming zone can rapidly change in response to *E. coli* loading but do not maintain an elevated concentration across the season. These findings are supported by observations that during the two sampling seasons at Prairie Rose Lake the swimming area met recreational standards (235 MPN/100 ml) in five of the eight sampling trips. Sampling at the alternate transect and open lake locations had a two-year median value below the *E. coli* detection limit of 10 MPN/100 ml and relatively low standard deviations (Table 10-3), indicating overall low concentrations in these environments.

Table 10-3. Basic Statistics from Bacteria Sampling at Prairie Rose Lake.
Water results reported as MPN/100 ml and sand results reported as MPN/gram (dry wt.).

Sampling Dataset	N	Mean	Median	St. Dev.	25th %	75th %
Prairie Rose Beach Swimming Zone	96	375	5	2009	5	28
Prairie Rose Open Lake Transects	111	13	5	20	5	10
Prairie Rose Open Lake	37	11	5	11	5	10
Prairie Rose Beach Sand	111	505	22	908	1.7	260
Prairie Rose Alternate Transect Rows 0-3	32	9	5	9	5	10
Prairie Rose Alternate Transect Rows 4-8	37	10	5	9	5	10

Data collected from the beach sand environment during both seasons showed a wide range of variability (Table 10-3). However, median and mean sample *E. coli* concentrations were well above detection limits of (0.1 MPN/gram) indicating that a standing stock of *E. coli* bacteria was consistently present in the beach sands at Prairie Rose Lake. These sand observations are consistent with investigations conducted on other systems in Iowa (Chapter 2.4).

Beach sand sampling conducted at Prairie Rose Lake Beach showed that the highest numeric *E. coli* concentrations were generally observed near the shoreline. However, unlike analysis results from other sampling locations (Chapter 2.4) an analysis of variation on ranks (ANOVA) showed that *E. coli* concentrations were statistically similar in sands across the beach surface. These observations indicate that a large percentage of the terrestrial beach area at Prairie Rose Lake contain elevated levels of *E. coli* bacteria. As with prior surveys, the sands on Prairie Rose Beach had *E. coli* concentrations many times higher than observed in adjacent swimming waters (Figure 10-6). Beach sand *E. coli* concentrations averaged over 9,300 times higher than those observed in adjacent swimming areas during the two-year sampling effort. These observations provide evidence of a near shore *E. coli* reservoir in the beach environment that can affect conditions in the nearshore swimming environment, as discussed in Chapter 2.

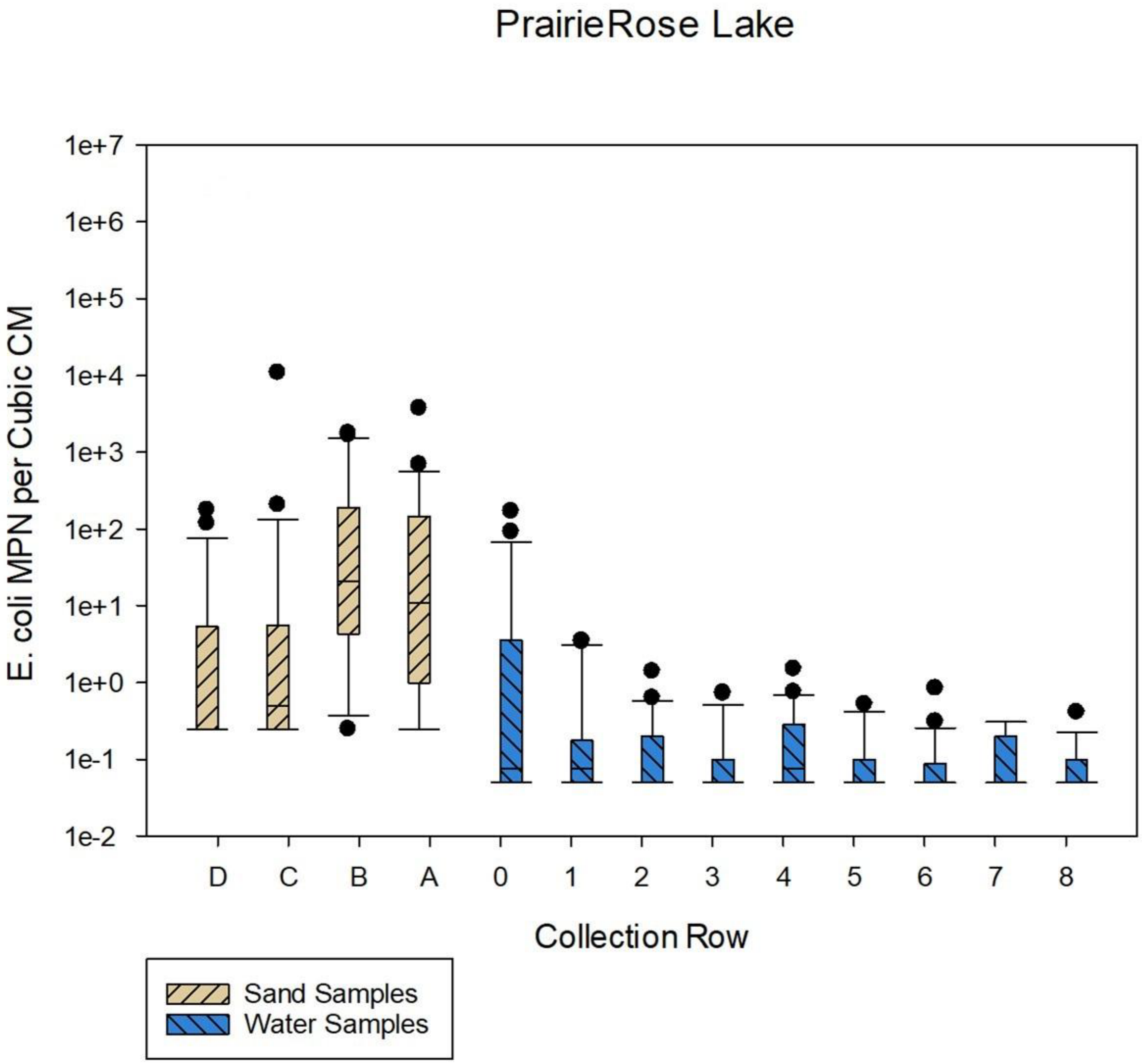

Figure 10-6. Box Plots of Sand and Water Sampling from Transects along Prairie Rose Beach. Reported in MPN/per cubic cm. Sampling points in figure correspond to following locations in relation to shoreline: A=shoreline, B (+2.5 m), C (+5m), D (+10M), 0 (Ankle deep), 1 (Knee deep), 2 (waist deep), 3 (chest deep), 4 (swimming rope), 5 to 8 (10 m spacing beyond swimming rope).

As highlighted earlier, intermittent spikes in *E. coli* concentrations were observed throughout the project. These spikes resulted in a number of days where the swimming environment exceeded recreational standards and triggered an advisory condition. The elevated conditions were largely driven by higher readings closer to the shoreline, as sampling data collected along transects radiating out from the shoreline into the lake (Figure 10-7) uncovered an association between *E. coli* concentrations and proximity to shore. Sampling points at the ankle-deep location of each beach transect were higher in *E. coli* concentrations than all other sampling points in the lake.

Statistical analysis of the Prairie Rose monitoring network uncovered trends and associations which closely mimicked findings of previous beach investigations (Chapter 2). Results highlighted in Table 10-4 demonstrate the dis-association of Beach *E. coli* concentrations and those observed in other areas of the sampling network. Beach swimming zone values were significantly higher than those observed in open lake transects, open lake sampling points and along alternate transect sampling locations. These findings are directly in line with analysis conducted as part of the original beach only bacteria data development (Chapter 2). The findings from this analysis validate the decision to address the *E. coli* bacteria impairments at Prairie Rose Beach with a framework that directly addresses beach capture shed specific sources of *E. coli*.

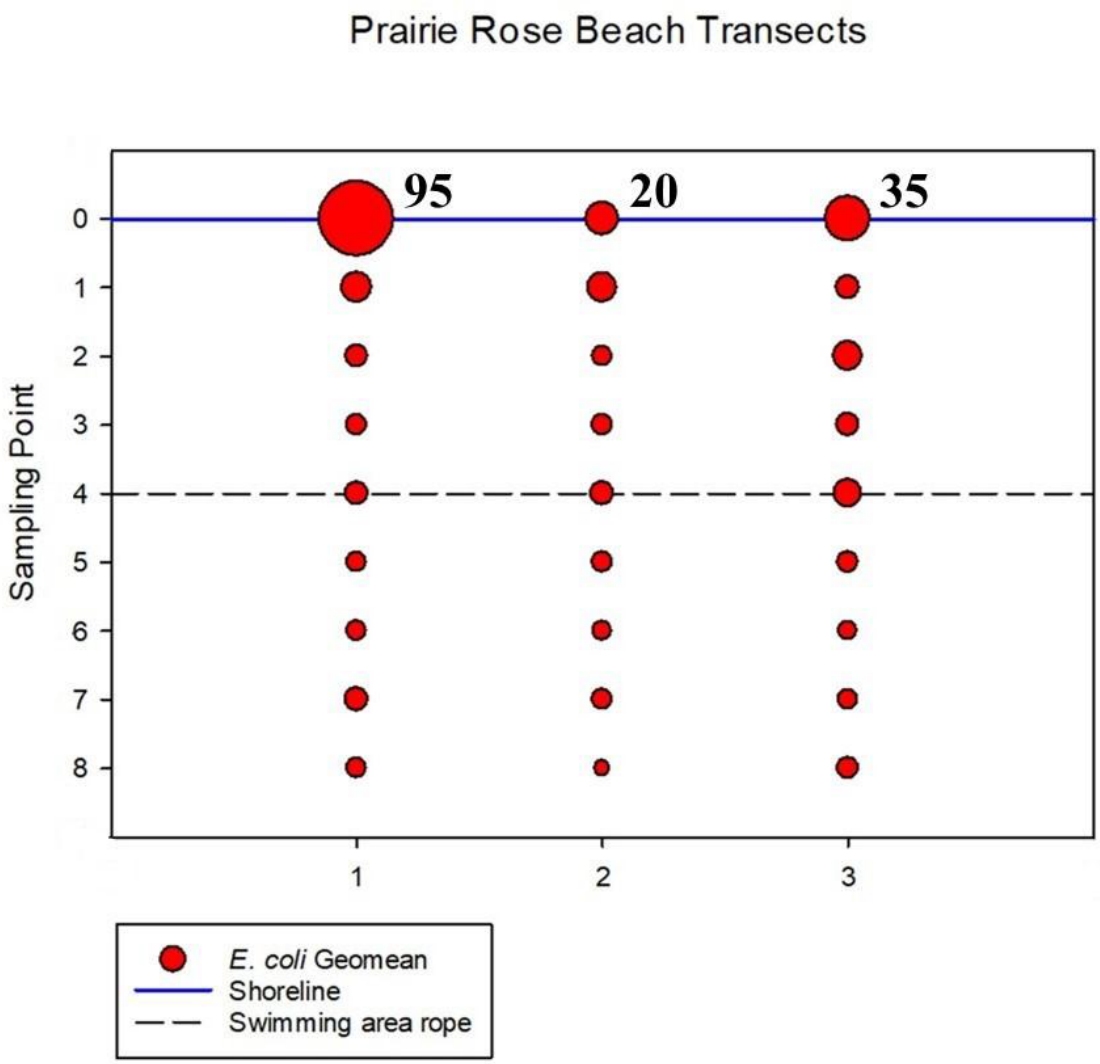

Figure 10-7. Bubble Plot of *E. coli* Sampling at Prairie Rose Beach Lake Transects Reported as MPN/100 ml.

Table 10-4. Analysis Results from Prairie Rose Lake Sampling Network.

Dataset Comparison	Test	Significance Level	Swimming Zone Higher
Swimming Zone vs Lake Transects	T-test	P<0.05	Yes
Swimming Zone vs Open Lake Points	T-test	P<0.05	Yes
Swimming Zone vs Alternate Transect	T-test	P<0.05	Yes

10.3 TMDL for Prairie Rose Lake Beach.

The water quality improvement plan (WQIP) has provided general background information around the impaired lake. However, the sampling and monitoring of the lake that resulted in the impairment are located in the swimming zone of the Prairie Rose State Park. Assessments conducted on the Prairie Rose beach and lake system (Chapter 10.2) show a clear signal for a beach specific impairment. Consequently, the TMDL will focus on the beach shed area and the swimming zone that it drains to.

Problem Identification

Prairie Rose Lake, IA 05-NSH-1462, was included on the 2012 303(d) impaired waters list for not fully supporting the Class A1 (primary contact recreation) use due to the presence of high levels of *E. coli*. Samples were collected during the recreational season (March 15-November 15) between 2008-2010 as part of the state's ambient water quality monitoring and assessment program.

Applicable Water Quality Standards

The designated uses of Prairie Rose Lake are: primary contact recreational use (Class A1); lakes and wetlands aquatic life use (Class B(LW)); human health (Class HH); and drinking water supply (Class C). The designated uses are defined in the Iowa Administrative Code (567 Iowa Administrative Code, Chapter 61, (IAC)). For a more detailed description of the designated uses see Appendix B.

In 2010 the State of Iowa enacted an antidegradation policy. This policy was designed to maintain and protect high quality waters and existing water quality in other waters from unnecessary pollution. Protection levels (or tiers) as defined by the Iowa Administrative Code (IAC) 567-61.2 are cited below.

- 567-61.2(2)(a) Tier 1 protection. Existing surface water uses and the level of water quality necessary to protect the existing uses will be maintained and protected.

Near Shore Beach Volume (NSBV)

The NSBV is the volume of water contained within the swimming zone of the Lake. Figure 10-8 shows the swimming and beach shed areas of Prairie Rose Lake. Table 10-5 is a summary of the NSBV data.

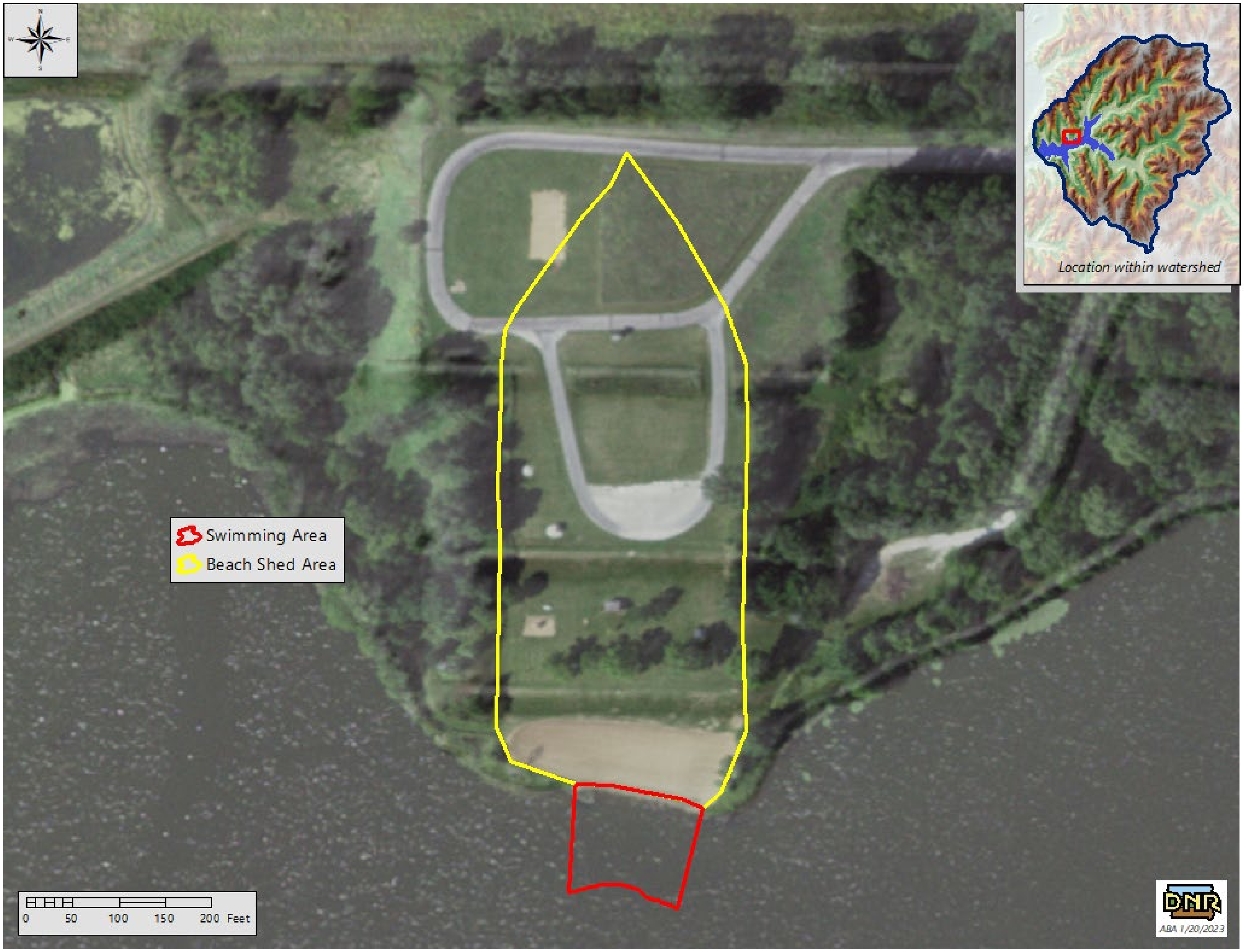

Figure 10-8. Swimming and Beach Shed Areas, Prairie Rose Lake.

Table 10-5. Prairie Rose NSBV Data.

Near Shore Beach Volume	0.65 acre-feet
Beach Front Length	140.6 feet
Radius from Shore at midpoint of beach	103.0 feet
Depth at Radius	4.1 feet (Elevation 1,223.9)
Beach Shed Area	3.5 Acres

Data Sources and Monitoring Sites

Table 10-6 lists the water quality monitoring locations used to develop the WQIP for Prairie Rose Lake. Figure 10-**9** shows the monitoring locations used. In addition to these sites, samples were collected adjacent to the beach along three transects and an alternate transect as shown in Figure 10-5. For a more detailed description of the samples collected along the transects see Chapter 10.2.

Water quality samples were collected as part of the state's ambient water quality monitoring and assessment program between 2008-2022. Additional water quality samples were collected in 2017 and 2021 by the DNR to study and assess the relationships between the nearshore beach environment and open lake conditions. Results of this study are presented in Chapter 10.2

Table 10-6. WQ Data Monitoring Sites at Prairie Rose Lake.

Site Name	Site ID	Longitude	Latitude
Pr Rose Inlet 1(1)	14000204	95° 12' 36"	41° 36' 13"
Pr Rose Inlet 2 (1)	14000205	95° 12' 43"	41° 36' 32"
Pr Rose Inlet 3 (1)	14000206	95° 13' 10"	41° 35' 53"
Pr Rose Inlet 4 (1)	14000207	95° 13' 14"	41° 36' 18"
Prairie Rose Lake(2)	22830002	95° 13' 39"	41° 36' 05"
Prairie Rose Beach(1) (2)	21830001	95° 13' 07"	41° 36' 17"

(1) 2017 and 2021 DNR Study sampling site.
(2) Ambient water quality sampling site.

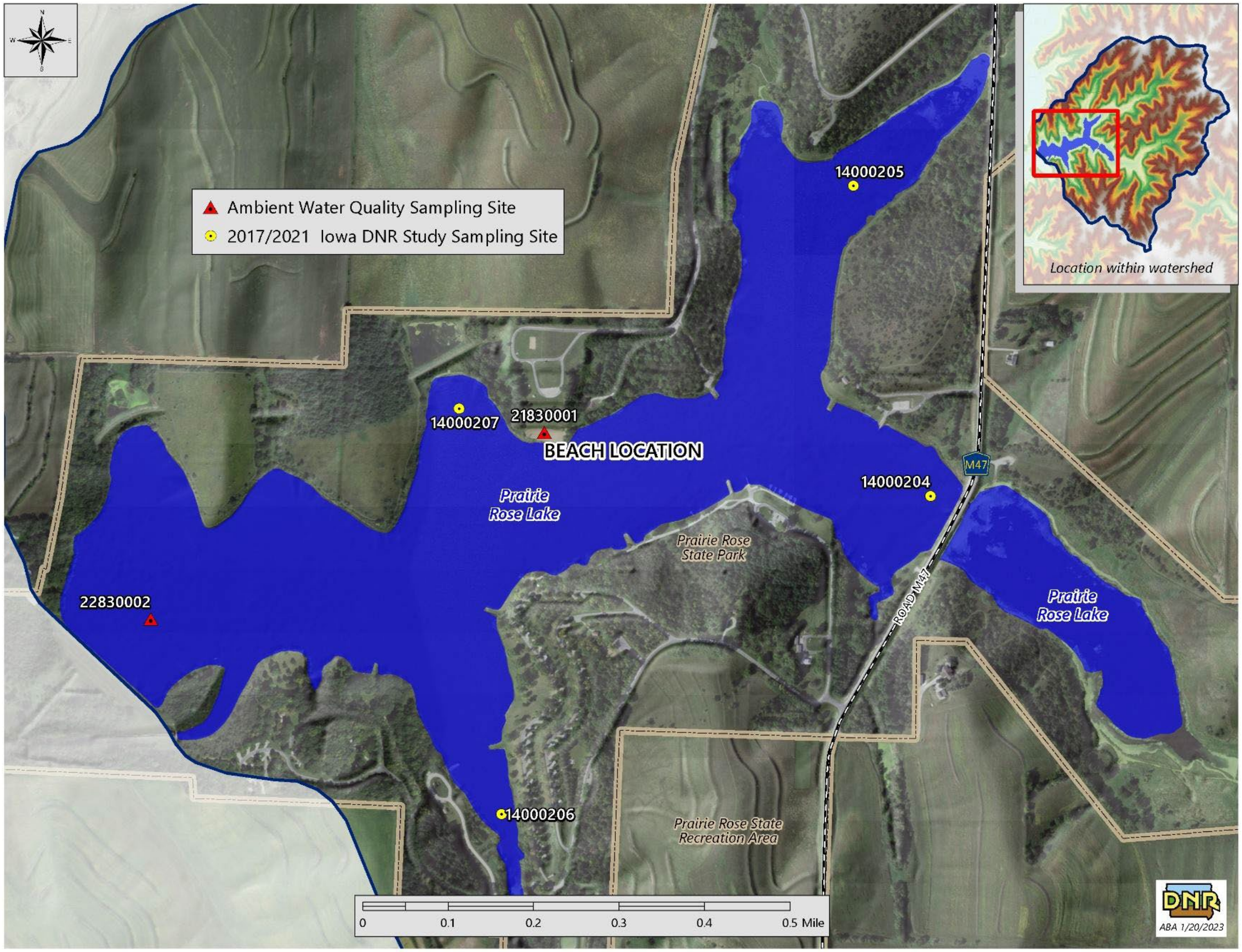

Figure 10-9. Sampling Locations, Prairie Rose Lake.

Interpretation of Data

Using data collected from 2008 - 2022, two box plots were developed. Figure 10-10 is a box plot of samples categorized by season (spring and summer) and a plot of the full data. There were no samples collected after September 7 consequently, Figure 10-10 did not contain a box plot of the fall data. The box has lines at the lower quartile, median, and upper quartile values. Whiskers extend from the top and bottom to the existing loading and the minimum load. The existing load for each box is the 90th percentile of observed *E. coli* concentrations. There is also a horizontal line representing the SSM concentration of 235 orgs/100 ml.

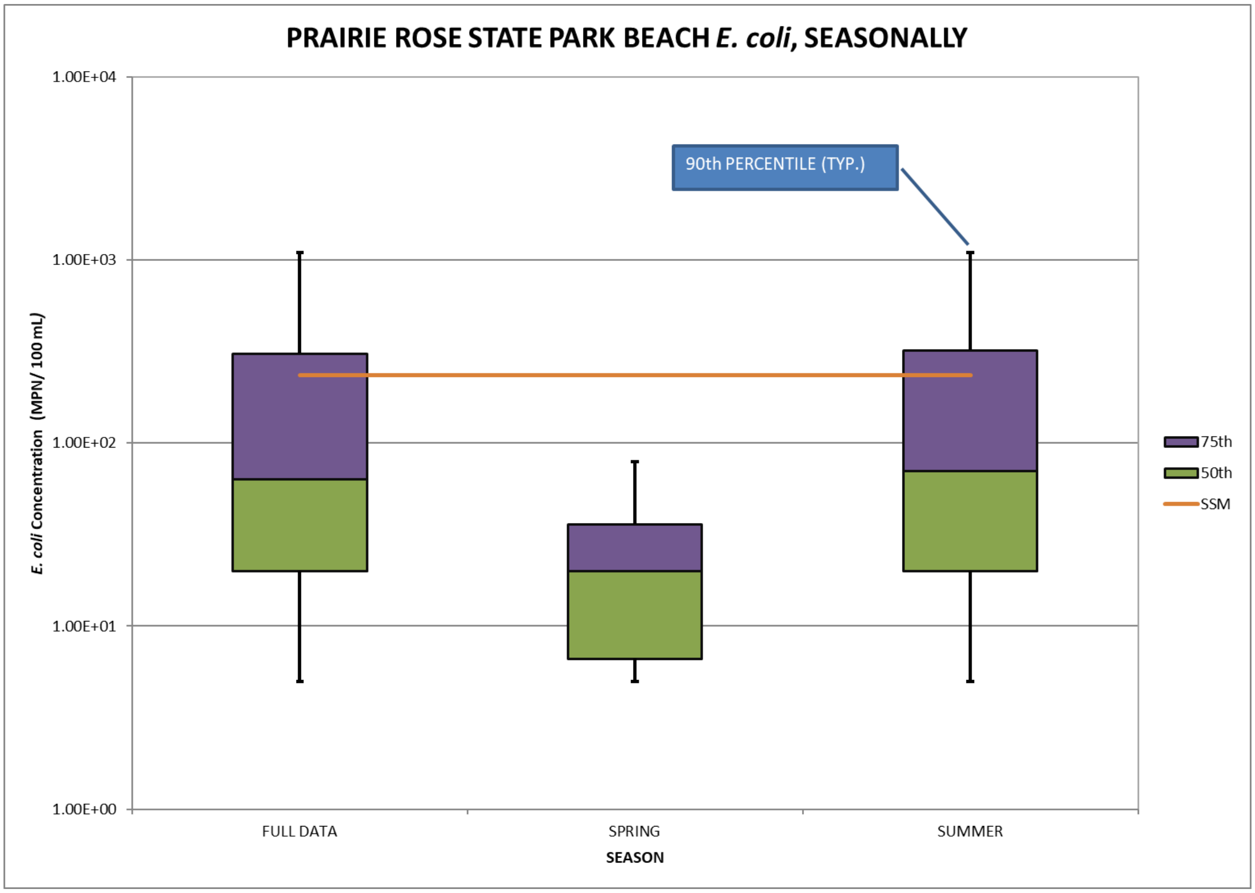

Figure 10-10. Seasonal Box Plot, Prairie Rose Lake.
Seasons defined as: Spring (March 15-May 22); Summer (May 23-September 7) and Fall (September 8-November 15).

Analysis of the data show *E. coli* levels that exceed the SSM (single sample max) concentration of 235 orgs/100 ml criterion set forth in Iowa's WQS for primary contact recreation approximately 29 percent of the time. Consequently, reductions in *E. coli* loading will be required to comply with the standards and fully support the designated recreational use in the impaired waterbody.

From Figure 10-10, elevated levels of bacteria occurred during the summer seasons at the Prairie Rose Lake beach.

In the second box plot graph, Figure 10-11, data is categorized by month. This box plot has the same format as previously described. This figure shows that *E. coli* levels are elevated above the SSM criterion of 235 orgs/100 ml throughout the sampling period, with the peak in August.

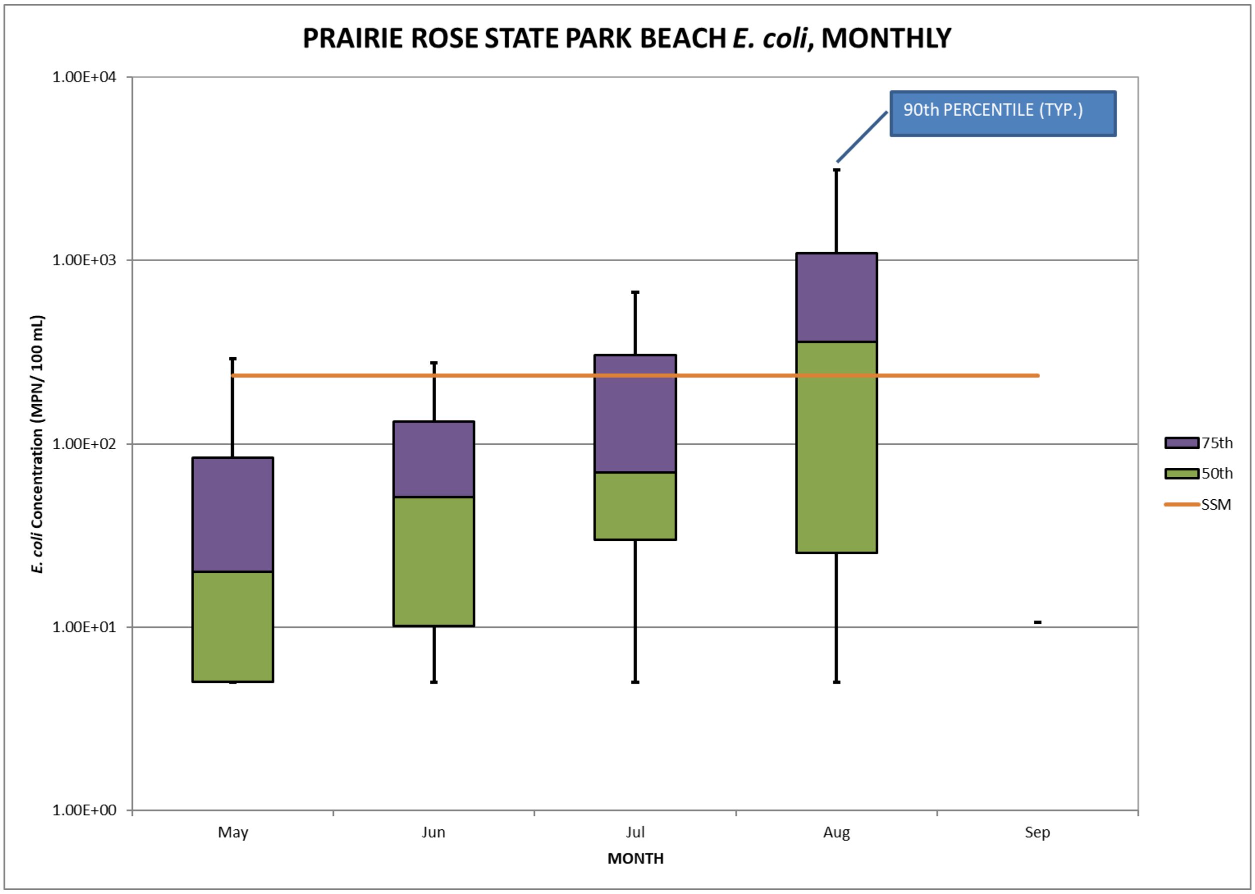

Figure 10-11. Monthly Box Plot, Prairie Rose Lake.

10.3.1 TMDL Target

General Description of Pollutant

Fecal material from warm-blooded animals contains many microorganisms. Some of these microorganisms can cause illness or disease if ingested by humans. The term pathogen refers to a disease-causing microorganism, and can include bacteria, viruses, and other microscopic organisms. Humans can become ill if they come into contact with and/or ingest water that contains pathogens.

Selection of Environmental Conditions

The critical period for the impairment occurs in the recreational season of March 15-November 15. The critical volume is the NSBV, which is adjacent to the beach area.

Consideration of Seasonal Variation

These TMDLs were developed based on the Iowa WQS primary contact recreational season that runs from March 15-November 15. In addition, sampling data collected during the recreational season were subdivided into three seasons: spring (March 15-May 22); summer (May 23-September 7) and fall (September 8-November 15). The 90th percentile of observed *E. coli* concentrations within each season was selected as the existing concentration for each season.

Waterbody Pollutant Loading Capacity

Attainment of the WQS to fully support primary contact recreation requires that the GM for *E. coli* concentrations be no greater than 126 orgs/100 ml and the SSM be not greater than 235 orgs/100 ml (Iowa Administrative Code 567, Chapter 61, Water Quality Standards for Class A1 uses). The methods used to develop the *E. coli* TMDL for the Prairie Rose Lake assumes that compliance with the SSM will coincide with attainment of the GM target (EPA, 2007). Therefore, the loading capacity of the TMDL is the maximum number of *E. coli* organisms that can be in the NSBV while meeting the SSM criterion of 235 orgs/100 ml.

Decision Criteria for WQS Attainment

The seasonal duration curve was constructed using daily sampling data. The SSM criterion was used to quantify the loading capacity of the NSBV, in terms of load (orgs/100 ml). Points above the green SSM line in Figure 10-12 represent violations of the WQS, whereas points below the line comply with WQS.

WQS will be attained in the NSBV when less than 10% of samples exceed the SSM criterion of 235 orgs/100 ml during the recreational season of March 15-November 15.

10.3.2 Pollution Source Assessment

Departure from Load Capacity

The seasonal load curve and observed loads for the seasonal load conditions are plotted in Figure 10-12. This methodology enables calculation of a TMDL target for each season. However, the highest percent reduction of the three seasons will be used as the target reduction for all impaired seasons. It is assumed that if the highest percent reduction rate is used and achieved then the WQS will be attained for GM and SSM criterion for all seasons.

Allowance for Increases in Pollutant Loads

Based on current land use and size of the beach shed area, it is unlikely that any new sources will be developed within the beach shed area.

10.3.3 Pollutant Allocations

Wasteload Allocations (WLA)

There are no point sources in the beach shed of Prairie Rose Lake. Therefore, the WLA portion of this TMDL is zero.

Load Allocations (LA)

Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the water body. Specific examples of potential nonpoint sources of bacteria include animals directly depositing into water bodies, manure applied to row crops, manure runoff from grazed land, non-permitted onsite wastewater systems, and natural sources such as wildlife.

Based on the results of the two-year study presented in Chapter 2 and Chapter 10.2 of this WQIP the source of the impairment is from the near shore beach environment. The main source of *E. coli* is likely from waterfowl and shore birds loafing on the beach and the regeneration/attenuation of *E. coli* in the sand environment.

Margin of Safety

An explicit margin of safety (MOS) of 10 percent is applied to the calculation of loading capacities in this TMDL.

Seasonal Load Curve

Figure 10-12 shows a seasonal load curve for the NSBV at Prairie Rose Lake. Table 10-7 and Table 10-8 are the existing load estimates and the TMDL summary, respectively for the NSBV at Prairie Rose Lake.

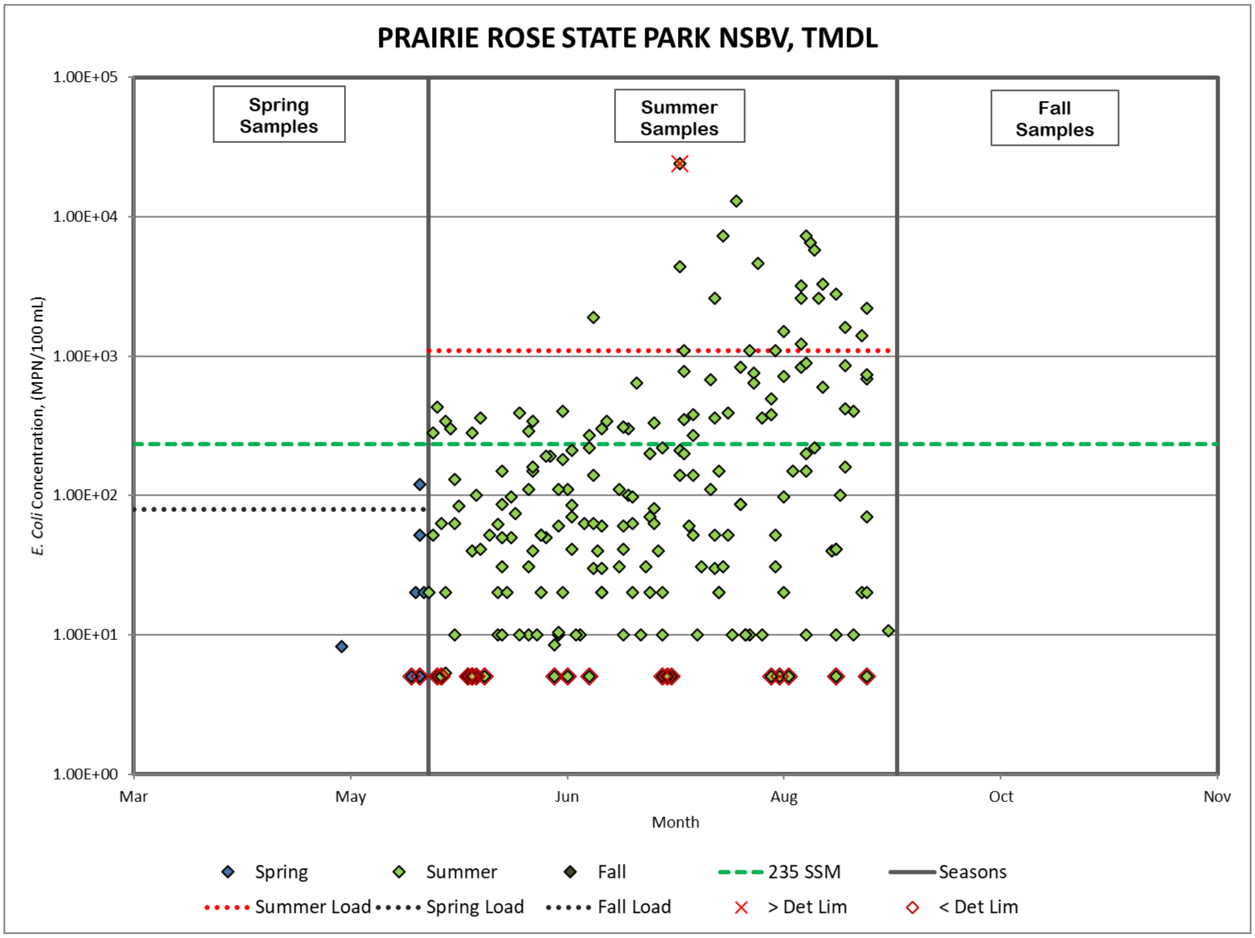

Figure 10-12. Seasonal Load Curve, Prairie Rose Lake, Near Shore Beach Volume.

Table 10-7. Existing Load Estimates for the NSBV at Prairie Rose Lake.

Load Summary	Seasonal Loads (MPN/100 ml)		
	Spring	Summer	Fall
Observed Load(1)	79.2	1,100.0	N/A
Departure	N/A	865.0	N/A
(% Reduction)	(0)	(78.6)	N/A

(1) Observed load is the 90th percentile of water quality samples.

Table 10-8 is a summary of the TMDL for the NSBV at Prairie Rose Lake. Because it is assumed that the NSBV is constant from year to year, the TMDL calculations do not change from season to season.

Table 10-8. TMDL Summary for the NSBV at Prairie Rose Lake.

	TMDL
TMDL (MPN/100 ml)	235.0
WLA (MPN/100 ml)	0.0
LA (MPN/100 ml)	211.5
MOS (MPN/100 ml))	23.5

10.3.4 TMDL Summary

This TMDL is based on meeting the water quality criteria for primary contact and children's recreational uses in Prairie Rose Lake. Although the WQS are based on *E. coli* concentration, the TMDL is also expressed as a load, in light of the November 2006 EPA memorandum. The following equation represents the total maximum daily load (TMDL) and its components:

$$TMDL = LC = \Sigma WLA + \Sigma LA + MOS$$

Where:
- TMDL = total maximum daily load
- LC = loading capacity
- ΣWLA = sum of wasteload allocations (point sources)
- ΣLA = sum of load allocations (nonpoint sources)
- MOS = margin of safety (to account for uncertainty)

Once the loading capacity, waste load allocations, load allocations, and margin of safety are determined for the lake, the general equation above can be expressed for *E. coli* as the allowable daily load. Using the values in Table 10-8 and a NSBV of 0.65 acre-feet, the TMDL for Prairie Rose Lake as a mass loading is presented in Table 10-9.

Table 10-9. Summary of Prairie Rose Lake.

	TMDL
TMDL (MPN/day)	1.90E+09
WLA (MPN/day)	0.00E+00
LA (MPN/day)	1.71E+09
MOS (MPN/day)	1.90E+08

Appendix 10.A Water Quality Data

Table 10.A-1. WQ Sampling Data, Beach Monitoring, Prairie Rose Lake, Site ID 21830001.

Date	*E. coli* (MPN/100 ml)	Date	*E. coli* (MPN/100 ml)	Date	*E. coli* (MPN/100 ml)
5/20/2008	< 10(2)	7/12/2010	70	8/5/2014	640
5/28/2008	130	7/19/2010	4,400	8/6/2014	4,600
6/2/2008	100	7/27/2010	30	8/12/2014	1,500
6/10/2008	50	8/2/2010	830	8/19/2014	5,800
6/18/2008	50	8/9/2010	< 10(2)	8/26/2014	860
6/23/2008	110	8/17/2010	7,300	5/18/2015	< 10(2)
6/30/2008	40	8/23/2010	40	5/26/2015	20
7/7/2008	100	8/30/2010	20	6/1/2015	< 10(2)
7/14/2008	40	5/23/2011	52	6/8/2015	31
7/21/2008	60	5/31/2011	< 10(2)	6/15/2015	340
7/28/2008	150	6/7/2011	20	6/17/2015	20
8/4/2008	10	6/14/2011	10	6/22/2015	20
8/11/2008	< 10(2)	6/20/2011	< 10(2)	6/29/2015	63
8/18/2008	6,500	6/27/2011	63	7/6/2015	310
8/25/2008	100	7/5/2011	31	7/8/2015	98
5/19/2009	20	7/11/2011	31	7/15/2015	20
5/26/2009	340	7/19/2011	210	7/22/2015	52
6/1/2009	280	6/12/2013	390	7/27/2015	2,600
6/8/2009	50	6/17/2013	52	7/30/2015	52
6/15/2009	40	6/24/2013	210	8/3/2015	10
6/22/2009	180	7/1/2013	20	8/12/2015	97
6/24/2009	70	7/8/2013	20	8/17/2015	150
6/29/2009	30	7/15/2013	< 10(2)	8/24/2015	< 10(2)
7/6/2009	60	7/22/2013	380	8/31/2015	2,200
7/13/2009	80	7/29/2013	31	5/24/2016	430
7/20/2009	350	8/5/2013	760	6/1/2016	< 10(2)
7/28/2009	20	8/12/2013	20	6/7/2016	10
8/3/2009	10	8/19/2013	220	6/14/2016	110
8/10/2009	1,100	8/26/2013	160	6/21/2016	110
8/17/2009	10	5/20/2014	120	6/28/2016	220
8/26/2009	1,600	5/28/2014	63	7/6/2016	41
8/31/2009	70	6/3/2014	41	7/12/2016	20
5/25/2010	< 10(2)	6/9/2014	20	7/19/2016	>24,000(4)
6/1/2010	40	6/16/2014	10	7/20/2016	780
6/8/2010	150	6/24/2014	41	7/26/2016	680
6/14/2010	290	7/1/2014	300	8/1/2016	13,000
6/21/2010	60	7/8/2014	63	8/9/2016	380
6/28/2010	270	7/15/2014	10	8/16/2016	3,200
7/1/2010	60	7/22/2014	270	8/24/2016	2,800
7/6/2010	10	7/29/2014	7,300	8/30/2016	1,400

Date	*E. coli* (MPN/100 ml)	Date	*E. coli* (MPN/100 ml)	Date	*E. coli* (MPN/100 ml)
5/2/2017	8[3]	5/21/2019	20	6/21/2021	10[3]
5/23/2017	281[3]	5/28/2019	10	6/23/2021	< 10[2]
5/24/2017	< 10[2]	6/4/2019	< 10[2]	6/29/2021	1,900
5/31/2017	< 10[2]	6/11/2019	74	7/7/2021	300
6/7/2017	62	6/18/2019	190	7/13/2021	330
6/14/2017	31	6/25/2019	10	7/20/2021	1,100
6/20/2017	9[3]	7/1/2019	20	7/27/2021	52
6/21/2017	10	7/9/2019	640	8/2/2021	86
6/28/2017	< 10[2]	7/16/2019	< 10[2]	8/10/2021	52
7/5/2017	110	7/23/2019	10	8/17/2021	890
7/12/2017	200	7/30/2019	390	8/24/2021	41
7/19/2017	140	8/7/2019	10	8/31/2021	690
7/26/2017	110	8/13/2019	< 10[2]	8/31/2021	731[3]
8/2/2017	86	8/20/2019	2,600	5/25/2022	63
8/9/2017	490	8/26/2019	420	6/1/2022	< 10[2]
8/16/2017	830	5/20/2020	52	6/8/2022	10
8/16/2017	1,215[3]	5/27/2020	300	6/15/2022	160
8/21/2017	600	6/3/2020	360	6/22/2022	400
8/28/2017	10	6/10/2020	97	6/29/2022	140
9/5/2017	11[3]	6/17/2020	52	7/6/2022	310
5/22/2018	20	6/24/2020	85	7/13/2022	63
5/29/2018	84	7/1/2020	30	7/20/2022	200
6/5/2018	52	7/15/2020	220	7/27/2022	360
6/12/2018	10	7/22/2020	140	8/3/2022	10
6/19/2018	190	7/28/2020	20	8/10/2022	31
6/26/2018	10	8/4/2020	1,100	8/16/2022	2,600
7/2/2018	340	8/12/2020	710	8/24/2022	41
7/10/2018	10	8/17/2020	200	8/31/2022	20
7/17/2018	< 10[2]	8/24/2020	10		
7/24/2018	31	8/31/2020	< 10[2]	Min =	5
7/31/2018	10	5/25/2021	< 10[2]	1st Quartile =	20
8/7/2018	360	5/26/2021	5[3]	Median =	63
8/14/2018	150	6/2/2021	< 10[2]	3rd Quartile =	308
8/21/2018	3,300	6/8/2021	86	Max =	24,000
8/28/2018	400	6/15/2021	150	Mean =	600

(1) Unless noted samples collected by the DNR as part of Ambient water quality monitoring.
(2) *E. coli* for the sample was not detected. The minimum detection limit is 10 MPN/100 ml. Consequently, 5 MPN/100 ml was used in calculations.
(3) Samples collected by DNR as part of 2017 and 2021 study.
(4) Sample above quantification limit.

Table 10.A-2. Sand Sampling Data from Transects, Prairie Rose Lake Beach.

Date	Row/ Transect	*E. coli* (MPN/cubic cm)				
		A	B	C	D	E
5/2/2017	1	4.9	0.4	1.7	2.6	< 0.1(1)
	2	10	10	1	< 0.1(1)	< 0.1(1)
	3	2,600	0.4	22	0.3	< 0.1(1)
5/23/2017	1	42	3.6	1.6	4	1.9
	2	160	190	4.8	27	2.4
	3	12	3.9	15	39	< 0.1(1)
6/20/2017	1	10	250	4.3	0.8	< 0.1(1)
	2	12	65	240	0.5	< 0.1(1)
	3	16	140	7.5	< 0.1(1)	< 0.1(1)
8/16/2017	1	> 2,600(2)	1,600	1,600	140	0.2
	2	260	>2,600(2)	650	28	25
	3	> 2,700(2)	180	180	16	6.8
9/5/2017	1	7	770	29	1,200	0.2
	2	8.8	> 2,500(2)	130	30	4.7
	3	1,600	200	> 2,400(2)	270	9.1
5/26/2021	1	2.1	2.3	0.1	0.1	---
	2	45	0.3	0.1	0.1	---
	3	2.8	0.5	0.1	0.2	---
6/21/2021	1	14	>2,600(2)	81	> 2,400(2)	---
	2	120	1,600	110	< 0.1(1)	---
	3	140	1,800	80	46	---
8/31/2021	1	> 2,600(2)	> 2,600(2)	1,400	180	---
	2	> 2,600(2)	2,600	> 2,600(2)	300	---
	3	2,600	> 2,500(2)	1,200	120	---

(1) *E. coli* for the sample was not detected. The non-detectable limit recorded was divided in half for calculation purposes.
(2) Individual *E. coli* result was greater than the quantification limit. In these cases, the value listed was used for calculation purposes.

Table 10.A-3. Water Sampling Data from Transects, Prairie Rose Lake Beach.

Date	Row/ Transect	*E. coli* (MPN/100 ml)								
		0	1	2	3	4	5	6	7	8
5/2/2017	1	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	20	10
	2	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	3	< 10(1)	< 10(1)	52	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	4	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
5/23/2017	1	4,400	10	10	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	2	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	3	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	4	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	31	10	< 10(1)
6/20/2017	1	41	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	2	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	3	< 10(1)	< 10(1)	< 10(1)	< 10(1)	150	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	4	10	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
8/16/2017	1	17,000	270	41	31	75	31	31	31	10
	2	1,600	97	31	20	20	52	84	20	< 10(1)
	3	120	20	63	31	31	52	20	31	41
	4	41	31	10	31	20	31	31	20	10
9/5/2017	1	10	< 10(1)	< 10(1)	< 10(1)	20	20	< 10(1)	10	10
	2	< 10(1)	10	< 10(1)	< 10(1)	31	< 10(1)	< 10(1)	10	< 10(1)
	3	85	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	10	< 10(1)	10
	4	< 10(1)	< 10(1)	< 10(1)	< 10(1)	20	30	< 10(1)	10	20
5/26/2021	1	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	
	2	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	
	3	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	20	
	4	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	
6/21/2021	1	20	10	20	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	
	2	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	
	3	41	< 10(1)	10	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	
	4	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	
8/31/2021	1	430	170	10	10	10	10	10	31	
	2	840	340	20	72	31	10	< 10(1)	20	
	3	9,200	350	140	74	62	31	< 10(1)	< 10(1)	
	4	10	< 10(1)	< 10(1)	20	10	< 10(1)	10	< 10(1)	

(1) *E. coli* for the sample was not detected. The minimum detection limit is 10.0 MPN/100 ml. 5.0 MPN/100 ml was used in calculations.

11. Lake Keomah TMDL

11.1 Description and History of Lake Keomah

Lake Keomah, IA 03-SSK-930, is located in Spring Creek Township, Mahaska County, Iowa approximately four and one-half (4.5) miles east of Oskaloosa. Lake Keomah was constructed in the 1930's by the Civilian Conservation Corps (CCC). The lake is located within the 366-acre Lake Keomah State Park owned and managed by the Iowa Department of Natural Resources (DNR). The lake and land surrounding it provide fishing, hiking, swimming, camping, and other outdoor recreational activities for the public.

The lake has a watershed area of 1,953 acres, a maximum depth of 18 feet, a shore length of approximately 3.1 miles, and an approximate volume of 672 acre-feet. Table 11-1 is a summary of the lake and watershed properties. Figure 11-1 is an aerial photograph with the boundaries of the watershed.

Table 11-1. Lake Keomah Watershed and Lake Information.

Waterbody Name	Lake Keomah
Waterbody ID	IA 03-SSK-930
12 Digit Hydrologic Unit Code (HUC)	070801051204
HUC-12 Name	Snyder Creek-South Skunk River
Location (Ambient Monitoring Site)	Section 13, T75N, R15W, Mahaska County Iowa
Water Quality Standard Designated Uses	Class A1 Primary Contact Recreation Class B(LW) Aquatic Life Class C Drinking Water Class HH Human Health
Antidegradation **Protection Level**	Tier 1
Tributaries	Unnamed Tributaries
Receiving Waterbody	Unnamed Tributary to South Skunk River
Watershed Area	1,953 acres
Lake Surface Area	78 acres(1)
Maximum Depth	18.3 feet(1)
Volume	672 ac-feet(1)
Length of Shoreline	3.1 miles
Watershed/Lake Area Ratio	25.0:1

(1) Data obtained from September 2019 DNR Bathymetric Survey.

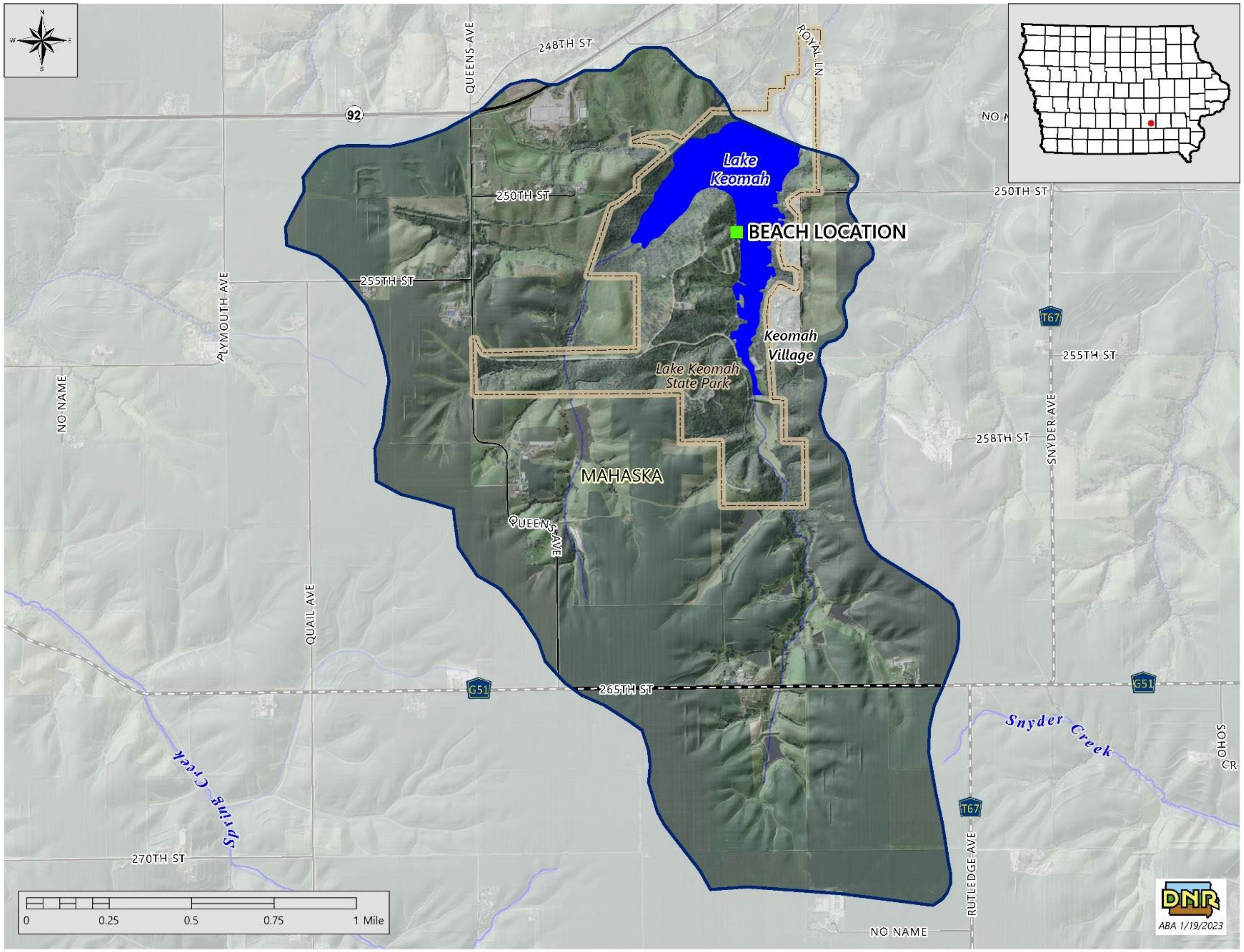

Figure 11-1. Lake Keomah Watershed.

Land Use

A Geographic Information System (GIS) coverage of land use information was developed using the 2021 USDA Cropland Data Layer (USDA, National Agricultural Statistics Service). The three dominant land uses are row crop (49%), grassland (22%), and forested (14%) (Table 11-2). The eight land uses shown in Table 11-2 were aggregated from the fourteen land uses in the cropland data layer as shown in the description column. Figure 11-2 shows the distribution of the various land uses throughout the Lake Keomah watershed in a pie-chart.

Table 11-2. Lake Keomah Watershed Land Uses.

Land Use	Description	Area (AC)	Percent of Total
Water/Wetland	Water and Wetlands	101	5.2%
Forested	Bottomland, Coniferous, Deciduous	279	14.3%
Grassland	Ungrazed, Grazed, & CRP-	434	22.2%
Alfalfa/Hay	Perennial Hay Crop-	22	1.1%
Row Crop	Corn, Soybeans, & other	956	49.0%
Roads	Roads Lightly Developed Urban	51	2.6%
Urban	Intensively Developed Urban	108	5.5%
Barren	Barren Land	2	0.1%
Total		1,953	100.0%

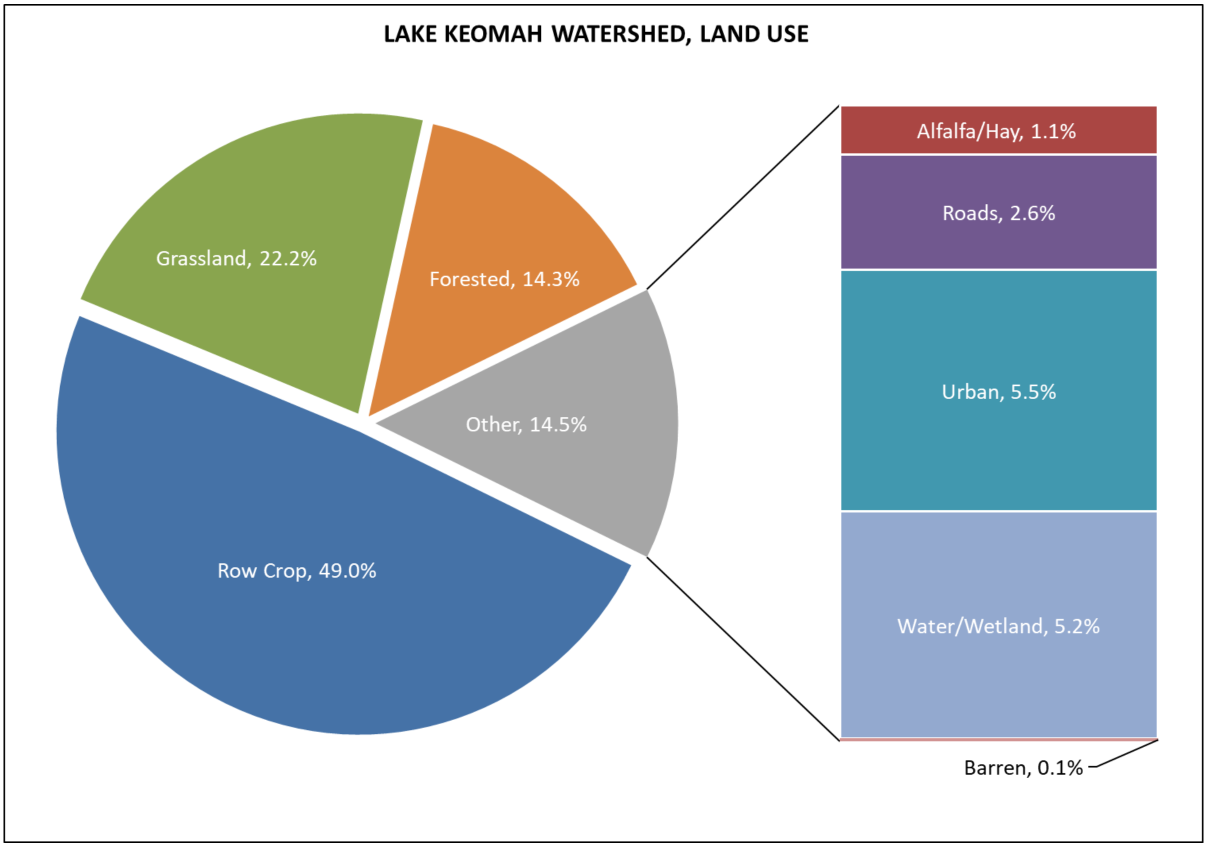

Figure 11-2. Land Use Composition of the Lake Keomah Watershed.

Hydrology, Soils, Climate, Topography

From data obtained from the NRCS, there are 16 soil series in this watershed. The top three soil series are the Ladoga, Clinton, and Mahaska soils, which make up 44% of the soils in the watershed. Each soil series has been grouped into one of four hydrologic soil group (HSG). HSGs are based on estimates of runoff potential. HSG-C makes up 74% of the watershed. The Lake Keomah watershed is in the Rolling Loess Prairies ecoregion. This landscape consists of numerous rills, creeks, and rivers branch out across the landscape, shaping the old glacial deposits into steeply rolling hills and valleys. (Prior, 1991).

The average rainfall for the Lake Keomah watershed from 2004 through 2022 was 39.3 inches with the majority (67%) falling between April 1st and September 30th. Lake evapotranspiration averages 45.3 inches per year, with more occurring in dryer years. Figure 11-3 shows the annual rainfall and lake evapotranspiration from 2004 to 2022. Figure 11-4 shows the monthly average relationship between watershed evapotranspiration and rainfall. In some drier summer months evapotranspiration may exceed rainfall, leading to a deficit in the water budget for the watershed.

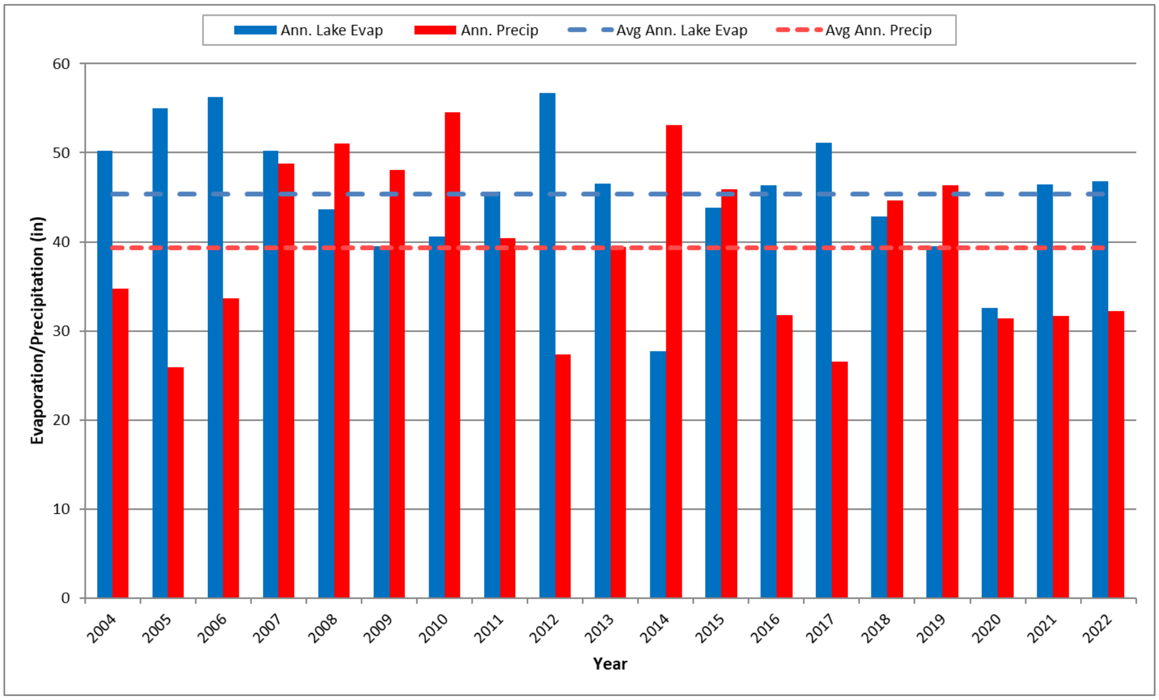

Figure 11-3. Annual Rainfall and Estimated Evapotranspiration Totals, Lake Keomah Watershed.

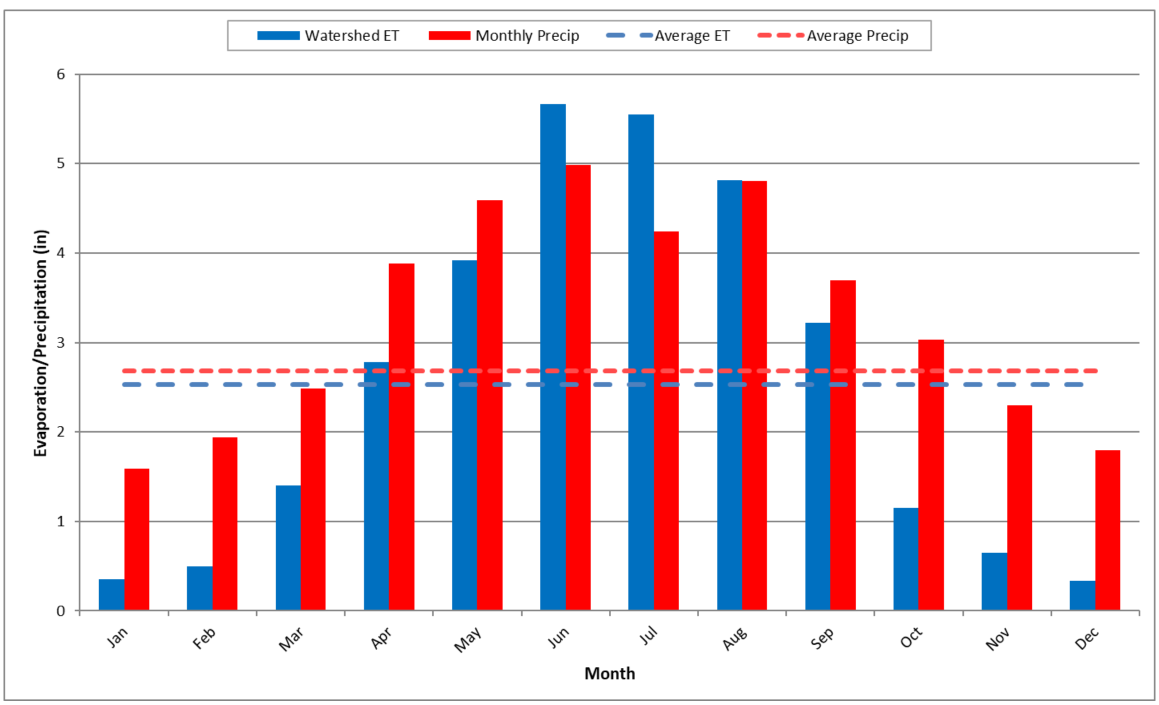

Figure 11-4. Monthly Rainfall and Estimated Evapotranspiration Totals, Lake Keomah Watershed.

11.2 Beach Investigation Sampling and Analysis

Swimming advisories are commonly posted at public beaches across Iowa every season. Weekly monitoring of public swimming zones at state and county beaches have resulted in the impairment of numerous lakes for Fecal Indicator Bacteria (FIB) contamination, a violation of the State of Iowa's water quality standards. These swimming beach impairments result in whole lake waterbodies being listed as impaired on the state's biennial 303(d) list. These impairment listings do not accurately reflect the condition(s) of the larger lake environment outside the swimming zone and fail to account for beach proximate conditions in the assessment process.

Traditionally, management of these systems has assumed that the larger watershed serves as the primary source of FIB to the recreational areas. However, sampling at numerous beach systems across Iowa have shown a disconnect between the open lake environment and FIB contamination in the swimming zone, which is driven by conditions in the foreshore sand environment. An extensive study conducted in 2015-2016 assessed the relationships between the nearshore beach environment, open lake conditions and watershed delivery of FIB (*E. coli*) in three representative beach / lake systems currently impaired for FIB contamination across Iowa (Chapter 2). The results of this study and subsequent TMDL development provided an assessment framework for other beach systems in the region. Following are the results of this assessment for Keomah Beach on Lake Keomah (IA 03-SSK-930).

Sampling and Data Collection

Samples were collected from the beach swimming zone, the open lake transect zone, the alternate transect, and the open water lake sampling points seasonally and in response to wet weather events from spring 2017 through the fall of 2017 and again from the spring of 2021 through the fall of 2021 (Figure 11-5). All water and sand sample collection and laboratory analyses were conducted following protocols highlighted in Chapter 2.3.

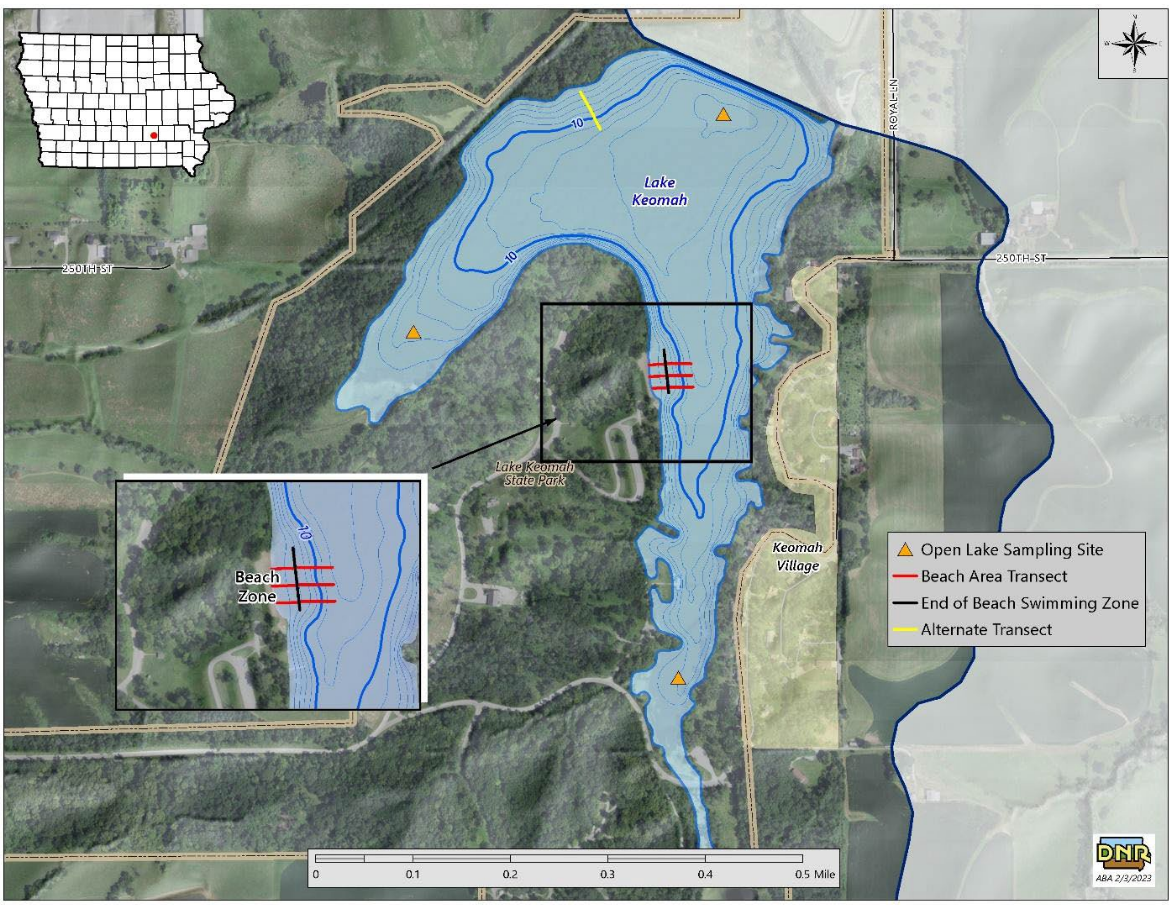

Figure 11-5. Overview of Monitoring Locations on Lake Keomah.

Sampling Results and Analysis

Water sample collection in the nearshore swimming zone showed a high degree of variability. Sample results commonly varied by hundreds of MPN/100 ml, indicating that this environment was highly sensitive to changes in *E. coli* loading. While these data showed that intermittent spikes in concentrations could be quite high, the bulk of data collected showed overall low *E. coli* concentrations. The observed median and mean concentration were 15 and 69 MPN/100 ml respectively, well below the seasonal geometric mean of 126 MPN/100 ml (Table 11-3). This information suggests that conditions in the recreational swimming zone can rapidly change in response to *E. coli* loading but do not maintain an elevated concentration across the season. These findings are supported by observations that during the two sampling seasons at Lake Keomah the swimming area met recreational standards (235 MPN/100 ml) in ten of the eleven sampling trips. Sampling at the alternate transect and open lake locations had a two-year median value below the *E. coli* detection limit of 10 MPN/100 ml and relatively low standard deviations (Table 11-3), indicating overall low concentrations in these environments.

Table 11-3. Basic Statistics from Bacteria Sampling at Lake Keomah.

Sampling Dataset	N	Mean	Median	St. Dev.	25th %	75th %
Lake Keomah Beach Swimming Zone	96	69	20	180	5	41
Lake Keomah Transects	108	12	5	12	5	18
Lake Keomah Open Lake	24	33	7.5	59	5	39
Lake Keomah Beach Sand	101	177	15	449	0.6	110
Lake Keomah Alternate Transect Rows 0-3	32	22	5	53	5	18
Lake Keomah Alternate Transect Rows 4-8	36	7	5	5	5	5

Water results reported as MPN/100 ml and sand results reported as MPN/gram (dry wt.)

Data collected from the beach sand environment during both seasons showed a wide range of variability (Table 11-3). However, median and mean sample *E. coli* concentrations were well above detection limits of (0.1 MPN/gram) indicating that a standing stock of *E. coli* bacteria was consistently present in the beach sands at Lake Keomah. These sand observations are consistent with investigations conducted on other systems in Iowa (Chapter 2.4).

Beach sand sampling conducted at Lake Keomah Beach revealed trends consistent with prior surveys (Chapter 2.4) as *E. coli* concentrations in beach sands generally increased with proximity to the shoreline. An analysis of variation (ANOVA) on ranks showed that transect points on row A (along waterline) were significantly higher in *E. coli* concentrations than C or D ($P<0.01$). These observations indicate that a significant amount of *E. coli* is present immediately adjacent to the active swimming zone on Lake Keomah Beach. As with prior surveys, the sands on Lake Keomah Beach had *E. coli* concentrations many times higher than observed in adjacent swimming waters (Figure 11-6). Beach sand *E. coli* concentrations averaged over 2,000 times higher than those observed in adjacent swimming areas during the two-year sampling effort. These observations provide evidence of a near shore *E. coli* reservoir in the beach environment that can affect conditions in the nearshore swimming environment, as discussed in Chapter 2.

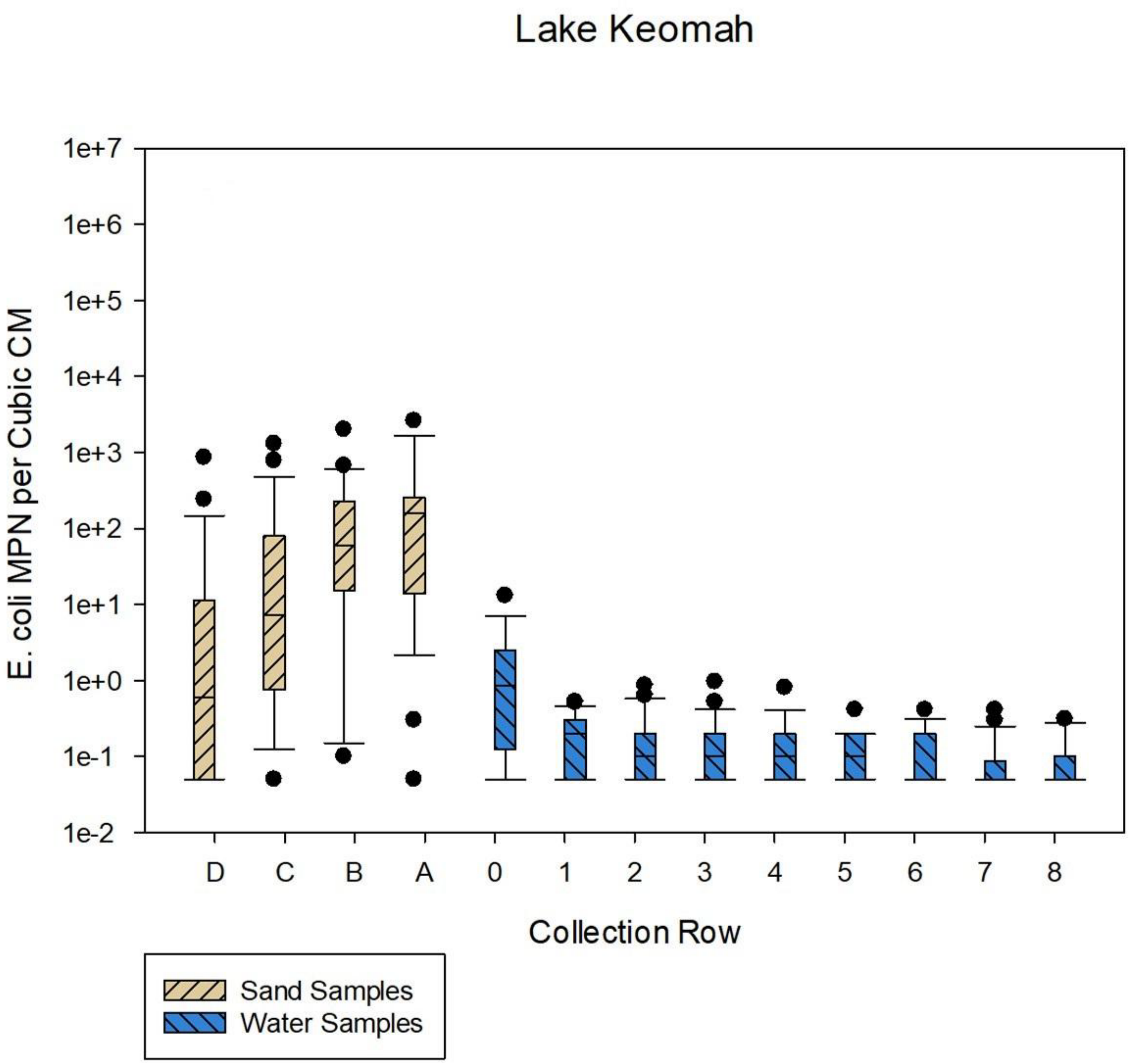

Figure 11-6. Box Plots of Sand and Water Sampling from Transects along Lake Keomah Beach.
Reported in MPN/per cubic cm. Sampling points in figure correspond to following locations in relation to shoreline: A=shoreline, B (+2.5 m), C (+5m), D (+10M), 0 (Ankle deep), 1 (Knee deep), 2 (waist deep), 3 (chest deep), 4 (swimming rope), 5 to 8 (10 m spacing beyond swimming rope).

As highlighted earlier, intermittent spikes in *E. coli* concentrations were observed throughout the project. These spikes resulted in a number of days where the swimming environment exceeded recreational standards and triggered an advisory condition. The elevated conditions were largely driven by higher readings closer to the shoreline, as sampling data collected along transects radiating out from the shoreline into the lake (Figure 11-7) uncovered an association between *E. coli* concentrations and proximity to shore. Sampling points at the ankle-deep location of each beach transect were higher in *E. coli* concentrations than all other sampling points in the lake.

Statistical analysis of the Lake Keomah monitoring network uncovered trends and associations which closely mimicked findings of previous beach investigations (Chapter 2). Results highlighted in Table 11-4 demonstrate the diss-association of beach *E. coli* concentrations and those observed in other areas of the sampling network. Beach swimming zone values were significantly higher than those observed in open lake transects, open lake sampling points and along alternate transect sampling locations. These findings are directly in line with analysis conducted as part of the original beach only bacteria data development (Chapter 2). The findings from this analysis validate the decision to address the *E. coli* bacteria impairments at Lake Keomah Beach with a framework that directly addresses beach capture shed specific sources of *E. coli*.

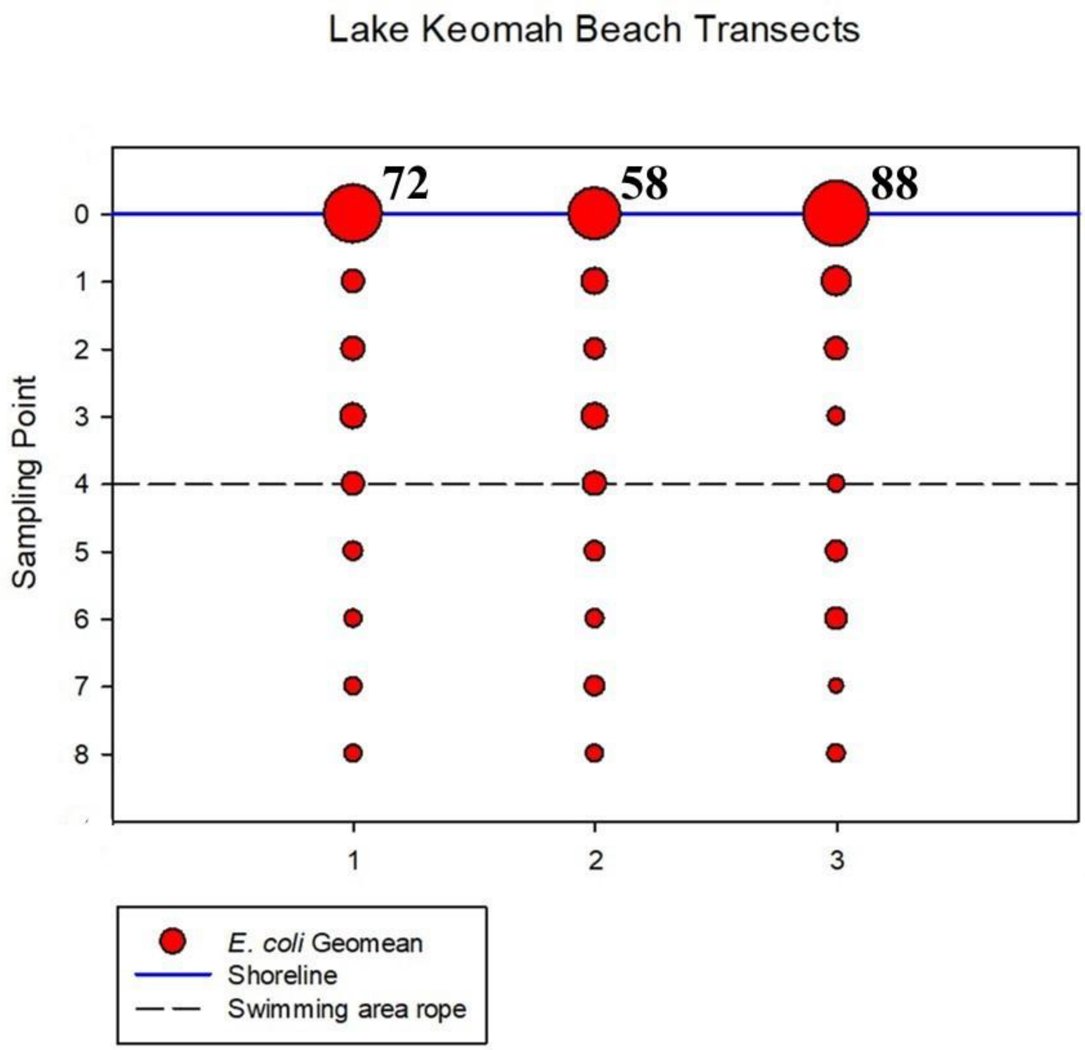

Figure 11-7. Bubble Plot of *E. coli* Sampling at Lake Keomah Beach Lake Transects Reported as MPN/100 ml.

Table 11-4. Analysis Results from Lake Keomah Sampling Network.

Dataset comparison	Test	Significance level	Swimming zone higher
Swimming Zone vs Lake Transects	T-test	P<0.05	Yes
Swimming Zone vs Open Lake Points	T-test	P<0.05	Yes
Swimming Zone vs Alternate Transect	T-test	P<0.05	Yes

11.3 TMDL for Lake Keomah Beach.

The water quality improvement plan (WQIP) has provided general background information around the impaired lake. However, the sampling and monitoring of the lake that resulted in the impairment are located in the swimming zone of the Lake Keomah State Park. Assessments conducted on the Lake Keomah beach and lake system (Chapter 11.2) show a clear signal for a beach specific impairment. Consequently, the TMDL will focus on the beach shed area and the swimming zone that it drains to.

Problem Identification

Lake Keomah, IA 03-SSK-930, was included on the 2008 303(d) impaired waters list for not fully supporting the Class A1 (primary contact recreation) use due to the presence of high levels of *E. coli*. Samples were collected during the recreational season (March 15 - November 15) between 2004 - 2006 as part of the state's ambient water quality monitoring and assessment program.

Applicable Water Quality Standards
The designated uses of Lake Keomah are: primary contact recreational use (Class A1); lakes and wetlands (Class B(LW)); human health (Class HH); and drinking water supply (Class C). The designated uses are defined in the Iowa Administrative Code (567 Iowa Administrative Code, Chapter 61, (IAC)). For a more detailed description of the designated uses, see Appendix B

In 2010 the State of Iowa enacted an antidegradation policy. This policy was designed to maintain and protect high quality waters and existing water quality in other waters from unnecessary pollution. Protection levels (or tiers) as defined by the Iowa Administrative Code (IAC) 567-61.2 are cited below.

- 567-61.2(2)(a) Tier 1 protection. Existing surface water uses and the level of water quality necessary to protect the existing uses will be maintained and protected.

Near Shore Beach Volume (NSBV)
The NSBV is the volume of water contained within the swimming zone of the Lake. Figure 11-8 shows the swimming and beach shed areas of Lake Keomah. Table 11-5 is a summary of the NSBV data.

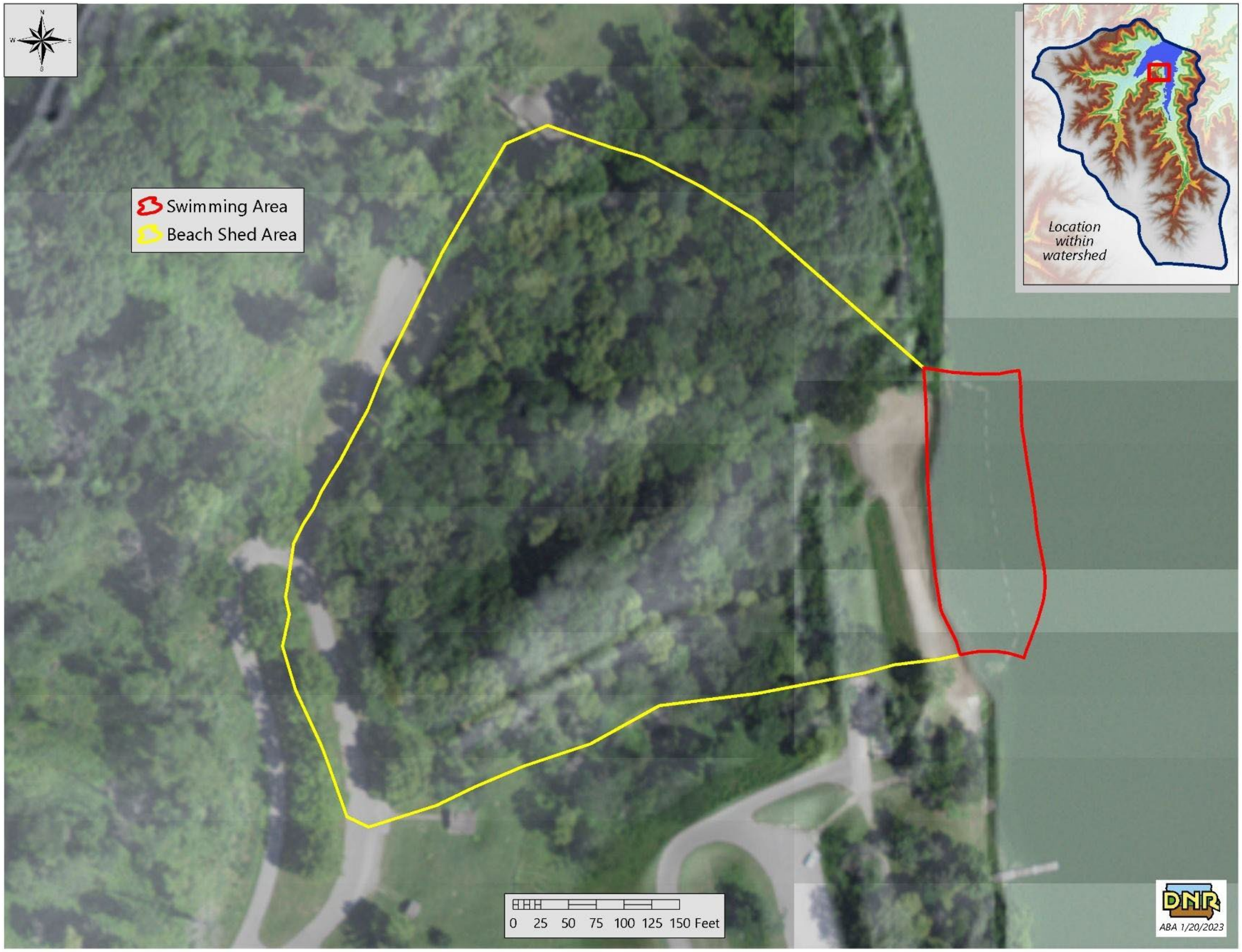

Figure 11-8. Swimming and Beach Shed Areas, Lake Keomah.

Table 11-5. Lake Keomah NSBV Data.

Near Shore Beach Volume	1.0 acre-feet
Beach Front Length	263.0 feet
Radius from Shore at midpoint of beach	94.1 feet
Depth at Radius	4.2 feet (Elevation 741.8)
Beach Shed Area	5.7 Acres

Data Sources and Monitoring Sites

Table 11-6 lists the water quality monitoring locations used to develop the WQIP for Lake Keomah. Figure 11-**9** shows the monitoring locations used. In addition to these sites, samples were collected adjacent to the beach along three transects and an alternate transect as shown in Figure 11-5. For a more detailed description of the samples collected along the transects see Chapter 11.2.

Water quality samples were collected as part of the state's ambient water quality monitoring and assessment program between 2004 - 2022. Additional water quality samples were collected in 2017 and 2021 by the DNR to study and assess the relationships between the nearshore beach environment and open lake conditions. Results of this study are presented in Chapter 11.2.

Table 11-6. WQ Data Monitoring Sites at Lake Keomah.

Site Name	Site ID	Longitude	Latitude
Keomah Inlet 1(1)	14000210	92° 32' 21"	41° 17' 12"
Keomah Inlet 2 (1)	14000211	92° 32' 39"	41° 17' 31"
Lake Keomah(2	22620002	92° 32' 17"	41° 17' 42"
Lake Keomah Beach (Lake Keomah State Park)(1) (2)	2132001	92° 32' 23"	41° 17' 28"

(1) 2017 and 2021 DNR Study Sampling Site.
(2) Ambient Water Quality Sampling Site.

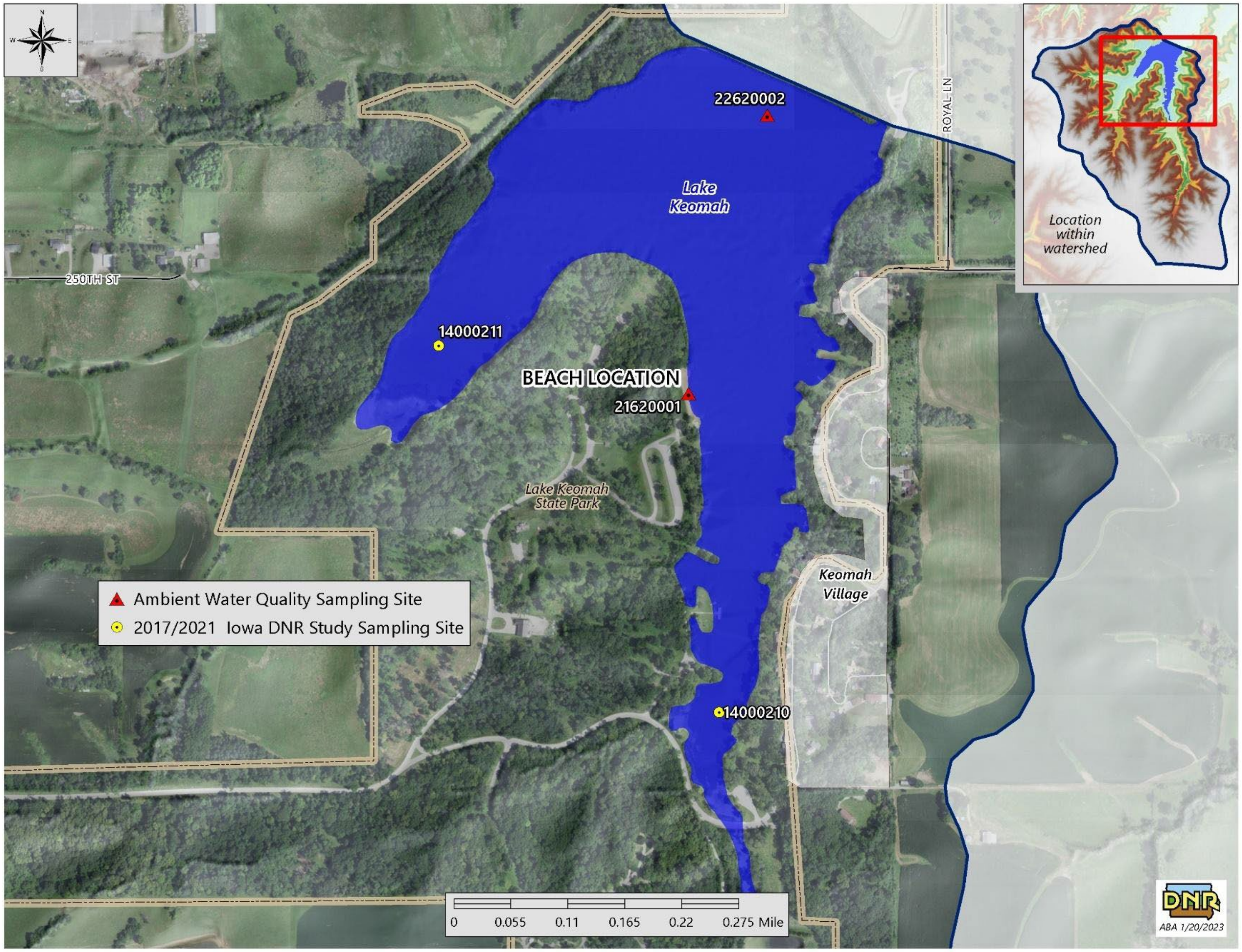

Figure 11-9. Sampling Locations, Lake Keomah.

Interpretation of Data

Using data collected from 2008 - 2022, two box plots were developed. Figure 11-10 is a box plot of samples categorized by season (spring, summer, and fall) and a plot of the full data. The box has lines at the lower quartile, median, and upper quartile values. Whiskers extend from the top and bottom to the existing loading and the minimum load. The existing load for each box is the 90th percentile of observed *E. coli* concentrations. There is also a horizontal line representing the SSM concentration of 235 orgs/100 ml.

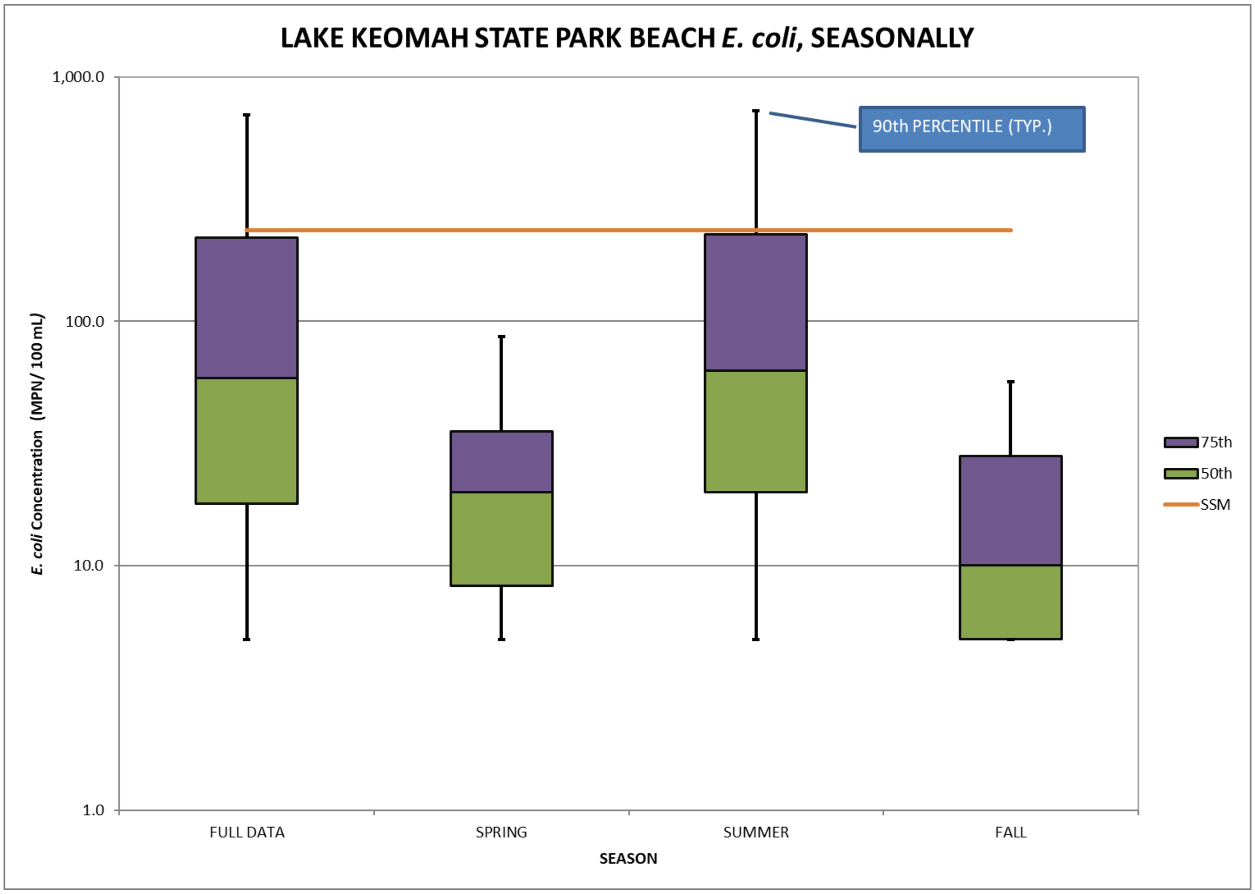

Figure 11-10. Seasonal Box Plot, Lake Keomah.
Seasons defined as: Spring (March 15-May 22); Summer (May 23-September 7) and Fall (September 8-November 15).

Analysis of the data show *E. coli* levels that exceed the SSM (single sample max) concentration of 235 orgs/100 ml criterion set forth in Iowa's WQS for primary contact recreation approximately 23 percent of the time. Consequently, reductions in *E. coli* loading will be required to comply with the standards and fully support the designated recreational use in the impaired waterbody.

Figure 11-10 illustrates that the summer season is the critical season for bacteria at the Lake Keomah State Park beach.

In the second box plot graph, Figure 11-11, data is categorized by month. This box plot has the same format as previously described. This figure shows that *E. coli* levels are elevated above the SSM concentration of 235 org/100 ml throughout the majority of the sampling period, peaking in August.

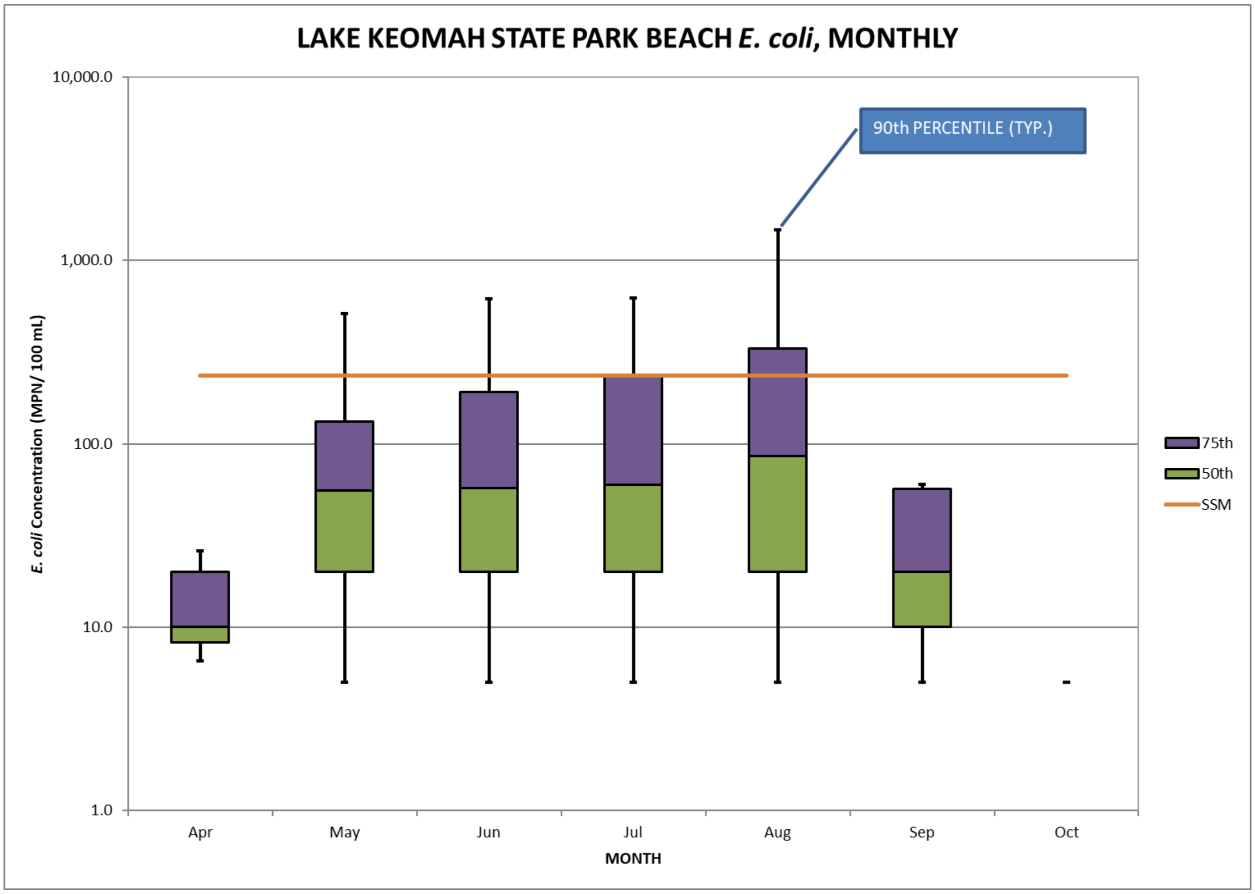

Figure 11-11. Monthly Box Plot, Lake Keomah.

11.3.1 TMDL Target

General Description of Pollutant

Fecal material from warm-blooded animals contains many microorganisms. Some of these microorganisms can cause illness or disease if ingested by humans. The term pathogen refers to a disease-causing microorganism, and can include bacteria, viruses, and other microscopic organisms. Humans can become ill if they come into contact with and/or ingest water that contains pathogens.

Selection of Environmental Conditions

The critical period for the impairment occurs in the recreational season of March 15-November 15. The critical volume is the NSBV, which is adjacent to the beach area.

Consideration of Seasonal Variation

These TMDLs were developed based on the Iowa WQS primary contact recreational season that runs from March 15-November 15. In addition, sampling data collected during the recreational season were subdivided into three seasons: spring (March 15-May 22); summer (May 23-September 7) and fall (September 8-November 15). The 90th percentile of observed *E. coli* concentrations within each season was selected as the existing concentration for each season.

Waterbody Pollutant Loading Capacity

Attainment of the WQS to fully support primary contact recreation requires that the GM for *E. coli* concentrations be no greater than 126 orgs/100 ml and the SSM be not greater than 235 orgs/100 ml (Iowa Administrative Code 567, Chapter 61, Water Quality Standards for the Class A1 use). The methods used to develop the *E. coli* TMDL for Lake Keomah assumes that compliance with the SSM will coincide with attainment of the GM target (EPA, 2007). Therefore, the loading capacity of the TMDL is the maximum number of *E. coli* organisms that can be in the NSBV while meeting the SSM criterion of 235 orgs/100 ml.

Decision Criteria for WQS Attainment
The seasonal duration curve was constructed using daily sampling data. The SSM criterion was used to quantify the loading capacity of the NSBV, in terms of load (orgs/100 ml). Points above the green SSM line in Figure 11-12 represent violations of the WQS, whereas points below the line comply with WQS.

WQS will be attained in the NSBV when less than 10% of samples exceed the SSM criterion of 235 orgs/100 ml during the recreational season of March 15 - November 15.

11.3.2 Pollution Source Assessment

Departure from Load Capacity
The seasonal load curve and observed loads for the seasonal load conditions are plotted in Figure 11-12. This methodology enables calculation of a TMDL target for each season. However, the highest percent reduction of the three seasons will be used as the target reduction for all impaired seasons. It is assumed that if the highest percent reduction rate is used and achieved then the WQS will be attained for GM and SSM criterion for all seasons.

Allowance for Increases in Pollutant Loads
Based on current land use and size of the beach shed area it is unlikely that any new sources will be developed within the beach shed area.

11.3.3 Pollutant Allocations

Wasteload Allocations (WLA)
There are no point sources in the beach shed of Lake Keomah. Therefore, the WLA portion of this TMDL is zero.

Load Allocations (LA)
Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the water body. Specific examples of potential nonpoint sources of bacteria include animals directly depositing into water bodies, manure applied to row crops, manure runoff from grazed land, non-permitted onsite wastewater systems, and natural sources such as wildlife.

Based on the results of the two-year study presented in Chapter 2 and Chapter 11.2 of this WQIP the source of the impairment is from the near shore beach environment. The main source of *E. coli* is likely from waterfowl and shore birds loafing on the beach and the regeneration/attenuation of *E. coli* in the sand environment.

Margin of Safety
An explicit margin of safety (MOS) of 10 percent is applied to the calculation of loading capacities in this TMDL.

Seasonal Load Curve
Figure 11-12 shows a seasonal load curve for the NSBV at Lake Keomah. Table 11-7 and Table 11-8 are the existing load estimates and the TMDL summary, respectively for the NSBV at Lake Keomah.

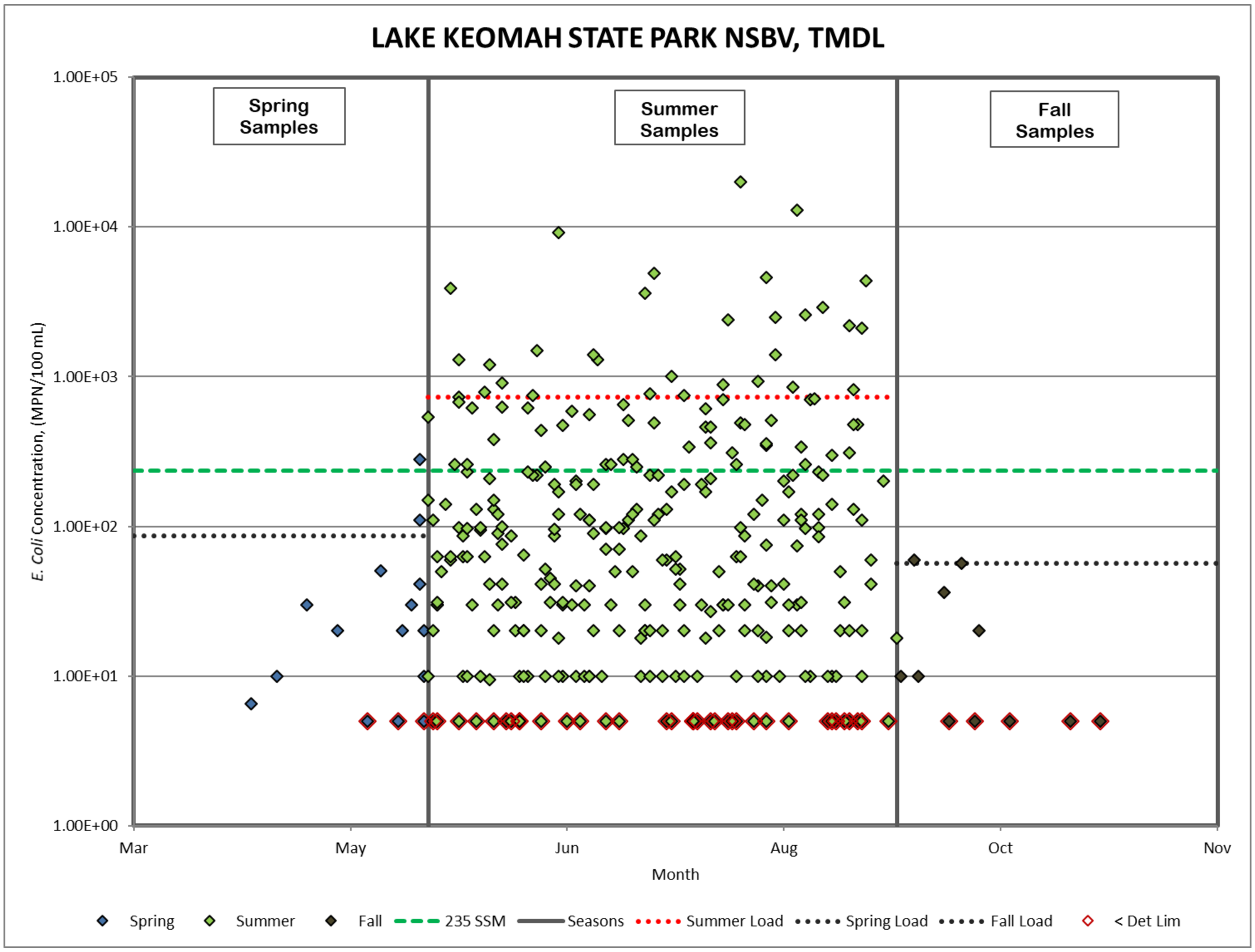

Figure 11-12. Seasonal Load Curve, Lake Keomah, Near Shore Beach Volume.

Table 11-7. Existing Load Estimates for the NSBV at Lake Keomah.

Load Summary	Seasonal Loads (MPN/100 ml)		
	Spring	Summer	Fall
Observed Load[(1)]	86.3	728.0	56.7
Departure	N/A	493.0	N/A
(% Reduction)	(0)	(67.7)	(0)

(1) Observed load is the 90th percentile of water quality samples.

Table 11-8 is a summary of the TMDL for the NSBV at Lake Keomah. Because it is assumed that the NSBV is constant from year to year the TMDL calculations do not change from season to season.

Table 11-8. TMDL Summary for the NSBV at Lake Keomah.

	TMDL
TMDL (MPN/100 ml)	235.0
WLA (MPN/100 ml)	0.0
LA (MPN/100 ml)	211.5
MOS (MPN/100 ml))	23.5

11.3.4 TMDL Summary

This TMDL is based on meeting the water quality criteria for primary contact and children's recreational uses in Lake Keomah. Although the WQS are based on *E. coli* concentration, the TMDL is also expressed as a load, in light of the November 2006 EPA memorandum. The following equation represents the total maximum daily load (TMDL) and its components:

$$TMDL = LC = \Sigma WLA + \Sigma LA + MOS$$

Where: TMDL = total maximum daily load
LC = loading capacity
ΣWLA = sum of wasteload allocations (point sources)
ΣLA = sum of load allocations (nonpoint sources)
MOS = margin of safety (to account for uncertainty)

Once the loading capacity, waste load allocations, load allocations, and margin of safety are determined for the lake, the general equation above can be expressed for *E. coli* as the allowable daily load. Using the values in Table 11-8 and a NSBV of 1.0 acre-feet the TMDL for Lake Keomah as a mass loading is presented in Table 11-9.

Table 11-9. Summary of Lake Keomah.

	TMDL
TMDL (MPN/day)	2.96E+09
WLA (MPN/day)	0.00E+00
LA (MPN/day)	2.66E+09
MOS (MPN/day)	2.96E+08

Appendix 11.A Water Quality Data

Table 11.A-1. Water Quality Sampling Data, Beach Monitoring, Lake Keomah, Site ID 21620001.

Date	*E. coli* (MPN/100 ml)	Date	*E. coli* (MPN/100 ml)	Date	*E. coli* (MPN/100 ml)
5/24/2004	30	10/24/2005	< 10[2]	8/13/2007	30
5/31/2004	230	4/17/2006	10	8/20/2007	98
6/7/2004	90	4/24/2006	30	8/27/2007	310
6/14/2004	620	5/1/2006	20	8/28/2007	130
6/21/2004	18	5/8/2006	< 10[2]	5/21/2008	< 10[2]
6/28/2004	40	5/15/2006	< 10[2]	5/27/2008	60
7/5/2004	70	5/22/2006	10	6/2/2008	< 10[2]
7/12/2004	220	5/29/2006	730	6/9/2008	< 10[2]
7/19/2004	30	6/5/2006	210	6/17/2008	< 10[2]
7/26/2004	27	6/12/2006	< 10[2]	6/23/2008	< 10[2]
8/2/2004	490	6/19/2006	45	6/25/2008	40
8/9/2004	40	6/26/2006	120	6/29/2008	20
8/16/2004	20	7/3/2006	30	7/2/2008	70
8/23/2004	10	7/10/2006	18	7/7/2008	110
8/30/2004	10	7/17/2006	170	7/9/2008	250
9/7/2004	18	7/24/2006	30	7/15/2008	10
5/16/2005	20	7/31/2006	310	7/16/2008	60
5/23/2005	20	8/7/2006	150	7/22/2008	< 10[2]
5/30/2005	10	8/14/2006	850	7/28/2008	50
6/6/2005	20	8/21/2006	2,900	7/29/2008	30
6/13/2005	64	8/28/2006	820	8/5/2008	120
6/20/2005	190	9/4/2006	200	8/6/2008	40
6/27/2005	30	9/11/2006	60	8/11/2008	10
7/4/2005	50	9/18/2006	36	8/13/2008	< 10[2]
7/11/2005	30	9/25/2006	< 10[2]	8/18/2008	10
7/18/2005	10	5/21/2007	10	8/25/2008	50
7/25/2005	18	5/29/2007	< 10[2]	5/18/2009	30
8/1/2005	260	6/4/2007	63	5/27/2009	3,900
8/8/2005	350	6/11/2007	20	6/1/2009	620
8/15/2005	30	6/18/2007	10	6/3/2009	10
8/22/2005	< 10[2]	6/25/2007	200	6/8/2009	100
8/29/2005	< 10[2]	7/2/2007	260	6/10/2009	< 10[2]
9/5/2005	< 10[2]	7/9/2007	130	6/16/2009	220
9/12/2005	10	7/16/2007	< 10[2]	6/17/2009	440
9/19/2005	< 10[2]	7/23/2007	10	6/22/2009	30
9/26/2005	20	7/30/2007	< 10[2]	6/24/2009	590
10/3/2005	< 10[2]	8/6/2007	934	6/29/2009	90
10/17/2005	< 10[2]	8/8/2007	359	7/6/2009	650

Date	*E. coli* (MPN/100 ml)
7/8/2009	50
7/13/2009	490
7/15/2009	60
7/20/2009	20
7/22/2009	< 10(2)
7/28/2009	20
7/29/2009	30
8/3/2009	20
8/5/2009	< 10(2)
8/12/2009	200
8/17/2009	260
8/25/2009	20
9/1/2009	60
5/24/2010	30
6/1/2010	30
6/7/2010	30
6/16/2010	1,500
6/21/2010	9,200
6/28/2010	110
7/6/2010	280
7/13/2010	4,900
7/20/2010	750
7/26/2010	210
8/3/2010	480
8/10/2010	2,500
8/16/2010	120
8/23/2010	140
8/30/2010	110
5/24/2011	63
5/31/2011	260
6/6/2011	130
6/13/2011	20
6/21/2011	170
6/28/2011	10
7/6/2011	97
7/12/2011	770
7/14/2011	120
7/18/2011	63
7/25/2011	610
8/1/2011	< 10(2)

Date	*E. coli* (MPN/100 ml)
8/8/2011	75
8/16/2011	340
8/18/2011	700
8/24/2011	< 10(2)
8/29/2011	480
9/8/2011	10
5/21/2012	20
5/30/2012	86
6/5/2012	41
6/12/2012	10
6/18/2012	52
6/25/2012	10
7/2/2012	97
7/11/2012	20
7/17/2012	< 10(2)
7/25/2012	460
7/30/2012	2,400
8/2/2012	20,000
8/8/2012	4,600
8/13/2012	170
8/20/2012	85
8/28/2012	480
5/20/2013	110
5/29/2013	1,300
6/4/2013	790
6/6/2013	150
6/11/2013	31
6/18/2013	250
6/20/2013	86
6/25/2013	190
7/1/2013	10
7/10/2013	10
7/16/2013	130
7/23/2013	< 10(2)
7/30/2013	30
8/6/2013	20
8/13/2013	20
8/20/2013	120
8/27/2013	< 10(2)
5/20/2014	280

Date	*E. coli* (MPN/100 ml)
5/22/2014	150
5/28/2014	260
5/29/2014	98
6/3/2014	95
6/10/2014	31
6/17/2014	41
6/24/2014	30
7/2/2014	98
7/8/2014	280
7/15/2014	20
7/22/2014	< 10(2)
7/29/2014	700
8/5/2014	41
8/12/2014	110
8/19/2014	710
8/26/2014	< 10(2)
5/23/2016	< 10(2)
5/31/2016	97
6/6/2016	380
6/8/2016	630
6/13/2016	20
6/15/2016	750
6/20/2016	41
6/22/2016	10
6/28/2016	110
7/5/2016	98
7/11/2016	20
7/19/2016	52
7/26/2016	< 10(2)
8/1/2016	63
8/8/2016	10
8/15/2016	13,000
8/17/2016	10
8/23/2016	300
8/30/2016	2,100
4/11/2017	7(3)
5/11/2017	51(3)
5/24/2017	31
5/31/2017	10
6/5/2017	9(3)

Date	*E. coli* (MPN/100 ml)
6/7/2017	120
6/14/2017	10
6/21/2017	10
6/28/2017	560
7/5/2017	< 10[2]
7/12/2017	10
7/19/2017	41
7/26/2017	360
8/2/2017	98
8/8/2017	18[3]
8/9/2017	510
8/16/2017	110
8/23/2017	< 10[2]
8/30/2017	20
5/23/2018	110
5/30/2018	63
6/6/2018	< 10[2]
6/13/2018	10
6/20/2018	96
6/27/2018	10
7/3/2018	260
7/11/2018	3,600
7/18/2018	52
7/25/2018	170
8/1/2018	10
8/8/2018	< 10[2]
8/15/2018	74
8/20/2018	230
8/27/2018	2,200
5/22/2019	540
5/29/2019	680
6/5/2019	1,200
6/12/2019	< 10[2]
6/19/2019	31

Date	*E. coli* (MPN/100 ml)
6/26/2019	< 10[2]
7/2/2019	< 10[2]
7/10/2019	86
7/17/2019	1,000
7/24/2019	190
7/31/2019	< 10[2]
8/6/2019	10
8/14/2019	220
8/21/2019	220
8/27/2019	20
5/20/2020	41
5/27/2020	63
6/3/2020	98
6/10/2020	86
6/17/2020	20
6/22/2020	31
6/30/2020	1,300
7/8/2020	120
7/14/2020	220
7/21/2020	340
7/29/2020	880
8/3/2020	30
8/12/2020	41
8/17/2020	2,600
8/26/2020	31
9/1/2020	41
5/25/2021	50[3]
5/26/2021	140
6/2/2021	130
6/8/2021	910
6/8/2021	76[3]
6/15/2021	220
6/22/2021	470
6/29/2021	1,400

Date	*E. coli* (MPN/100 ml)
6/29/2021	192[3]
7/7/2021	510
7/13/2021	110
7/20/2021	190
7/27/2021	< 10[2]
8/3/2021	86
8/10/2021	1,400
8/17/2021	97
8/24/2021	10
8/31/2021	4,400
9/22/2021	57[3]
5/24/2022	< 10[2]
5/31/2022	63
6/8/2022	41
6/14/2022	230
6/21/2022	120
6/28/2022	10
7/5/2022	20
7/12/2022	20
7/20/2022	10
7/26/2022	460
8/2/2022	63
8/9/2022	31
8/16/2022	31
8/22/2022	10
8/30/2022	< 10[2]
Min =	5
1st Quartile =	18
Median =	58
3rd Quartile =	220
Max =	20,000
Mean =	393

(1) Unless noted samples collected by the DNR as part of Ambient water quality monitoring.
(2) *E. coli* for the sample was not detected. The minimum detection limit is 10 MPN/100 ml. Consequently, 5 MPN/100 ml was used in calculations.
(3) Samples collected by DNR as part of 2017 and 2018 study.

Table 11.A-2. Sand Sampling Data from Transects, Lake Keomah Beach.

Date	Row/ Transect	*E. coli* (MPN/cubic cm)				
		A	B	C	D	E
4/11/2017	1	16	0.2	0.7	< 0.1(1)	---
	2	< 0.1(1)	0.1	0.4	< 0.1(1)	---
	3	0.3	0.6	< 0.1(1)	< 0.1(1)	---
5/11/2017	1	46	310	7.9	2.4	4.9
	2	450	0.1	0.2	< 0.1(1)	---
	3	16	7.1	0.9	0.2	---
6/5/2017	1	> 250(2)	82	110	24	1.8
	2	31	15	0.3	< 0.1(1)	---
	3	54	28	< 0.1(1)	< 0.1(1)	---
8/8/2017	1	210	200	1,300	2.4	0.6
	2	7.2	49	6.7	< 0.1(1)	0.1
	3	4	2,000	86	< 0.1(1)	< 0.1(1)
5/25/2021	1	260	15	64	<1	---
	2	13	26	3.5	<10	---
	3	7.4	21	3.1	<10	---
6/8/2021	1	> 260(2)	> 250(2)	110	> 240(2)	---
	2	250	63	6	0.7	---
	3	> 250(2)	> 250(2)	2.8	55	---
6/29/2021	1	> 260(2)	110	8.2	9.3	---
	2	> 260(2)	> 250(2)	30	12	---
	3	> 260(2)	240	17	240	---
9/22/2021	1	110	56	9.2	18	---
	2	> 260(2)	88	> 240(2)	0.4	---
	3	> 270(2)	63	180	0.3	---

(1) *E. coli* for the sample was not detected. The non-detectable limit recorded was divided in half for calculation purposes.
(2) Individual *E. coli* value was greater than the upper quantification value. In these cases, the value listed was used for calculation purposes.

Table 11.A-3. Water Sampling Data from Transects, Lake Keomah Beach.

Date	Row/ Transect	*E. coli* (MPN/100 ml)								
		0	1	2	3	4	5	6	7	8
4/11/2017	1	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	20	< 10(1)	< 10(1)	< 10(1)
	2	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	31	20	< 10(1)
	3	20	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)
	4	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)
5/11/2017	1	190	20	20	31	10	10	20	20	10
	2	160	10	52	31	41	20	20	41	10
	3	170	30	41	10	20	20	30	10	31
	4	20	< 10(1)	10	10	10	< 10(1)	< 10(1)	10	< 10(1)
6/5/2017	1	10	< 10(1)	10	10	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	2	< 10(1)	20	< 10(1)	10	20	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	3	41	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	4	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
8/8/2017	1	10	30	10	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10
	2	20	30	31	10	20	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	3	75	20	20	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)
	4	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
5/25/2021	1	97	< 10(1)	20	10	80	10	< 10(1)	< 10(1)	---
	2	52	20	< 10(1)	< 10(1)	10	20	< 10(1)	< 10(1)	---
	3	190	41	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	---
	4	290	31	< 10(1)	20	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---
6/8/2021	1	650	< 10(1)	10	52	10	< 10(1)	< 10(1)	< 10(1)	---
	2	63	52	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---
	3	270	31	< 10(1)	< 10(1)	10	10	31	< 10(1)	---
	4	31	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---
6/29/2021	1	710	51	< 10(1)	< 10(1)	20	20	< 10(1)	< 10(1)	---
	2	710	10	< 10(1)	31	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---
	3	1,300	31	10	20	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---
	4	10	120	20	30	< 10(1)	20	< 10(1)	< 10(1)	---
9/22/2021	1	160	20	63	20	10	< 10(1)	20	30	---
	2	320	10	20	96	41	20	10	20	---
	3	41	31	86	10	< 10(1)	41	41	< 10(1)	---
	4	< 10(1)	< 10(1)	10	10	10	31	< 10(1)	< 10(1)	---

(1) *E. coli* for the sample was not detected. The minimum detection limit is 10.0 MPN/100 ml. 5.0 MPN/100 ml was used in calculations.

12. North Twin Lake TMDL (Protective TMDL)

North Twin Lake has three beaches were samples are collected (See Figure 12-1). The lake was assessed as "partially supported" for the 2012 assessment/listing cycle due to samples collected at the West Beach not meeting *E. coli* criteria. However, four things occurred worth noting 1) samples collected and analyzed during subsequent assessment cycles at the West Beach met *E. coli* criteria, which would have resulted in North Twin Lake being delisted during the 2018 assessment cycle, 2) samples collected at Treman Park Beach did not meet *E. coli* criteria during the 2016 assessment cycle resulting in the lake remaining on the impaired waters list beyond the 2018 assessment cycle, 3) additional sampling of Treman Park Beach did not commence until 2019, and 4) based on DNR's assessment methodology the lake was delisted for the 2020 assessment/listing cycle (https://programs.iowadnr.gov/adbnet/Segments/1167/Assessment/2020). Consequently, Treman Park Beach was the focus of this TMDL.

However, since the TMDL analysis for the lake was in process before the delisting occurred, the analysis was completed and the TMDL for this lake is being submitted as a protective TMDL. In the future, if the lake is added back to the impaired waters list due to samples not meeting *E. coli* criteria at any of the other beaches, the TMDL will need to be edited to address those beaches along with updated sampling data.

12.1 Description and History of North Twin Lake

North Twin Lake, IA 04-RAC-1167, is located in Sherman Township, Calhoun County, Iowa approximately four (4) miles north of Rockwell City. North Twin Lake is a natural glacial lake. There are three recreational beaches on North Twin Lake. Twin Lake State Park and the west beach are owned and operated by the Iowa Department of Natural Resources (DNR). The third beach, Treman Park Beach, is owned and operated by Calhoun County. Much of the shoreline has also been developed by private residential tracts. The lake and land surrounding it provide fishing, camping, hiking and other outdoor recreational activities for the public.

The lake has a watershed area of 2,556 acres, a maximum depth of approximately 12-feet, a shore length of approximately 6.0 miles, and an approximate volume of 3,833 acre-feet. Table 12-1 is a summary of the lake and watershed properties. Figure 12-1 is an aerial photograph with the boundaries of the watershed.

Table 12-1. North Twin Lake Watershed and Lake Information.

Waterbody Name	North Twin Lake
Waterbody ID	IA 04-RAC-1167
12 Digit Hydrologic Unit Code (HUC)	071000060603
HUC-12 Name	Drainage Ditch 13-Lake Creek
Location (Ambient Monitoring Site)	Section 33, T89N, R32W, Calhoun County, Iowa
Water Quality Standard Designated Uses	Class A1 Primary Contact Recreation Class B(LW) Aquatic Life Class HH Human Health
Antidegradation Protection Level	Tier 1
Tributaries	Unnamed Tributary
Receiving Waterbody	South Twin Lake
Watershed Area	2,556 acres
Lake Surface Area	463.0 acres(1)
Maximum Depth	11.7 feet(1)
Volume	3,833 acre-feet(1)
Length of Shoreline	5.7 miles
Watershed/Lake Area Ratio	5.52:1

(1) Data obtained from November 2019 DNR Bathymetric Survey.

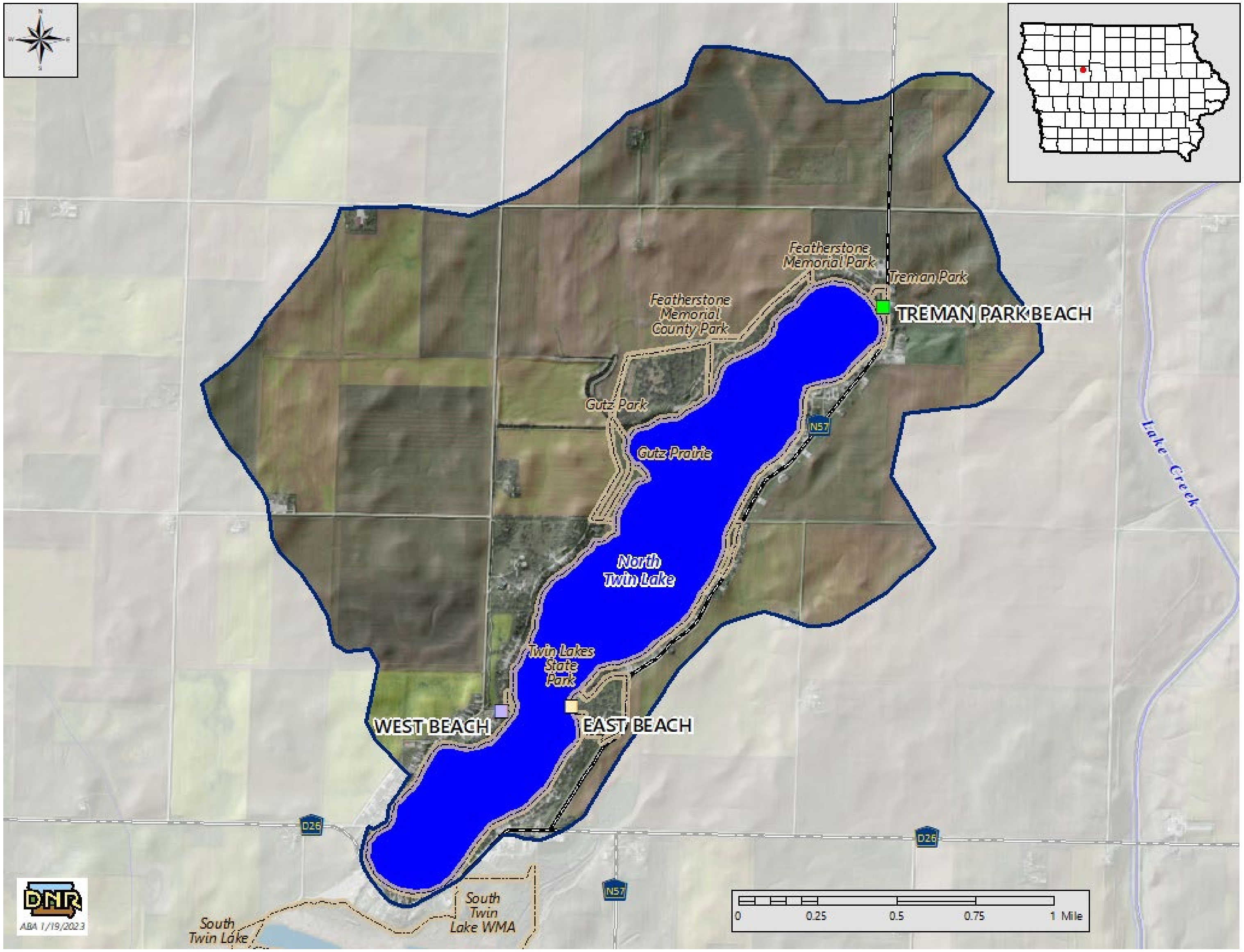

Figure 12-1. North Twin Lake Watershed.

Land Use

A Geographic Information System (GIS) coverage of land use information was developed using the 2021 USDA Cropland Data Layer (USDA, National Agricultural Statistics Service). The dominant land use is row crops (corn and soybeans rotations) making up approximately 65% of the land use (Table 12-2). The eight land uses shown in Table 12-2 were aggregated from the fourteen land uses in the cropland data layer as shown in the description column. Figure 12-2 shows the distribution of the various land uses throughout the North Twin Lake watershed in a pie-chart.

Table 12-2. North Twin Lake Watershed Land Uses.

Land Use	Description	Area (AC)	Percent of Total
Water/Wetland	Water and Wetlands	506	19.8%
Forested	Bottomland, Coniferous, Deciduous	16	0.6%
Grassland	Ungrazed, Grazed, & CRP-	99	3.9%
Alfalfa/Hay	Perennial Hay Crop-	1	<0.1%
Row Crop	Corn, Soybeans, & other	1,650	64.6%
Roads	Roads Lightly Developed Urban	128	5.0%
Urban	Intensively Developed Urban	154	6.0%
Barren	Barren Land	2	0.1%
Total		**2,556**	**100.0%**

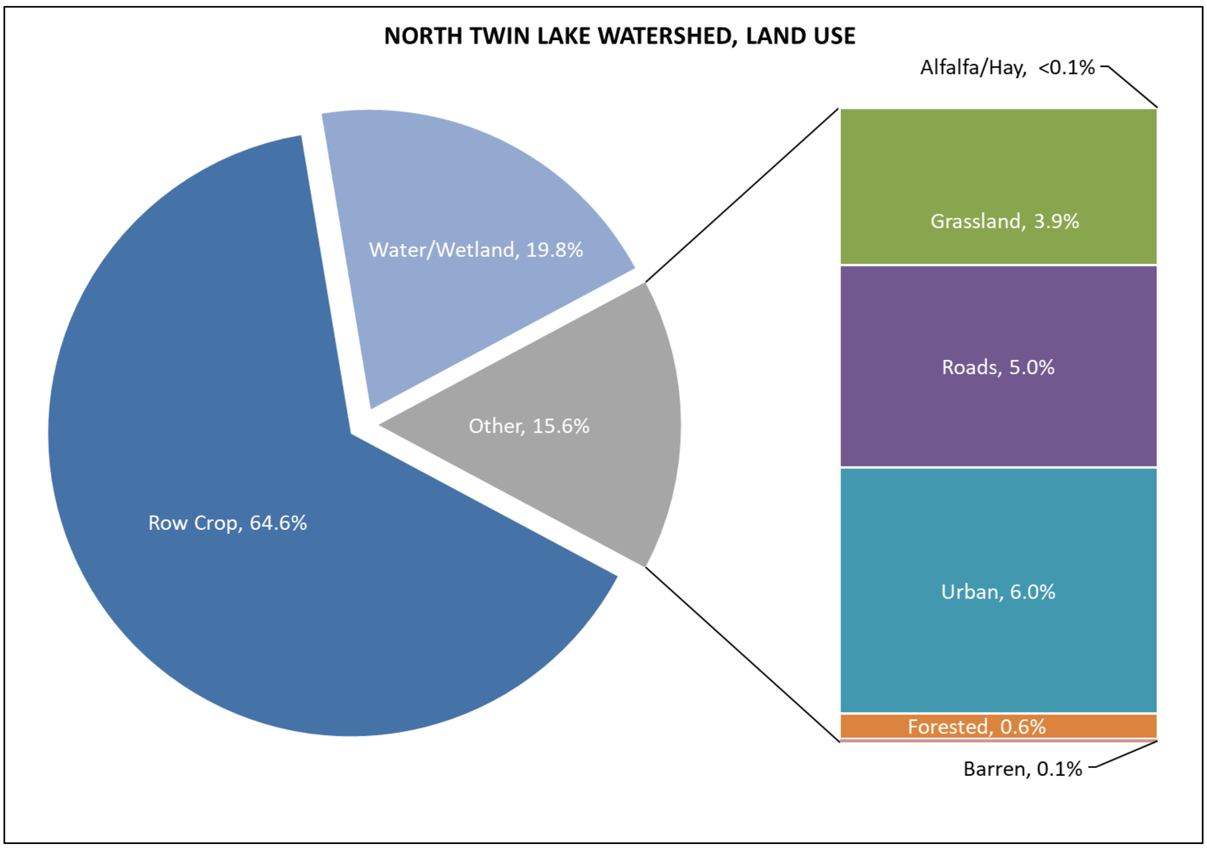

Figure 12-2. Land Use Composition of the North Twin Lake Watershed.

Hydrology, Soils, Climate, Topography

From data obtained from the NRCS, the four most common soils series are the Webster, Nicollet, Canisteo, and Clarion, which make up 67% of the soils in the watershed. No other soil series makes up more than 10% soils in the watershed. The lake itself makes up 18% of the area in the watershed. Of the seven hydrologic soil groups, hydrologic soil group (HSG) C/D makes up the majority of the HSGS in the watershed at approximately 84%. The North Twin Lake watershed is located in the Des Moines Lobe landform. This landform consists of poorly drained landscape of pebbly deposits from the stagnant decaying ice, sand and gravel from swiftly flowing meltwater streams, as well as clay and peat from glacial lakes. In addition, broadly curved bands of ridges and knobby hills set among irregular ponds and wetlands punctuate the otherwise subtle terrain of this freshly glaciated landscape (Prior, 1991).

The average rainfall for the North Twin Lake watershed from 2008 through 2022 is 33.0 inches with the majority (72%) falling between April 1st and September 30th. Lake evapotranspiration averages 41.9 inches per year with more occurring in dryer years on average. Figure 12-3 shows the annual rainfall and lake evapotranspiration from 2008 to 2022. Figure 12-4 shows the monthly average relationship between watershed evapotranspiration and rainfall. In some drier summer months, evapotranspiration may exceed rainfall, leading to a deficit in the water budget for the watershed.

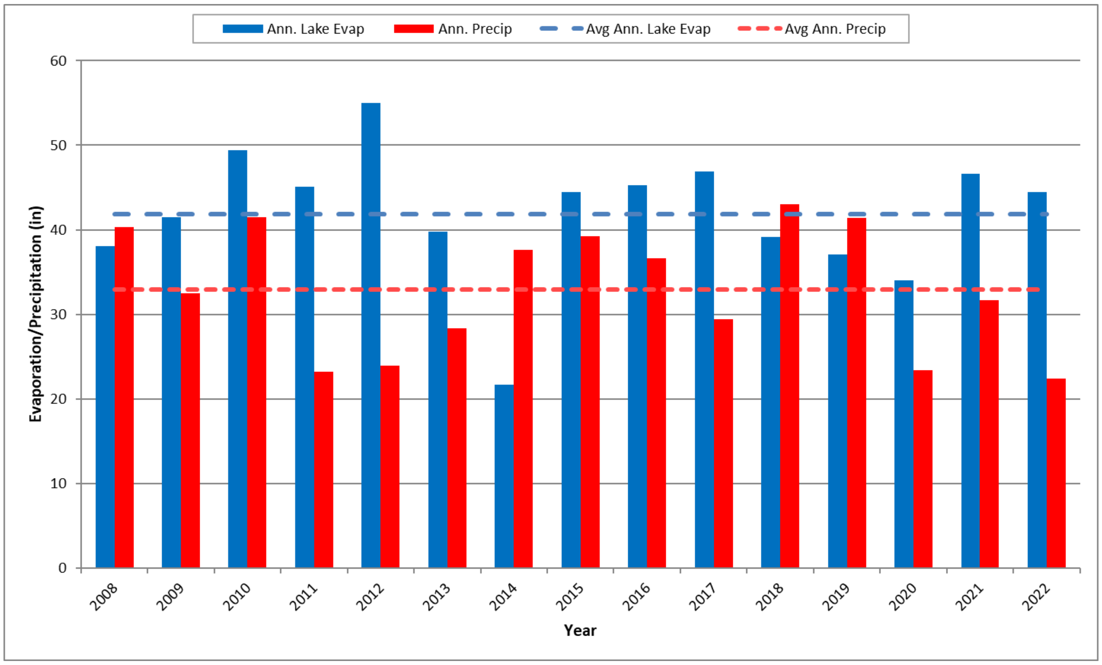

Figure 12-3. Annual Rainfall and Estimated Evapotranspiration Totals, North Twin Lake Watershed.

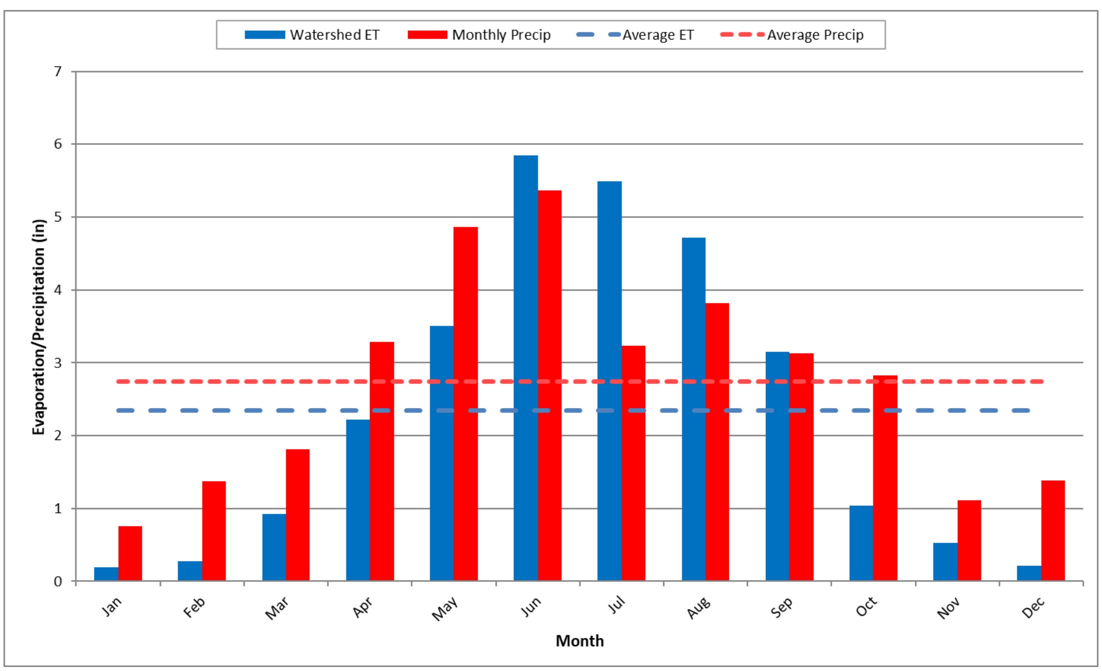

Figure 12-4. Monthly Rainfall and Estimated Evapotranspiration Totals, North Twin Lake Watershed.

12.2 Beach Investigation Sampling and Analysis

Swimming advisories are commonly posted at public beaches across Iowa every season. Weekly monitoring of public swimming zones at state and county beaches have resulted in the impairment of numerous lakes for Fecal Indicator Bacteria (FIB) contamination, a violation of the State of Iowa's water quality standards. These swimming beach impairments result in whole lake waterbodies being listed as impaired on the state's biennial 303(d) list3. These impairment listings do not accurately reflect the condition(s) of the larger lake environment outside the swimming zone and fail to account for beach proximate conditions in the assessment process.

Traditionally, management of these systems has assumed that the larger watershed serves as the primary source of FIB to the recreational areas. However, sampling at numerous beach systems across Iowa have shown a disconnect between the open lake environment and FIB contamination in the swimming zone, which is driven by conditions in the foreshore sand environment. An extensive study conducted in 2015-2016 assessed the relationships between the nearshore beach environment, open lake conditions and watershed delivery of FIB (*E. coli*) in three representative beach / lake systems currently impaired for FIB contamination across Iowa (Chapter 2). The results of this study and subsequent TMDL development provided an assessment framework for other beach systems in the region. Following are the results of this assessment for Treman Park Beach on North Twin Lake (IA 04-RAC-1167).

Sampling and Data Collection

Samples were collected from the beach swimming zone, the open lake transect zone, the alternate transect, and the open lake sampling points seasonally and in response to wet weather events from spring through the fall of 2019, 2020 and 2021 (Figure 12-5). All water and sand sample collections and laboratory analyses were conducted following protocols highlighted in Chapter 2.3.

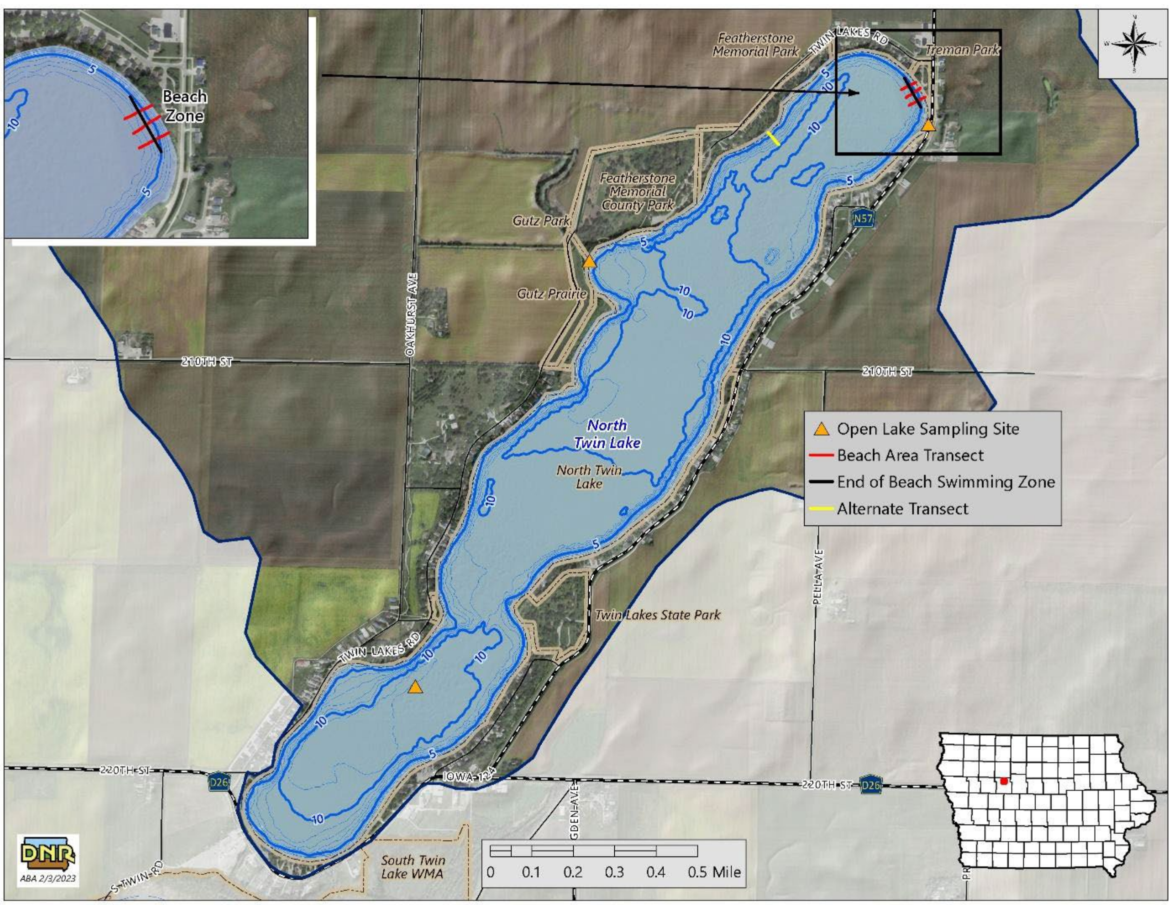

Figure 12-5. Overview of Monitoring Locations on North Twin Lake.

Sampling Results and Analysis

Water sample collection in the nearshore swimming zone showed a high degree of variability. Sample results commonly varied by thousands of MPN/100 ml, indicating that this environment was highly sensitive to changes in *E. coli* loading. While these data showed that intermittent spikes in concentrations could be quite high, the bulk of data collected showed overall low *E. coli* concentrations. The observed median concentration was 10 MPN/100 ml, right at the detection limit of 10 MPN/100 ml (Table 12-3). This information suggests that conditions in the recreational swimming zone can rapidly change in response to *E. coli* loading but do not maintain an elevated concentration across the season. These findings are supported by observations that during the three sampling seasons at Treman Park the swimming area met recreational standards (235 MPN/100 ml) in six of the fourteen sampling trips. Sampling at the alternate transect and open lake locations had a median value below the *E. coli* detection limit of 10 MPN/100 ml and relatively low standard deviations (Table 12-3), indicating overall low concentrations in these environments.

Table 12-3. Basic Statistics from Bacteria Sampling at North Twin Lake.

Sampling Dataset	N	Mean	Median	St. Dev.	25th %	75th %
Treman Park Beach Swimming Zone	168	212	31	460	10	140
Treman Park Transects	117	35	10	67	5	26
N Twin Lake Open Lake	37	122	10	545	5	20
Treman Park Beach Sand	156	605	18	2,961	2.6	123
N Twin Lake Alternate Transect Rows 0-3	48	24	10	26	5	31
N Twin Lake Alternate Transect Rows 4-8	39	15	5	22	5	10

Water results reported as MPN/100 ml and sand results reported as MPN/gram (dry wt.)

Data collected from the beach sand environment during both seasons showed a wide range of variability (Table 12-3). However, median and mean sample *E. coli* concentrations were well above detection limits of (0.1 MPN/gram) indicating that a standing stock of *E. coli* bacteria was consistently present in the beach sands at Treman Park Beach. These sand observations are consistent with investigations conducted on other systems in Iowa (Chapter 2.4).

Beach sand sampling conducted at Treman Park Beach revealed trends consistent with prior surveys (Chapter 2.4) as *E. coli* concentrations in beach sands generally increased with proximity to the shoreline. An analysis of variation (ANOVA) on ranks showed that transect points on row B (close to the waterline) were significantly higher in *E. coli* concentrations than C or D ($P<0.01$). These observations indicate that a significant amount of *E. coli* is present immediately adjacent to the active swimming zone on Treman Park Beach. As with prior surveys, the sands on Treman Park Beach had *E. coli* concentrations many times higher than observed in adjacent swimming waters (Figure 12-6). Beach sand *E. coli* concentrations averaged nearly 2,200 times higher than those observed in adjacent swimming areas during the two-year sampling effort. These observations provide evidence of a near shore *E. coli* reservoir in the beach environment that can affect conditions in the nearshore swimming environment, as discussed in Chapter 2.

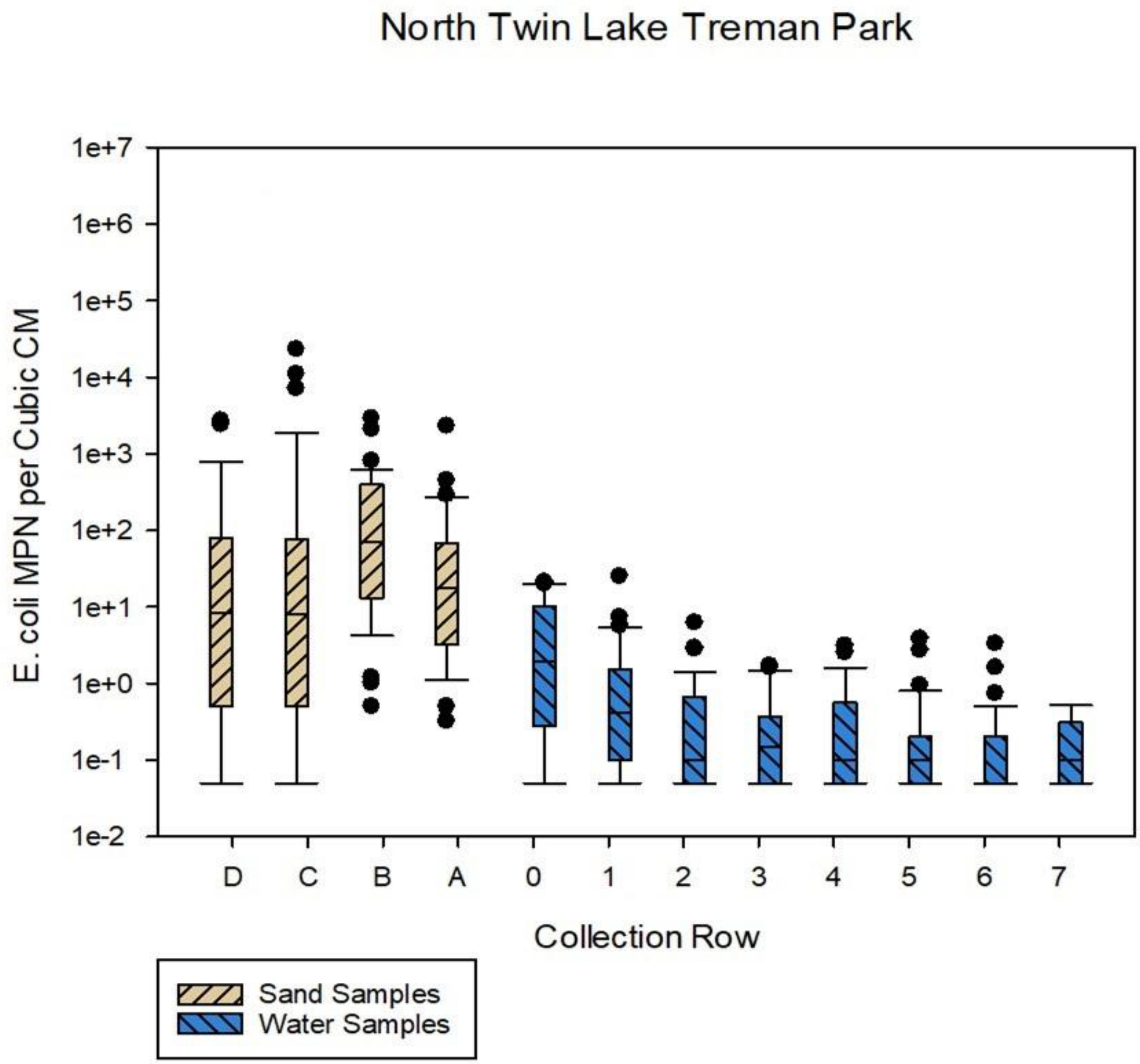

Figure 12-6. Box Plots of Sand and Water Sampling from Transects along North Twin Lake Beach. Reported in MPN/per cubic cm. Sampling points in figure correspond to following locations in relation to shoreline: A=shoreline, B (+2.5 m), C (+5m), D (+10M), 0 (Ankle deep), 1 (Knee deep), 2 (waist deep), 3 (chest deep), 4 (swimming rope), 5 to 8 (10 m spacing beyond swimming rope).

As highlighted earlier, intermittent spikes in *E. coli* concentrations were observed throughout the project. These spikes resulted in a number of days where the swimming environment exceeded recreational standards and triggered an advisory condition. The elevated conditions were largely driven by higher readings closer to the shoreline, as sampling data collected along transects radiating out from the shoreline into the lake (Figure 12-7) uncovered an association between *E. coli* concentrations and proximity to shore. Sampling points at the ankle-deep location of each beach transect were higher in *E. coli* concentrations than all other sampling points in the lake.

Statistical analysis of the North Twin Lake monitoring network uncovered trends and associations which closely mimicked findings of previous beach investigations (Chapter 2). Results highlighted in Table 12-4 demonstrate the diss-association of beach *E. coli* concentrations and those observed in other areas of the sampling network. Beach swimming zone values were significantly higher than those observed in open lake transects, open lake sampling points and along alternate transect sampling locations. These findings are directly in line with analysis conducted as part of the original beach only bacteria data development (Chapter 2). The findings from this analysis validate the decision to address the *E. coli* bacteria impairments at Treman Park Beach with a framework that directly addresses beach capture shed specific sources of *E. coli*.

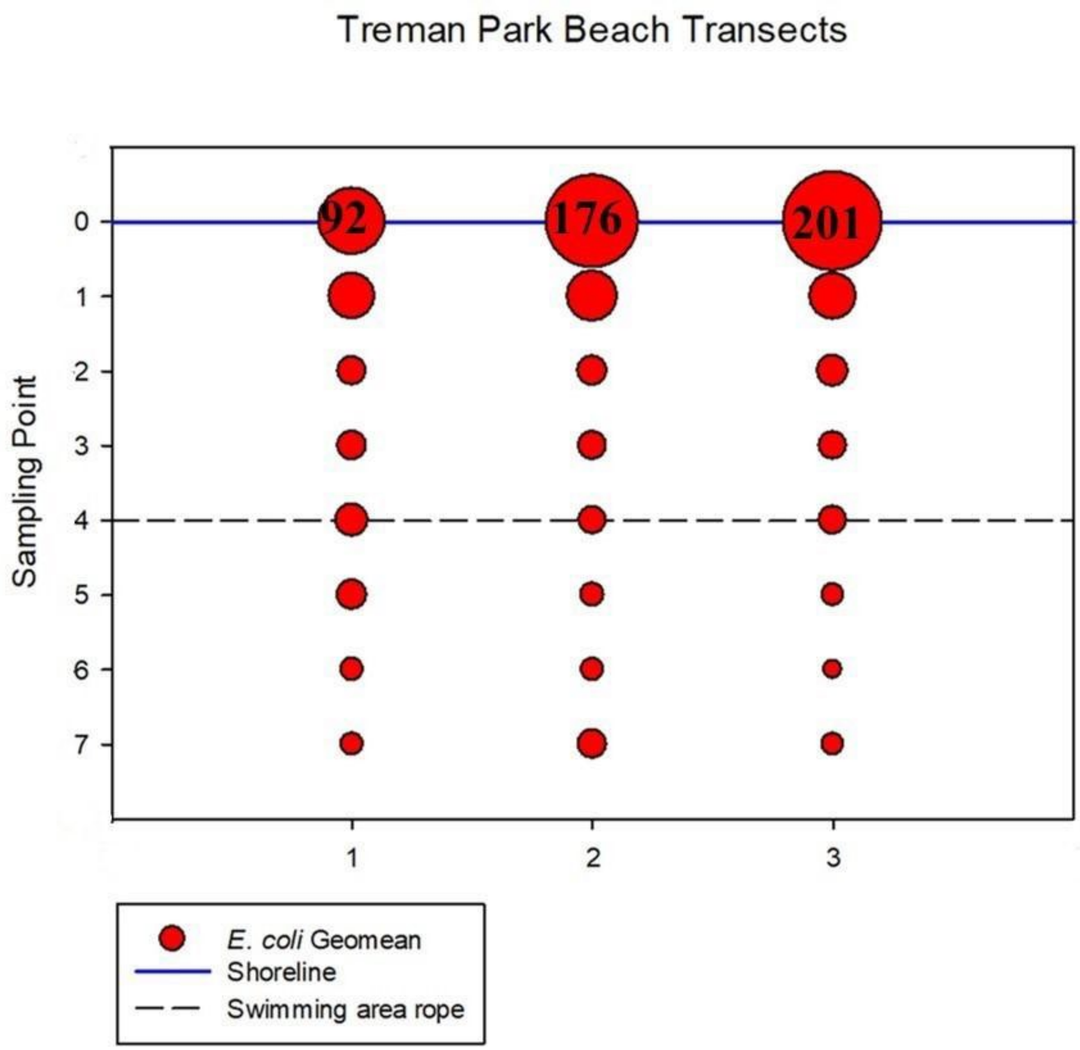

Figure 12-7. Bubble Plot of *E. coli* Sampling at North Twin Lake Beach Lake Transects Reported as MPN/100 ml.

Table 12-4. Analysis Results from North Twin Lake, Sampling Network.

Dataset comparison	Test	Significance level	Swimming zone higher
Swimming Zone vs Lake Transects	T-test	P<0.05	Yes
Swimming Zone vs Open Lake Points	T-test	P<0.05	Yes
Swimming Zone vs Alternate Transect	T-test	P<0.05	Yes

12.3 TMDL for North Twin Lake, Treman Park Beach.

The water quality improvement plan (WQIP) has provided general background information around the impaired lake. However, the sampling and monitoring of the lake that resulted in the impairment are located in the swimming zone of the Treman Park Beach on North Twin Lake. Assessments conducted on the beach and lake system (Chapter 12.2) show a clear signal for a beach specific impairment. Consequently, the TMDL will focus on the beach shed area and the swimming zone that it drains to.

Problem Identification

North Twin Lake, IA 04-RAC-1167, was included on the 2012 303(d) impaired waters list for not fully supporting the Class A1 (primary contact recreation) use due to the presence of high levels of *E. coli*. Samples were collected during the recreational season (March 15 - November 15) between 2008 - 2010 as part of the state's ambient water quality monitoring and assessment program.

There are three (3) recreational beaches at North Twin Lake, Treman Beach, Twin Lakes State Park, and the west side beach. Samples have been collected and analyzed at all three beaches. Of these three beaches, Treman beach samples were the only ones that did not meet water quality standards for *E. coli*. Consequently, Treman beach samples are the only ones that will be considered in this TMDL.

Applicable Water Quality Standards
The designated uses of North Twin Lake are: primary contact recreational use (Class A1); lakes and wetlands (Class B(LW)); and human health (Class HH). The designated uses are defined in the Iowa Administrative Code (567 Iowa Administrative Code, Chapter 61, (IAC)). For a more detailed description of the designated uses see Appendix B.

In 2010 the State of Iowa enacted an antidegradation policy. This policy was designed to maintain and protect high quality waters and existing water quality in other waters from unnecessary pollution. Protection levels (or tiers) as defined by the Iowa Administrative Code (IAC) 567-61.2 are cited below.

- 567-61.2(2)(a) Tier 1 protection. Existing surface water uses and the level of water quality necessary to protect the existing uses will be maintained and protected.

Near Shore Beach Volume (NSBV)
The NSBV is the volume of water contained within the swimming zone of the Lake. Figure 12-8 shows the swimming and beach shed areas of North Twin Lake. Table 12-5 is a summary of the NSBV data.

Figure 12-8. Swimming and Beach Shed Areas, North Twin Lake, Treman Park.

Table 12-5. North Twin Lake, Treman Park Beach NSBV Data.

Near Shore Beach Volume	1.52 acre-feet
Beach Front Length	503.9 feet
Radius from Shore at midpoint of beach	73.6 feet
Depth at Radius	4.2 feet (Elevation 1211.8)
Beach Shed Area	6.7 Acres

Data Sources and Monitoring Sites

Table 12-6 lists the water quality monitoring locations used to develop the WQIP for North Twin Lake. Figure 12-9 shows the monitoring locations used. In addition to these sites, samples were collected adjacent to the beach along three transects and an alternate transect as shown in Figure 12-5. For a more detailed description of the samples collected along the transects see Chapter 12.2.

Water quality samples were collected as part of the state's ambient water quality monitoring and assessment program between 2008 - 2022. Additional water quality samples were collected in 2019, 2020, and 2021 by the DNR to study and assess the relationships between the nearshore beach environment and open lake conditions. Results of this study are presented in Chapter 12.2.

Table 12-6. WQ Data Monitoring Sites at North Twin Lake.

Site Name	Site ID	Longitude	Latitude
North Twin West Inlet (1)	14000340	94° 37' 49"	42° 29' 31"
North Twin North Inlet(1)	14000341	94° 36' 52"	42° 29' 48"
Treman Park Beach(1) (2)	21130003	94° 36' 52"	42° 29' 53"
North Twin Lake (1) (2	22130001	94° 38' 17"	42° 28' 37"

(1) 2019, 2020, & 2021 DNR Study sampling site.
(2) Ambient water quality sampling site.

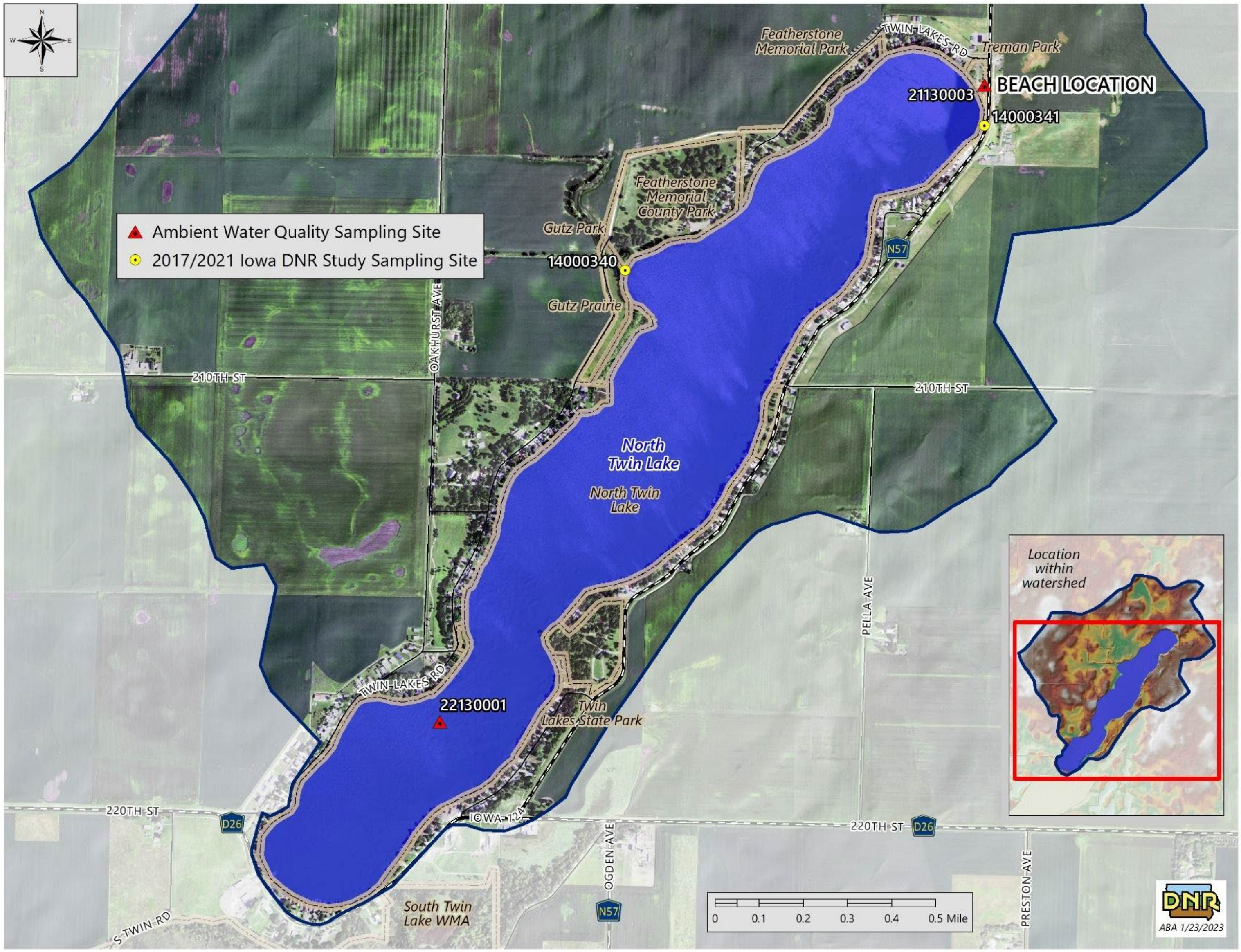

Figure 12-9. Sampling Locations, North Twin Lake.

Interpretation of Data
Using data collected from 2008-2022, two box plots were developed. Figure 12-10 is a box plot of samples categorized by season (spring, summer, and fall) and a plot of the full data. The box has lines at the lower quartile, median, and upper quartile values. Whiskers extend from the top and bottom to the existing loading and the minimum load. The existing load for each box is the 90th percentile of observed *E. coli* concentrations. There is also a horizontal line representing the SSM concentration of 235 orgs/100 ml.

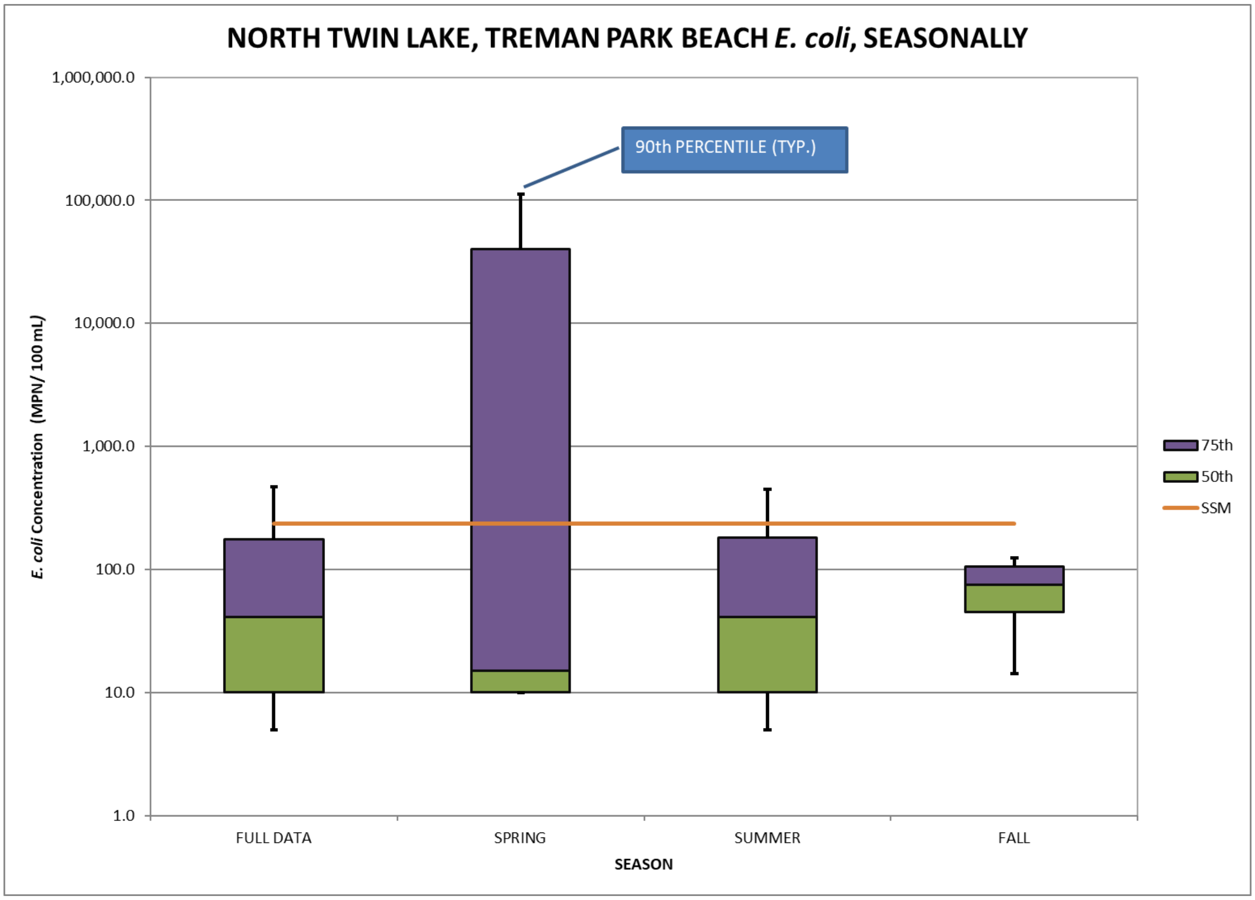

Figure 12-10. Seasonal Box Plot, North Twin Lake, Treman Park Beach. Seasons defined as: Spring (March 15-May 22); Summer (May 23-September 7) and Fall (September 8-November 15).

Analysis of the data show *E. coli* levels that exceed the SSM (single sample max) concentration of 235 orgs/100 ml criterion set forth in Iowa's WQS for primary contact recreation approximately 21 percent of the time. Consequently, reductions in *E. coli* loading will be required to comply with the standards and fully support the designated recreational use in the impaired waterbody.

From Figure 12-10 it can be seen that there are elevated levels of bacteria during the spring and summer seasons at the Treman Park beach. It should be noted that the high *E. coli* loading during the spring is due to a single sample, which exceeds the next largest sample in the spring season by over 150,000 MPN/100 ml.

In the second box plot graph, Figure 12-11, data is categorized by month. This box plot has the same format as previously described. From this figure it can be seen that *E. coli* levels start high in May and June and begin a consistent decrease in July to September, with a peak in May, which can be attributed to one sample of 160,000 orgs/100 ml.

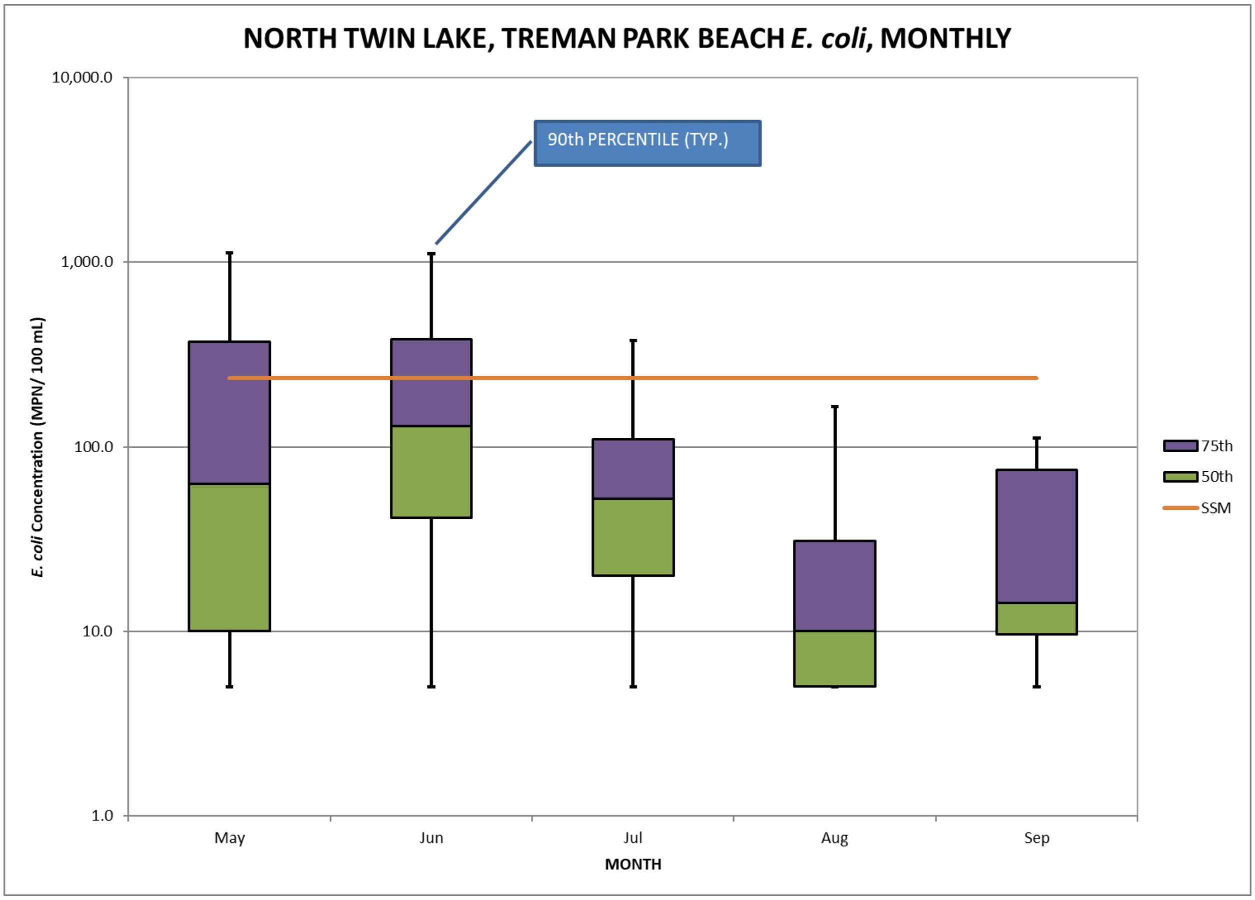

Figure 12-11. Monthly Box Plot, North Twin Lake, Treman Park Beach.

12.3.1 TMDL Target

General Description of Pollutant

Fecal material from warm-blooded animals contains many microorganisms. Some of these microorganisms can cause illness or disease if ingested by humans. The term pathogen refers to a disease-causing microorganism, and can include bacteria, viruses, and other microscopic organisms. Humans can become ill if they come into contact with and/or ingest water that contains pathogens.

Selection of Environmental Conditions

The critical period for the impairment occurs in the recreational season of March 15-November 15. The critical volume is the NSBV, which is adjacent to the beach area.

Consideration of Seasonal Variation

These TMDLs were developed based on the Iowa WQS primary contact recreational season that runs from March 15-November 15. In addition, sampling data collected during the recreational season were subdivided into three seasons: spring (March 15-May 22); summer (May 23-September 7) and fall (September 8-November 15). The 90th percentile of observed *E. coli* concentrations within each season was selected as the existing concentration for each season.

Waterbody Pollutant Loading Capacity

Attainment of the WQS to fully support primary contact recreation requires that the GM for *E. coli* concentrations be no greater than 126 orgs/100 ml and the SSM be not greater than 235 orgs/100 ml (Iowa Administrative Code 567, Chapter 61, Water Quality Standards for Class A1 uses). The methods used to develop the *E. coli* TMDL for the North Twin Lake assumes that compliance with the SSM will coincide with attainment of the GM target (EPA, 2007). Therefore, the loading capacity of the TMDL is the maximum number of *E. coli* organisms that can be in the NSBV while meeting the SSM criterion of 235 orgs/100 ml.

Decision Criteria for WQS Attainment
The seasonal duration curve was constructed using daily sampling data. The SSM criterion was used to quantify the loading capacity of the NSBV, in terms of load (orgs/100 ml). Points above the green SSM line in Figure 12-12 represent violations of the WQS, whereas points below the line comply with WQS.

WQS will be attained in the NSBV when less than 10% of samples exceed the SSM criterion of 235 orgs/100 ml during the recreational season of March 15-November 15.

12.3.2 Pollution Source Assessment

Departure from Load Capacity
The seasonal load curve and observed loads for the seasonal load conditions are plotted in Figure 12-12. This methodology enables calculation of a TMDL target for each season. However, the highest percent reduction of the three seasons will be used as the target reduction for all impaired seasons. It is assumed that if the highest percent reduction rate is used and achieved then the WQS will be attained for GM and SSM criterion for all seasons.

Allowance for Increases in Pollutant Loads
Based on current land use and size of the beach shed area it is unlikely that any new sources will be developed within the beach shed area.

12.3.3 Pollutant Allocations

Wasteload Allocations (WLA)
There are no point sources in the beach shed of North Twin Lake. Therefore, the WLA portion of this TMDL is zero.

Load Allocations (LA)
Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the water body. Specific examples of potential nonpoint sources of bacteria include animals directly depositing into water bodies, manure applied to row crops, manure runoff from grazed land, non-permitted onsite wastewater systems, and natural sources such as wildlife.

Based on the results of the two-year study presented in Chapter 2 and Chapter 12.2 of this WQIP the source of the impairment is from the near shore beach environment. The main source of *E. coli* is likely from waterfowl and shore birds loafing on the beach and the regeneration/attenuation of *E. coli* in the sand environment.

Margin of Safety
An explicit margin of safety (MOS) of 10 percent is applied to the calculation of loading capacities in this TMDL.

Seasonal Load Curve
Figure 12-12 shows a seasonal load curve for the NSBV at North Twin Lake. Table 12-7 and Table 12-8 are the existing load estimates and the TMDL summary, respectively for the NSBV at North Twin Lake.

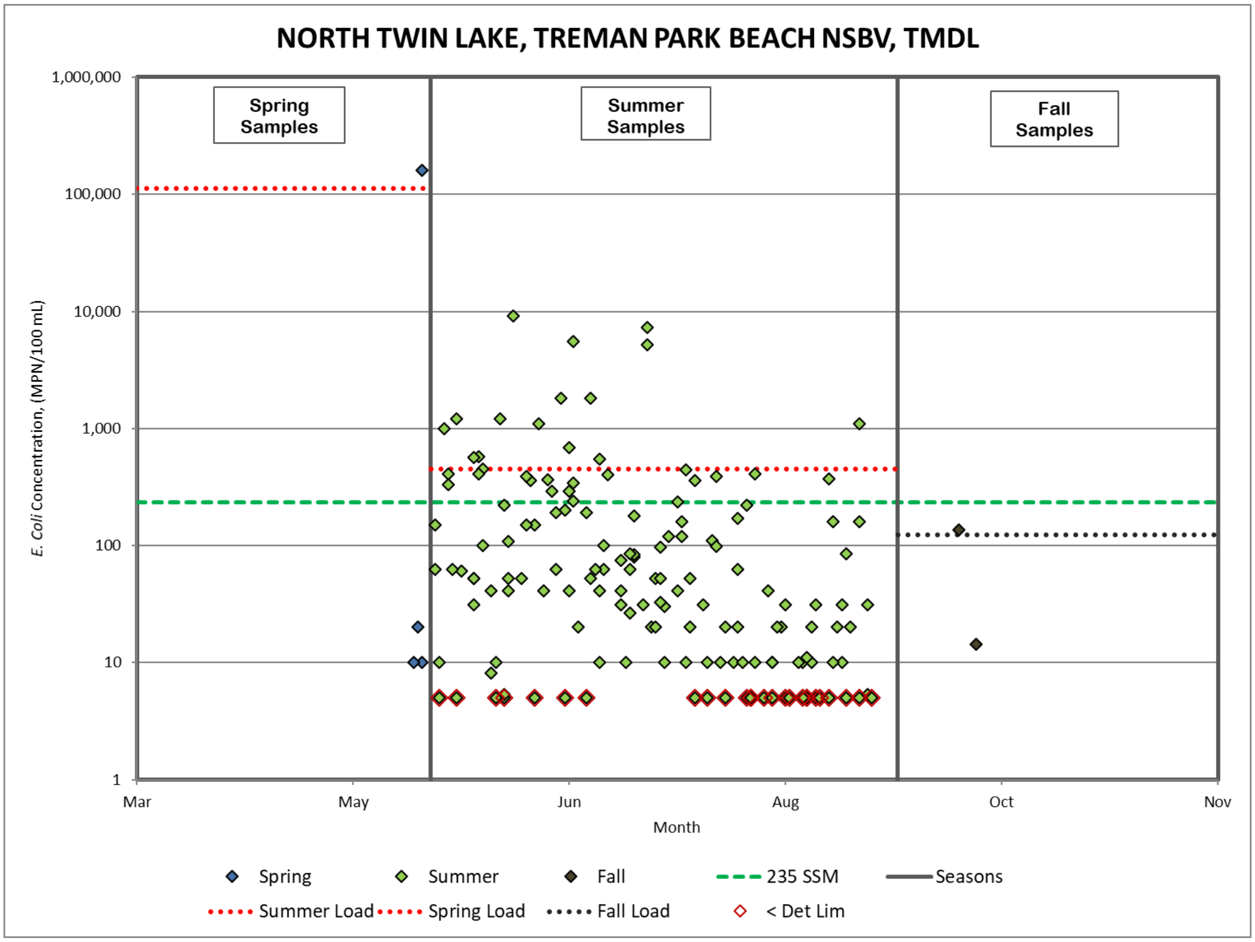

Figure 12-12. Seasonal Load Curve, North Twin Lake, Treman Park Beach, NSBV.

Table 12-7. Existing Load Estimates for the NSBV at North Twin Lake, Treman Park Beach.

Load Summary	Seasonal Loads (MPN/100 ml)		
	Spring	Summer	Fall
Observed Load(1)	112,006.0	448.0	123.9
Departure	111,794.5	213.0	N/A
(% Reduction)	(99.8)	(47.5)	(0)

(1) Observed load is the 90th percentile of water quality samples.

Table 12-8 is a summary of the TMDL for the NSBV at North Twin Lake. Because it is assumed that the NSBV is constant from year to year the TMDL calculations do not change from season to season.

Table 12-8. TMDL Summary for the NSBV at North Twin Lake, Treman Park Beach.

	TMDL
TMDL (MPN/100 ml)	235.0
WLA (MPN/100 ml)	0.0
LA (MPN/100 ml)	211.5
MOS (MPN/100 ml))	23.5

12.3.4 TMDL Summary

This TMDL is based on meeting the water quality criteria for primary contact and children's recreational uses in North Twin Lake. Although the WQS are based on *E. coli* concentration, the TMDL is also expressed as a load, in light of the November 2006 EPA memorandum. The following equation represents the total maximum daily load (TMDL) and its components:

$$TMDL = LC = \Sigma WLA + \Sigma LA + MOS$$

Where:
- TMDL = total maximum daily load
- LC = loading capacity
- ΣWLA = sum of wasteload allocations (point sources)
- ΣLA = sum of load allocations (nonpoint sources)
- MOS = margin of safety (to account for uncertainty)

Once the loading capacity, waste load allocations, load allocations, and margin of safety are determined for the lake, the general equation above can be expressed for *E. coli* as the allowable daily load. Using the values in Table 12-8 and a NSBV of 1.5 acre-feet the TMDL for North Twin Lake as a mass loading is presented in Table 12-9.

Table 12-9. Summary of North Twin Lake, Treman Park Beach.

	TMDL
TMDL (MPN/day)	4.43E+09
WLA (MPN/day)	0.00E+00
LA (MPN/day)	3.99E+09
MOS (MPN/day)	4.43E+08

Appendix 12.A Water Quality Data

Table 12.A-1. WQ Sampling Data, North Twin Lake, Treman Park, Site ID 21130003.

Date	*E. coli* (MPN/100 ml)
5/20/2008	10
5/28/2008	< 10[2]
6/3/2008	100
6/24/2008	240
7/1/2008	100
7/8/2008	80
7/15/2008	30
7/22/2008	< 10[2]
7/29/2008	< 10[2]
8/5/2008	410
8/12/2008	< 10[2]
8/19/2008	< 10[2]
8/26/2008	< 10[2]
5/24/2011	10
6/1/2011	31
6/7/2011	1,200
6/14/2011	360
6/21/2011	1,800
6/27/2011	190
7/5/2011	41
7/12/2011	20
7/19/2011	120
7/26/2011	110
8/1/2011	170
8/9/2011	10
8/16/2011	10
8/23/2011	160
8/29/2011	< 10[2]
5/23/2012	150
5/29/2012	61
6/5/2012	41
6/12/2012	52
6/19/2012	290
6/25/2012	20
7/2/2012	400
7/10/2012	31
7/16/2012	120
7/24/2012	31
7/31/2012	10
8/7/2012	< 10[2]
8/13/2012	< 10[2]
8/20/2012	< 10[2]
8/27/2012	20
5/20/2013	160,000
5/28/2013	1,200
6/3/2013	450
6/10/2013	9,200
6/17/2013	41
6/24/2013	5,500
7/1/2013	63
7/8/2013	180
7/15/2013	10
7/22/2013	360
7/29/2013	20
8/5/2013	10
8/12/2013	31
8/19/2013	31
8/26/2013	85
5/19/2014	20
5/27/2014	63
6/2/2014	570
6/9/2014	41
6/16/2014	1,100
6/23/2014	41
6/30/2014	41
7/7/2014	63
7/14/2014	97
7/21/2014	52
7/28/2014	10
8/4/2014	< 10[2]
8/11/2014	20
8/18/2014	10
8/25/2014	10
5/18/2015	10
5/26/2015	410
6/1/2015	52
6/8/2015	220
6/15/2015	150
6/22/2015	200
6/29/2015	63
7/6/2015	10
7/13/2015	52
7/20/2015	10
7/27/2015	390
8/3/2015	< 10[2]
8/10/2015	20
8/17/2015	< 10[2]
8/24/2015	20
8/31/2015	31
5/23/2016	63
6/6/2016	10
6/13/2016	150
6/20/2016	63
6/27/2016	< 10[2]
7/5/2016	75
7/11/2016	5,200
7/18/2016	41
7/25/2016	< 10[2]
8/1/2016	63
8/8/2016	41
8/15/2016	10
8/22/2016	370
8/29/2016	1,100
6/5/2019	8[3]
6/18/2019	364[3]
6/24/2019	340
7/8/2019	84
7/18/2019	236[3]
9/25/2019	14[3]
5/26/2020	330
6/1/2020	563[3]
6/2/2020	410
6/9/2020	52
6/9/2020	108[3]

Date	*E. coli* (MPN/100 ml)
6/23/2020	690
6/30/2020	10
6/30/2020	550[3]
7/7/2020	85
7/14/2020	52
7/14/2020	33[3]
7/21/2020	20
8/3/2020	223[3]
8/4/2020	< 10[2]
8/17/2020	11[3]
8/18/2020	20
8/25/2020	31
8/31/2020	5[3]
9/1/2020	< 10[2]
5/25/2021	1,000
6/1/2021	52
6/8/2021	< 10[2]
6/8/2021	5[3]

Date	*E. coli* (MPN/100 ml)
6/15/2021	< 10[2]
6/22/2021	< 10[2]
6/23/2021	292[3]
6/28/2021	52
7/7/2021	27[3]
7/13/2021	20
7/20/2021	440
7/27/2021	98
8/2/2021	10
8/9/2021	< 10[2]
8/17/2021	< 10[2]
8/23/2021	10
9/21/2021	136[3]
5/24/2022	< 10[2]
6/6/2022	< 10[2]
6/13/2022	390
6/20/2022	190
6/28/2022	1,800

Date	*E. coli* (MPN/100 ml)
7/5/2022	31
7/11/2022	7,300
7/19/2022	160
7/25/2022	10
8/1/2022	20
8/9/2022	10
8/16/2022	< 10[2]
8/22/2022	< 10[2]
8/29/2022	160
Min =	5
1st Quartile =	10
Median =	41
3rd Quartile =	175
Max =	160,000
Mean =	1,328

(1) Unless noted samples collected by the DNR as part of Ambient water quality monitoring.
(2) *E. coli* was not detectable. The minimum detection limit is 10 MPN/100 ml. Consequently, 5 MPN/100 ml was used in calculations.
(3) Samples collected by DNR as part of 2017 and 2018 study.

Table 12.A-2. Sand Sampling Data from Transects, North Twin Lake, Treman Park Beach.

Date	Row/ Transect	*E. coli* (MPN/cubic cm)			
		A	B	C	D
6/5/2019	1	17	8.5	< 0.1(1)	< 0.1(1)
	2	140	160	13	0.71
	3	5.3	270	100	40
6/18/2019	1	290	370	340	730
	2	40	460	96	16
	3	450	530	260	> 2,700(2)
7/18/2019	1	18	400	130	610
	2	34	440	76	2
	3	19	2,900	7100	> 26,000(2)
9/25/2019	1	1.1	7.5	< 0.1(1)	0.31
	2	2.2	6.3	25	50
	3	4.3	2,100	37	340
6/1/2020	1	31	16	0.19	3.5
	2	130	39	68	790
	3	84	810	16	79
6/9/2020	1	0.32	6.7	< 0.1(1)	0.22
	2	1.7	440	6	< 0.1(1)
	3	2.5	21	0.72	3.1
6/30/2020	1	62	4.2	1.8	8.3
	2	64	55	33	1.9
	3	37	160	20	2,400
7/14/2020	1	3.2	90	6	160
	2	3.2	25	17	< 0.1(1)
	3	69	72	5.2	53
8/3/2020	1	4.4	140	0.92	0.93
	2	16	28	< 0.1(1)	0.1
	3	270	65	11,000	130
8/17/2020	1	5.6	620	< 0.1(1)	< 0.1(1)
	2	7.9	44	0.1	< 0.1(1)
	3	20	270	0.2	3.1
6/3/2021	1	< 1(1)	1	< 1(1)	< 1(1)
	2	3.2	< 1(1)	7.9	< 1(1)
	3	1.1	10	< 1(1)	< 1(1)
7/7/2021	1	50	13	1,900	13
	2	2,300	97	1.1	76
	3	190	1.2	> 23,000(2)	16

(1) *E. coli* for the sample was not detected. The non-detectable limit recorded was divided in half for calculation purposes.
(2) Individual *E. coli* value was greater than the upper quantification limit. In these cases, the value listed was used for calculation purposes.

Table 12.A-3. Water Sampling Data from Transects, North Twin Lake, Treman Park Beach.

Date	Row/ Transect	E. coli (MPN/100 ml)								
		0	1	2	3	4	5	6	7	8
6/5/2019	1	< 10(1)	10	10	10	20	< 10(1)	10	---	---
	2	20	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---	---
	3	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---	---
	4	< 10(1)	10	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---	---
6/18/2019	1	1,600	330	140	160	310	380	330	---	---
	2	2,100	98	130	85	250	270	160	---	---
	3	560	120	63	110	41	74	41	---	---
	4	110	85	63	74	63	97	86	---	---
7/18/2019	1	860	31	10	10	20	10	< 10(1)	---	---
	2	400	120	41	31	< 10(1)	< 10(1)	10	---	---
	3	2,100	20	10	31	31	10	< 10(1)	---	---
	4	63	31	10	< 10(1)	< 10(1)	10	< 10(1)	---	---
9/25/2019	1	31	20	< 10(1)	10	10	< 10(1)	10	---	---
	2	10	< 10(1)	< 10(1)	< 10(1)	10	41	10	---	---
	3	10	20	< 10(1)	20	10	10	20	---	---
	4	31	10	10	31	< 10(1)	10	10	---	---
6/1/2020	1	640	210	280	31	---	---	---	---	---
	2	1,000	720	620	170	---	---	---	---	---
	3	1,900	730	290	160	---	---	---	---	---
	4	---	---	---	---	---	---	---	---	---
6/9/2020	1	74	20	< 10(1)	10	10	< 10(1)	< 10(1)	---	---
	2	510	130	< 10(1)	< 10(1)	< 10(1)	20	10	---	---
	3	700	160	85	< 10(1)	20	< 10(1)	< 10(1)	---	---
	4	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	31	---	---
6/30/2020	1	280	140	52	20	---	---	---	---	---
	2	1,300	2,500	< 10(1)	20	---	---	---	---	---
	3	2,100	150	30	< 10(1)	---	---	---	---	---
	4	---	---	---	---	---	---	---	---	---
7/14/2020	1	31	63	10	20	31	10	< 10(1)	---	---
	2	97	31	10	10	41	< 10(1)	20	---	---
	3	140	31	10	10	75	< 10(1)	< 10(1)	---	---
	4	10	30	< 10(1)	20	10	10	< 10(1)	---	---
8/3/2020	1	75	510	120	63	86	52	20	---	---
	2	180	97	75	98	110	10	31	---	---
	3	2,000	86	41	75	10	20	< 10(1)	---	---
	4	52	41	31	20	< 10(1)	10	31	---	---

Date	Row/ Transect	E. coli (MPN/100 ml)								
		0	1	2	3	4	5	6	7	8
8/17/2020	1	41	< 10(1)	10	< 10(1)	10	10	10	---	---
	2	< 10(1)	< 10(1)	31	10	10	20	< 10(1)	---	---
	3	20	10	10	< 10(1)	61	20	10	---	---
	4	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	10	20	---	---
8/31/2020	1	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	---	---
	2	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---	---
	3	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---	---
	4	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---	---
6/23/2021	1	1,100	250	10	52	160	41	< 10(1)	10	---
	2	1,300	560	140	170	160	20	20	31	---
	3	350	470	86	20	120	20	< 10(1)	< 10(1)	---
	4	84	52	20	10	41	< 10(1)	< 10(1)	20	---
7/7/2021	1	41	52	52	10	20	63	74	31	---
	2	84	31	< 10(1)	10	10	< 10(1)	< 10(1)	10	---
	3	20	50	< 10(1)	20	< 10(1)	20	20	52	---
	4	20	10	10	< 10(1)	10	< 10(1)	10	< 10(1)	---
9/21/2021	1	210	< 10(1)	< 10(1)	31	< 10(1)	94	< 10(1)	< 10(1)	---
	2	500	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	20	---
	3	1,300	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---
	4	< 10(1)	41	41	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	---

(1) *E. coli* for the sample was not detected. The minimum detection limit is 10.0 MPN/100 ml. 5.0 MPN/100 ml was used in calculations.

Appendix E. Public Participation

Public involvement is important in the TMDL process since it is the land owners, tenants, and citizens who directly manage land and live in the watershed that determine the water quality in the Iowa Lakes.

As additional beach bacteria TMDLs are prepared and public meetings held, Appendix E will be amended to reflect the new submittals.

E.1 Public Meetings

A public presentation was posted on the DNR's YouTube channel for public viewing on July 20, 2023. A link to the presentation was posted on the DNR;'s website at https://www.iowadnr.gov/environmental-protection/water-quality/watershed-improvement/water-improvement-plans. The presentation was available for viewing through the public comment period.

Table E-1 is a listing of past and current public meetings and presentations. The DNR will amend Table E-1 to reflect all additional beach bacteria meetings into the future.

Table E-1. Past Public Meetings.

Lake	Location	Date & Time	WQIP Chapter	Addendum No.
Hickory Grove Lake	Virtual - youtube.com/iowadnr	During Public Comment Period March 5, 2020-May 18, 2020	4	--
Clear Lake	Virtual - youtube.com/iowadnr	During Public Comment Period March 5, 2020-May 18, 2020	5	--
Nine Eagles Lake	Virtual - youtube.com/iowadnr	During Public Comment Period March 5, 2020-May 18, 2020	6	--
Brushy Creek Lake	Virtual - youtube.com/iowadnr	During Public Comment Period Sept. 2, 2021-Oct. 4, 2021	7	1
Lake Ahquabi	Virtual - youtube.com/iowadnr	During Public Comment Period Sept. 2, 2021-Oct. 4, 2021	8	1
Lake Macbride	Virtual - youtube.com/iowadnr	During Public Comment Period Sept. 2, 2021-Oct. 4, 2021	9	1
Prairie Rose Lake	Virtual - youtube.com/iowadnr	During Public Comment Period July 20, 2023-Aug. 21, 2023	10	2
Lake Keomah	Virtual - youtube.com/iowadnr	During Public Comment Period July 20, 2023-Aug. 21, 2023	11	2
North Twin Lake	Virtual - youtube.com/iowadnr	During Public Comment Period July 20, 2023-Aug. 21, 2023	12	2

E.2 Written Comments

A press release was issued on July 20, 2023 which began the 30-day public comment period that ended on August 21, 2023. During the public comment period the DNR received no public comments.

E.3 Public Comments

The DNR received no public comments on the Statewide Beach Bacteria TMDL, Addendum #2.