UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
11201 Renner Boulevard
Lenexa, Kansas 66219

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

RE: Approval of TMDL document for Statewide Beach Bacteria Addendum #1

Dear Ms. Lyon:

This letter responds to the *Escherichia coli* Total Maximum Daily Load submission from the Iowa Department of Natural Resources for Brushy Creek Lake, Lake Ahquabi, and Lake Macbride. This TMDL document was originally received by the U.S. Environmental Protection Agency, Region 7 on December 10, 2021. Following comments from the EPA, revisions were submitted on February 22, 2022, and March 22, 2022.

Brushy Creek Lake and Lake Ahquabi were identified on the 2012 Iowa Clean Water Act Section 303(d) List as not supporting their primary contact recreation uses. Lake Macbride was identified on the 2006 Iowa CWA Section 303(d) List as not supporting its primary contact recreation use. This submission fulfills the statutory requirement to develop TMDLs for impairments listed on a state's CWA Section 303(d) List. The specific impairments are:

Water Body Name	WBIDs	Causes
Brushy Creek Lake	IA 04-UDM-1276	*E. coli*
Lake Ahquabi	IA 04-LDM-1080	*E. coli*
Lake Macbride	IA 02-IOW-629	*E. coli*

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 March 22, 2022, for *E. coli* impairments for Brushy Creek Lake, Lake Ahquabi, and Lake Macbride. 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.

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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 #1 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, as appropriate, in future efforts by the Iowa DNR, to develop TMDLs. If you have any questions, contact Chelsea Paxson, of my staff, at (913) 551-7609.

Sincerely,

JEFFERY ROBICHAUD Digitally signed by JEFFERY ROBICHAUD
Date: 2022.04.26 08:12:10 -05'00'

Jeffery Robichaud
Director
Water Division

Enclosure

cc: Lori McDaniel, Water Quality Bureau Chief, Iowa DNR
Roger Bruner, Water Quality Bureau Supervisor, Iowa DNR
James Hallmark, TMDL Modeler, Iowa DNR

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

Statewide Beach Bacteria TMDL: Addendum #1
Iowa

Escherichia coli

JEFFERY ROBICHAUD Digitally signed by JEFFERY ROBICHAUD
Date: 2022.04.26 08:12:55 -05'00'

Jeffery Robichaud — Date
Director
Water Division

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EPA Region 7 TMDL Review

Submittal Date || Initial: December 10, 2021
|| Final: March 22, 2022 **Approved: Yes**

Statewide Beach Bacteria TMDL: Addendum 1

ATTAINs Action Identifier	IA 04-UDM-1276
State	Iowa
Document Name	Brushy Creek Lake TMDL
Basin(s)	Brushy Creek
HUC(s)	0710000405
Water body(ies)	Brushy Creek Lake
Tributary(ies)	Brushy Creek
Number of Segments	1 Lake Beach
Number of Segments for Protection 303(d)(3)	0
Causes	Recreational Use Impairment for *Escherichia coli*

ATTAINs Action Identifier	IA 04-LDM-1080
State	Iowa
Document Name	Lake Ahquabi TMDL
Basin(s)	Lower Squaw Creek
HUC(s)	071000080804
Water body(ies)	Lake Ahquabi
Tributary(ies)	Unnamed Stream
Number of Segments	1 Lake Beach
Number of Segments for Protection 303(d)(3)	0
Causes	Recreational Use Impairment for *Escherichia coli*

ATTAINs Action Identifier	IA 02-IOW-629
State	Iowa
Document Name	Lake Macbride TMDL
Basin(s)	Lake Macbride-Mill Creek
HUC(s)	070802081008
Water body(ies)	Lake Macbride
Tributary(ies)	Mill Creek and Jordan Creek
Number of Segments	1 Lake Beach
Number of Segments for Protection 303(d)(3)	0
Causes	Recreational Use Impairment for *Escherichia coli*

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 December 10, 2021. Following comments from the EPA, revisions were submitted on February 22, 2022 and March 22, 2022. The EPA approves the latest version of the TMDL document received on March 22, 2022.

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 first 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 Brushy Creek Lake (IA 04-UDM-1276), Lake Ahquabi (IA 04-LDM-1080), and Lake Macbride (IA 02-IOW-629). Each water body is listed on the Iowa 2020 list of impaired waters for *E. coli* impairment of the primary contact recreation use. These uses are designated through Iowa's *Surface Water Classification* as Brushy Creek Lake (numbers 366 and 623), Lake Ahquabi (number 606), and Lake Macbride (number 327).

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 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 of 235 organisms per 100 milliliters 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. $TMDL = LC = \Sigma WLA + \Sigma LA + MOS$

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).

Therefore, the daily maximum TMDL for Brushy Creek Lake is:

Equation 2. TMDL = LC ($4.67x10^9$ orgs/day) = ΣWLA (0 orgs/day) + ΣLA ($4.20x10^9$ orgs/day) + MOS ($4.67x10^8$ orgs/day)

Therefore, the daily maximum TMDL for Lake Ahquabi is:

Equation 3. TMDL = LC ($3.18x10^9$ orgs/day) = ΣWLA (0 orgs/day) + ΣLA ($2.86x10^9$ orgs/day) + MOS ($3.18x10^8$ orgs/day)

Therefore, the daily maximum TMDL for Lake Macbride is:

Equation 4. TMDL = LC ($4.37x10^9$ orgs/day) = ΣWLA (0 orgs/day) + ΣLA ($3.94x10^9$ orgs/day) + MOS ($4.37x10^8$ orgs/day)

The existing loads must be reduced by 54.1% at Brushy Creek Lake, 51.1% at Lake Ahquabi, and 59.1% at Lake Macbride. 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.

Brushy Creek Lake, Lake Ahquabi, and Lake Macbride 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, Lake Ahquabi is 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 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 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)).

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 WQS[1].

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 LC. 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 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 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 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 percent 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 percent 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 15th to November 15th, with particular emphasis on the summer months from May 23rd to September 7th when bacteria concentrations are 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 September 2, 2021 to October 4, 2021. A comment was received from the public and the Iowa DNR included the comment and response in Appendix E of the TMDL document.

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.

As there are no point sources located in the NSBE, reasonable assurances are not a required component of this TMDL document. 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.

December 1, 2021

Jeff Robichaud
U.S. EPA, Region VII
11201 Renner Blvd.
Lenexa, KS 66219

Subject: Submittal of Statewide Beach Bacteria TMDL, Addendum #1 for EPA approval

Dear Mr. Robichaud:

Enclosed is the Final Statewide Beach Bacteria Total Maximum Daily Load, Addendum #1 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:

- Brushy Creek Lake
- Lake Ahquabi
- Lake Macbride

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 September 2, 2021 until October 4, 2021. 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 DNR receive one public comment on the draft. The comment and Iowa DNRs response can be found at the end of the document.

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: 2021.12.07 16:25:57 -06'00'

Kayla Lyon, Director
Department of Natural Resources

Enclosure

Addendum #1 Statewide Beach Bacteria TMDL
Summary of Updates

This addendum to the Statewide Beach Bacteria TMDL addresses bacteria TMDL's at three lakes: Brushy Creek Lake, Lake Ahquabi, and Lake Macbride.

This document addresses tables, figures, table of contents, list of figures, list of tables, and appendices that require updating to reflect the TMDL's addressed in this addendum. In addition, this document includes new TMDL chapters for Brushy Creek Lake (Chapter 7), Lake Ahquabi (Chapter 8), and Lake Macbride (Chapter 9). 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 #1 in the header. This figure was updated from the 2016 assessment cycle to the pending 2020 assessment cycle. Updates include identifying beach bacteria TMDL's that have been approved, beaches that have been delisted, potential future projects, and beach bacteria TMDL's that are included with the current addendum.
- Replace Table 1 with the attached Table 1 identified with Addendum #1 in the header. This table was updated from the 2016 assessment cycle to the pending 2020 assessment cycle. Updates include identifying beach bacteria TMDL's that have been approved, beaches that have been delisted, and beach bacteria TMDL's that are included with the current addendum.
- Insert Chapter 7, Brushy Creek TMDL.
- Insert Chapter 8, Lake Ahquabi TMDL.
- Insert Chapter 9, Lake Macbride TMDL.
- Replace Appendix E. Public Participation with the attached Appendix E. Public Participation identified with Addendum #1 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 #1

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

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

Iowa Department of Natural Resources
Watershed Improvement Section
2022

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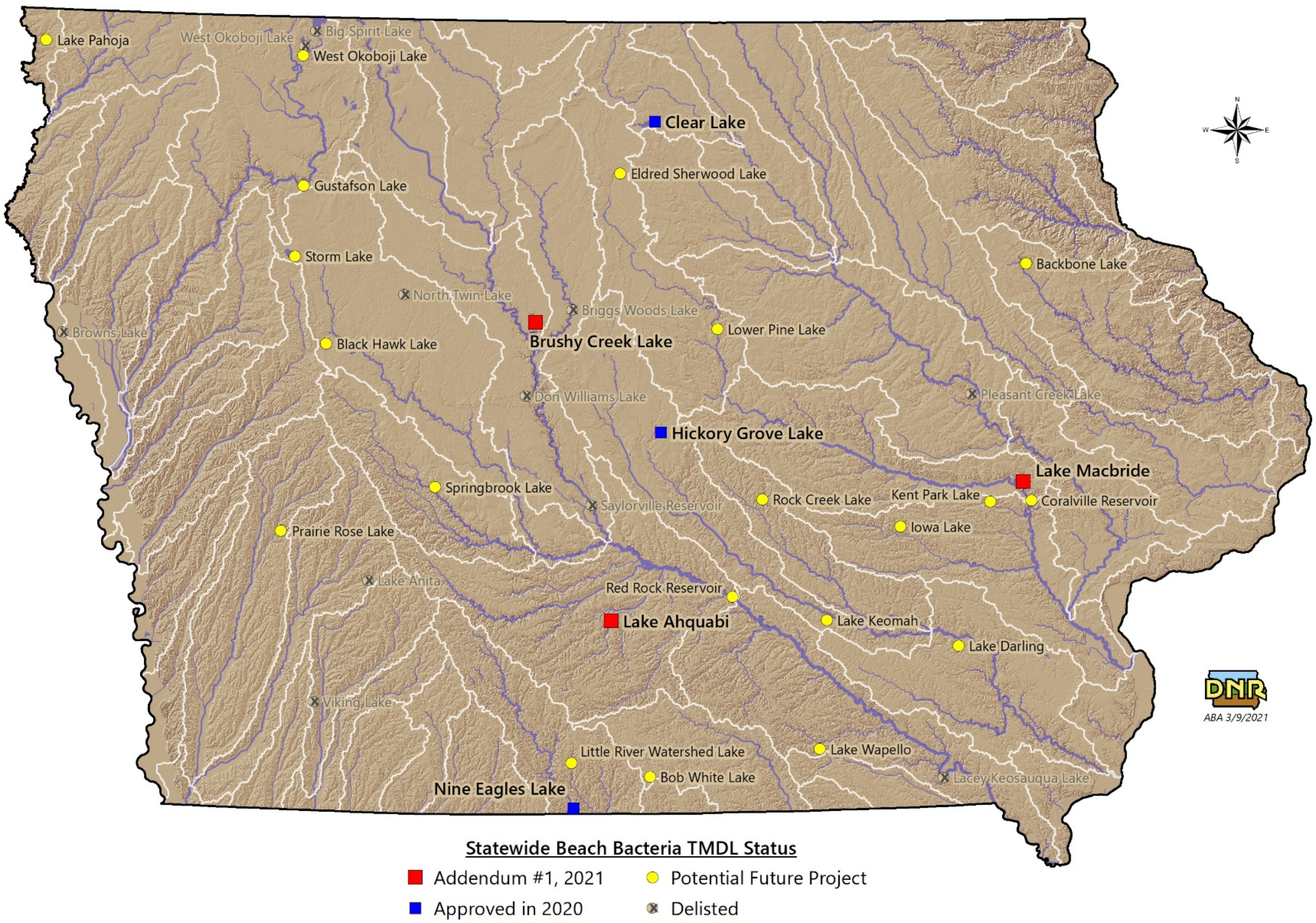

Figure 1. Location Map of Lakes Impaired for *E. coli*.

Table 1. Impaired Lakes for *E. coli*.

Lake Name	Chapter[3]	TMDL Year Submitted[4]	ADB Code	HUC-8 Subbasin	County	Cycle Listed
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
Brushy Creek Lake	7	2021[2]	04-UDM-1276	Middle Des Moines	Webster	2012
Clear Lake[1] Clear Lake St Park McIntosh Woods	5	2020	02-WIN-841	Winnebago	Cerro Gordo	 2004 2010
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
Hickory Grove Lake	4	2020	03-SSK-950	South Skunk	Story	2008
Iowa Lake	---	---	02-IOW-677	Lower Iowa	Iowa	2012
Kent Park Lake	---	---	02-IOW-694	Lower Iowa	Johnson	2014
Lake Ahquabi	8	2021[2]	04-LDM-1080	Lake Red Rock	Warren	2012
Lake Darling			03-SKU-924	Skunk	Washington	2018
Lake Keomah	---	---	03-SSK-930	South Skunk	Mahaska	2008
Lake Macbride	9	2021[2]	02-IOW-629	Middle Iowa	Johnson	2006
Lake Pahoja	---	---	06-BSR-1532	Lower Big Sioux	Lyon	2016
Lake Wapello	---	---	04-LDM-1035	Lower Des Moines	Davis	2012
Little River Lake	---	---	05-GRA-1358	Thompson	Decatur	2014
Lower Pine Lake	---	---	02-IOW-758	Upper Iowa	Hardin	2006
Nine Eagles Lake	6	2020	05-GRA-1361	Thompson	Decatur	2006
Prairie Rose Lake	---	---	05-NSH-1462	West Nishnabotna	Shelby	2012
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
Briggs Woods Lake	Delisted	2018	04-UDM-1255	Boone	Hamilton	2016
Browns Lake	Delisted	2018	06-WEM-1735	Blackbird-Soldier	Woodbury	2008

Lake Name	Chapter(3)	TMDL Year Submitted(4)	ADB Code	HUC-8 Subbasin	County	Cycle Listed
Lacey Keosauqua Lake	Delisted	2018	04-LDM-1008	Lower Des Moines	Van Buren	2012
Lake Anita	Delisted	2018	05-NSH-1435	East Nishnabotna	Cass	2010
Saylorville Reservoir	Delisted	2018	04-UDM-1213	Middle Des Moines	Polk	2006
West Okoboji Lake	Delisted	2018	06-LSR-1653	Little Sioux	Dickinson	2014
Big Spirit Lake	Delisted	2020	06-LSR-1655	Little Sioux	Dickinson	2008
Don Williams Lake	Delisted	2020	04-UDM-1249	Middle Des Moines	Boone	2018
North Twin Lake	Delisted	2020	04-RAC-1167	North Raccoon	Calhoun	2012
Pleasant Creek Lake	Delisted	2020	02-CED-459	Middle Cedar	Linn	2012
Viking Lake	Delisted	2020	05-NOD-1407	West Nodaway	Montgomery	2006

(1) 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.

(2) Addendum #1

(3) This column lists the associated chapter of the lake TMDL or if the lake has been delisted it will have the designation "Delisted".

(4) This column indicates the year the TMDL was submitted or if the lake has been delisted it is the year of the assessment cycle in which it was delisted.

7. Brushy Creek Lake TMDL

7.1. Description and History of Brushy Creek Lake

Brushy Creek Lake, IA 04-UDM-1276, is located in Washington Township, Webster County, Iowa approximately 5 miles east of Lehigh, 16.5 miles southwest of Webster City, and 17 miles southeast of Fort Dodge. The lake was constructed in 1998 and is located within the 6,500-acre Brushy Creek State Recreation Area, which is owned and operated by the Iowa DNR. 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 57,000 acres, a maximum depth of 77.5 feet, a shore length of approximately 17.3 miles, and an approximate volume of 18,410 acre-feet. Figure 7-1 is an aerial photograph with the boundaries of the watershed. Table 7-1 is a summary of the lake and watershed properties.

Table 7-1. Brushy Creek Lake Watershed and Lake Information.

Waterbody Name	Brushy Creek Lake
Waterbody ID	IA 04-UDM-1276
10 Digit Hydrologic Unit Code (HUC)	0710000405
HUC-10 Name	Brushy Creek
Location (Ambient Monitoring Site)	Section 34, T88N, R27W, Webster County Iowa
Water Quality Standard Designated Uses	Class A1 Primary Contact Recreation Class B(LW) Aquatic Life Class HH Human Health
Antidegredation Protection Level	Tier 1
Tributaries	Brushy Creek
Receiving Waterbody	Brushy Creek to Des Moines River
Watershed Area	57,028 acres
Lake Surface Area(1)	690 acres
Maximum Depth(1)	77.5 feet
Volume(1)	18,410 ac-feet
Length of Shoreline	17.3 miles
Watershed/Lake Area Ratio	81.6:1

(1) Per June 2013 Bathymetric Survey.

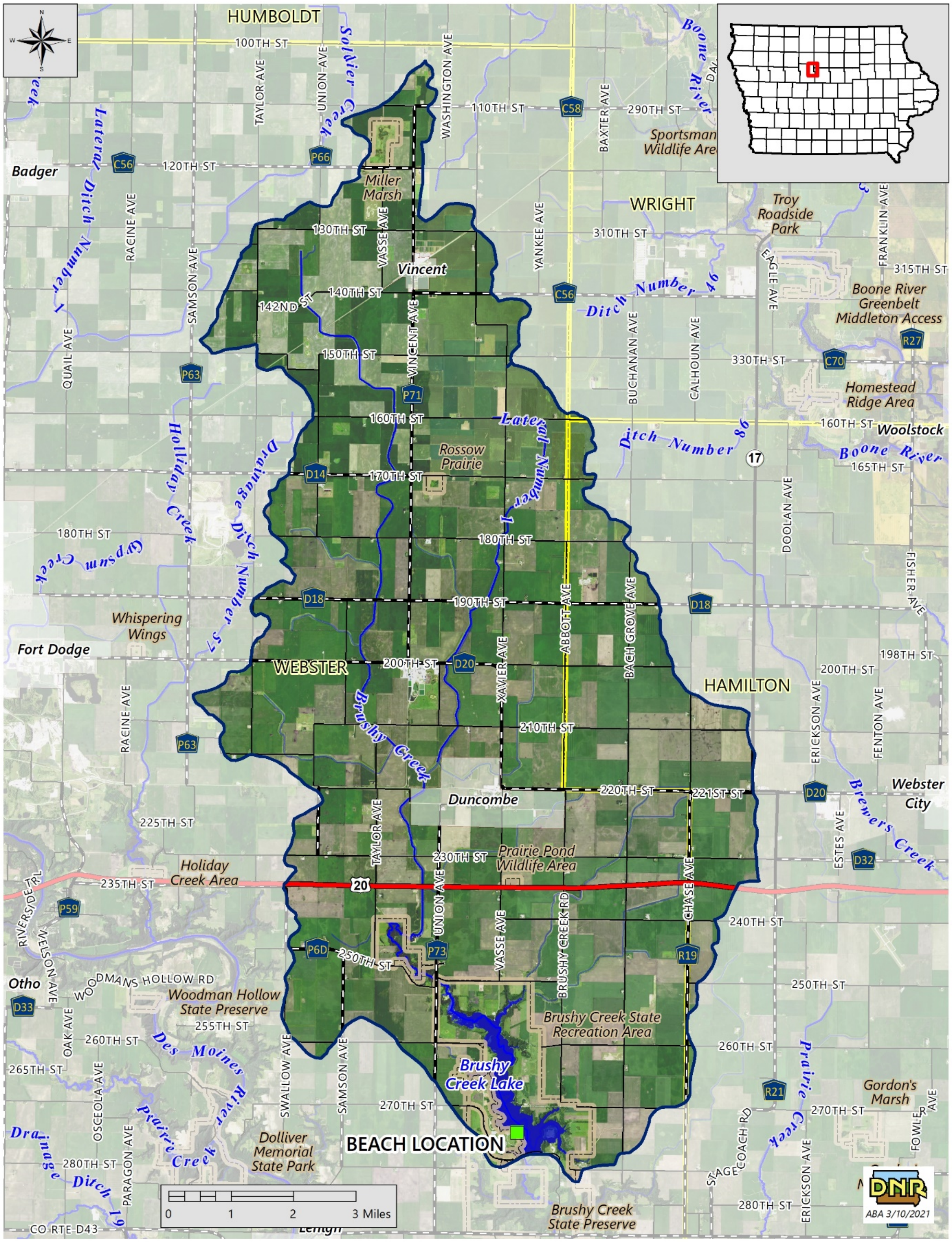

Figure 7-1. Brushy Creek Lake Watershed.

Land Use

A Geographic Information System (GIS) coverage of land use information was developed using the 2014 USDA Cropland Data Layer (USDA, National Agricultural Statistics Service). The dominate land use is row crops (corn and soybeans rotations) making up approximately 84.1% (Table 7-2). The eight land uses shown in Table 7-2 were aggregated from the fourteen land uses in the cropland data layer as shown in the description column. Figure 7-2 shows the distribution of the various land uses throughout the Brushy Creek Lake watershed in a pie-chart.

Table 7-2. Brushy Creek Lake Watershed Land Uses.

Land Use	Description	Area (AC)	Percent of total
Water/Wetland	Water and Wetlands	806	1.4%
Forested	Bottomland, Coniferous, Deciduous	838	1.5%
Grassland	Ungrazed, Grazed, & CRP-	3,883	6.8%
Alfalfa/Hay	Perennial Hay Crop-	188	0.3%
Row Crop	Corn, Soybeans, & other	47,936	84.1%
Roads	Roads Lightly Developed Urban	2,637	4.6%
Urban	Intensively Developed Urban	704	1.2%
Barren	Barren Land	36	0.1%
Total		**57,028**	**100.0%**

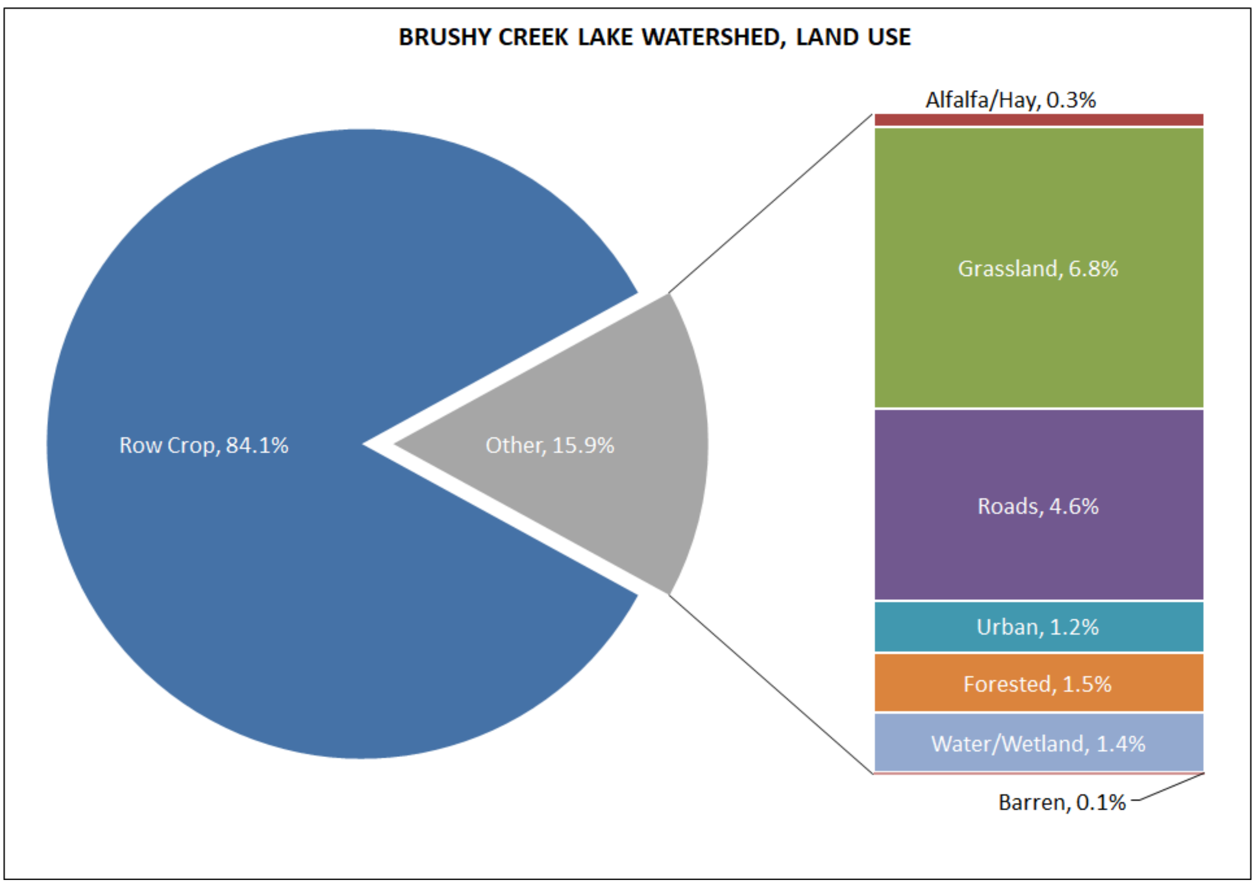

Figure 7-2. Land Use Composition of the Brushy Creek Lake Watershed.

Hydrology, Soils, Climate, Topography
From data obtained from the NRCS, there are four main soils types in this watershed. No soil type makes up a majority in the area. Four soils, the Webster, Canisteo, Nicollet, and Clarion soils make up 86% of soil types in the watershed. Hydrologic soil type B/D makes up the majority of the soils in the watershed at 66.5%. The topography for the Brushy Creek Lake watershed consists of relatively flat uplands with a few prairie pothole features typical of the upper Des Moines Lobe landform region that it occupies. As a result, the upland slopes tend to be less than 3 percent.

The average rainfall for the Brushy Creek Lake watershed from 2008 through 2020 is 37.7 inches with the majority (72%) falling between April 1st and September 30th. Lake evapotranspiration averages 39.6 inches per year with more occurring in dryer years on average. Figure 7-3 shows the annual rainfall and reference evapotranspiration from 2008 to 2020. Figure 7-4 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.

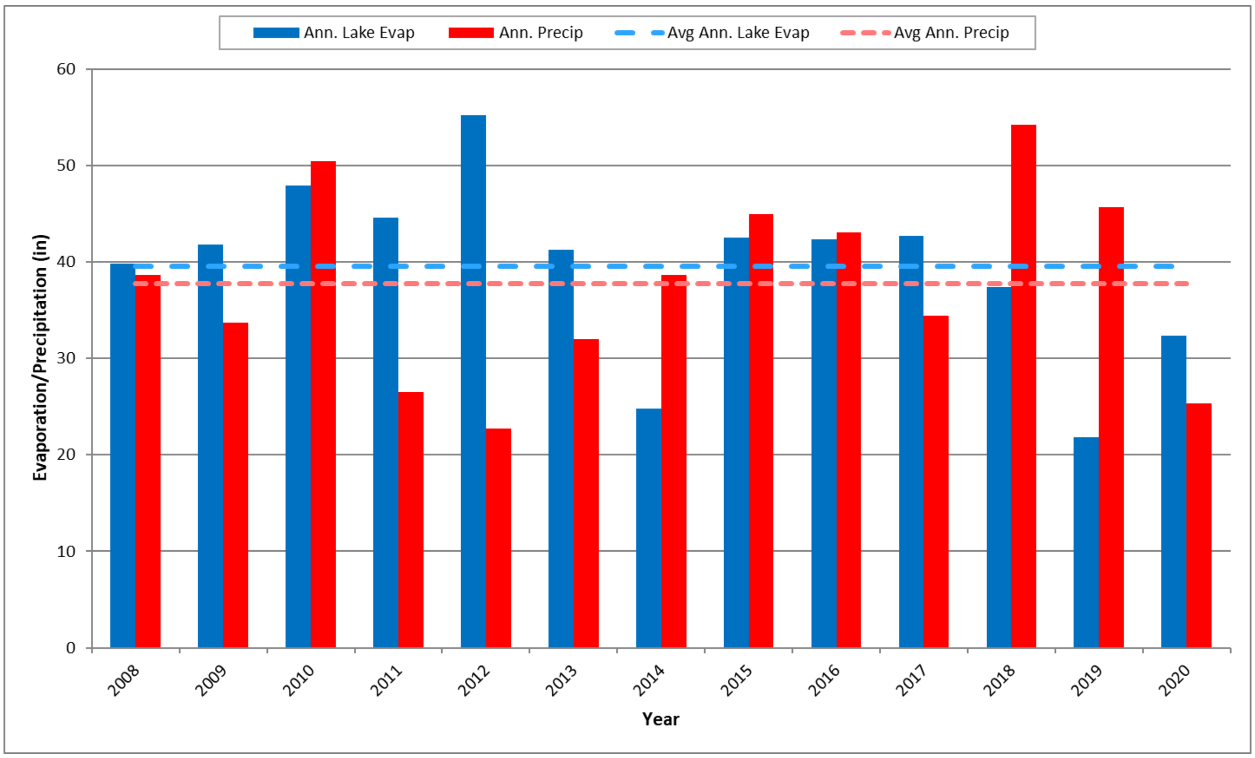

Figure 7-3. Annual Rainfall and Estimated Evapotranspiration Totals, Brushy Creek Watershed.

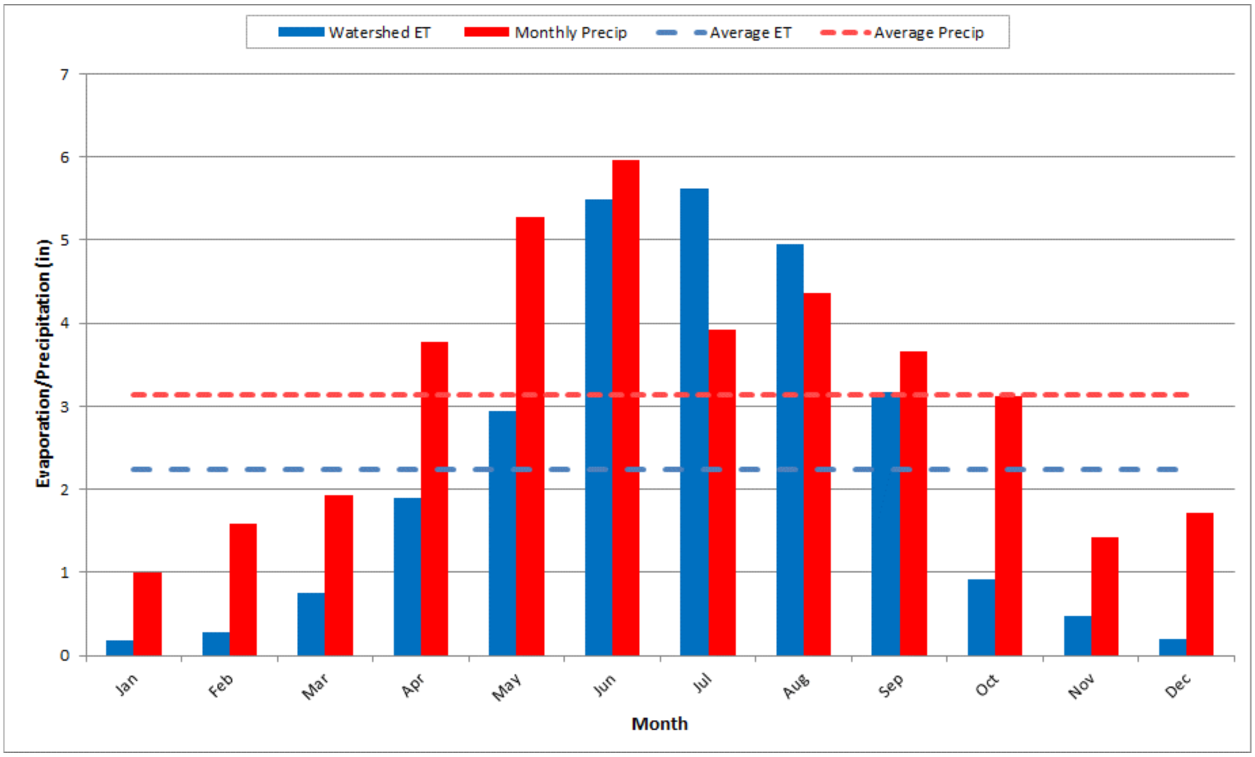

Figure 7-4. Monthly Rainfall and Estimated Evapotranspiration Totals, Brushy Creek Watershed.

7.2. 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 based impairments result in whole lake waterbodies being listed as impaired on the states 303(d) list each cycle. 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 (section 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 Brushy Creek Beach on Brushy Creek Lake (IA 04-UDM-1276).

Sampling and Data Collection

Beach, open lake and alternate transects as well as open lake sampling points were sampled seasonally and in response to wet weather events from spring 2017 through the fall of 2018 (Figure 7-5). All water and sand sample collection and laboratory analysis was conducted following protocols highlighted in Section 2.3.

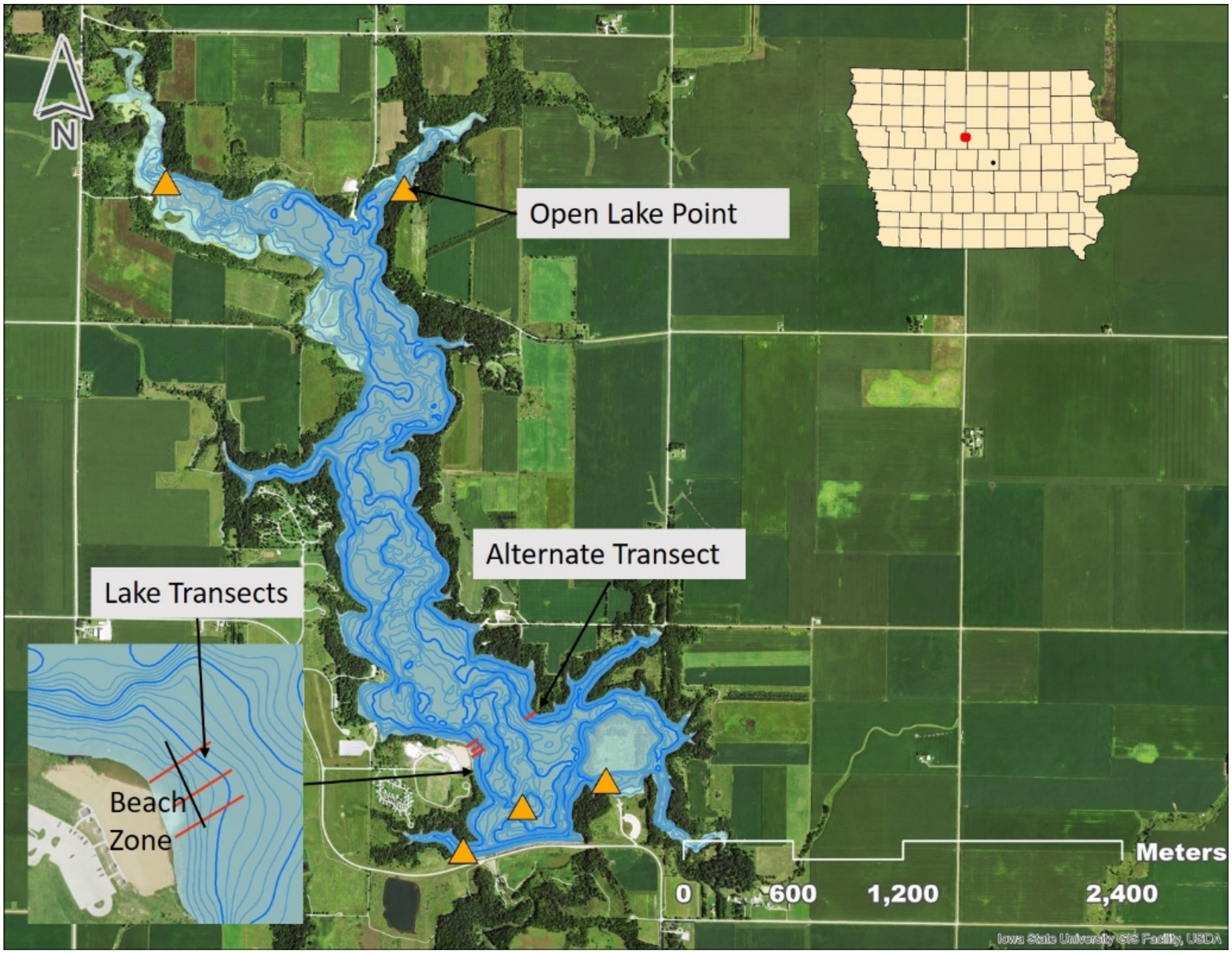

Figure 7-5. Overview of Monitoring Locations on Brushy Creek Lake.

Sampling Results and Analysis
Data collected from the beach sand environment during both seasons showed a wide range of variability (Table 7-3). However, median sample *E. coli* concentrations were well above detection limits of (0.1 MPN/gram). This trend is consistent with analysis conducted on other systems in Iowa (Section 2.4).

Table 7-3. Basic Statistics from Bacteria Sampling at Brushy Creek Lake.

Sampling Dataset	N	Mean	Median	St. Dev.	25^{th} %	75^{th} %
Brushy Creek Swimming Zone	168	232	20	933	5	86
Brushy Creek Lake Transects	195	19	5	27	5	20
Brushy Creek Open Lake	52	145	5	531	5	28
Brushy Creek Beach Sand	174	49	2.4	190	0.1	14.8

Water results reported as MPN/ 100mL and sand results reported as MPN/dry wt. gram

Water sample collection in the nearshore swimming zone showed a high degree of variability. Sample results commonly varied by hundreds of MPN/ 100mL, 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 very low *E. coli* concentrations as median dataset concentrations were only slightly above the detection limit of 10 MPN/ 100mL (Table 7-

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 year sampling effort at Brushy Creek, the swimming area met recreational standards (235 MPN/ 100mL) during ten of the fourteen 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/ 100mL and relatively low standard deviations, indicating overall low concentrations in these environments.

Beach sand sampling conducted at Brushy Creek Beach revealed trends consistent with prior surveys (Section 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 A and B were significantly higher in *E. coli* concentrations than C or D (P<0.01). As with prior surveys, the sands on Brushy Creek Beach had *E. coli* concentrations many times higher than observed in adjacent swimming waters (Figure 7-6). Beach sand *E. coli* concentrations averaged over 900 times higher than those observed in adjacent swimming areas during the two-year sampling period. 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 Section 2.

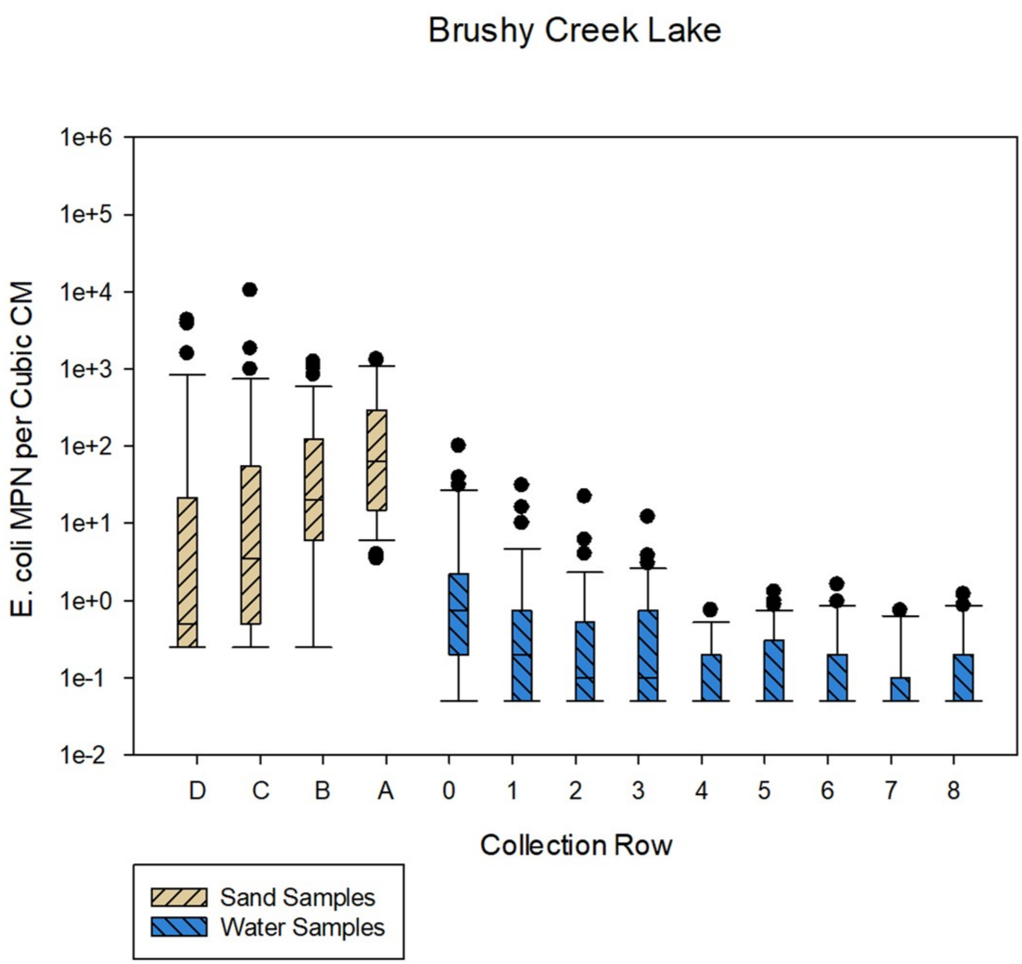

Figure 7-6. Box Plots of Sand and Water Sampling from Transects along Brushy Creek Beach. Reported in MPN/per cubic cm. Sampling points in figure correspond to following locations in relation to shoreline: A=shoreline, B (+2.5 m), C (+5m), D (+10M), 0 (Ankle deep), 1 (Knee deep), 2 (waist deep), 3 (chest 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 7-7) 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 Brushy Creek monitoring network uncovered trends and associations that closely mimicked findings of previous beach investigations (Section 2). Results highlighted in Table 7-4 demonstrate the dissassociation 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 (Section 2). The findings from this analysis validate the decision to address the *E. coli* bacteria impairments at Brushy Creek Lake Beach with a framework that directly addresses beach specific sources of *E. coli*.

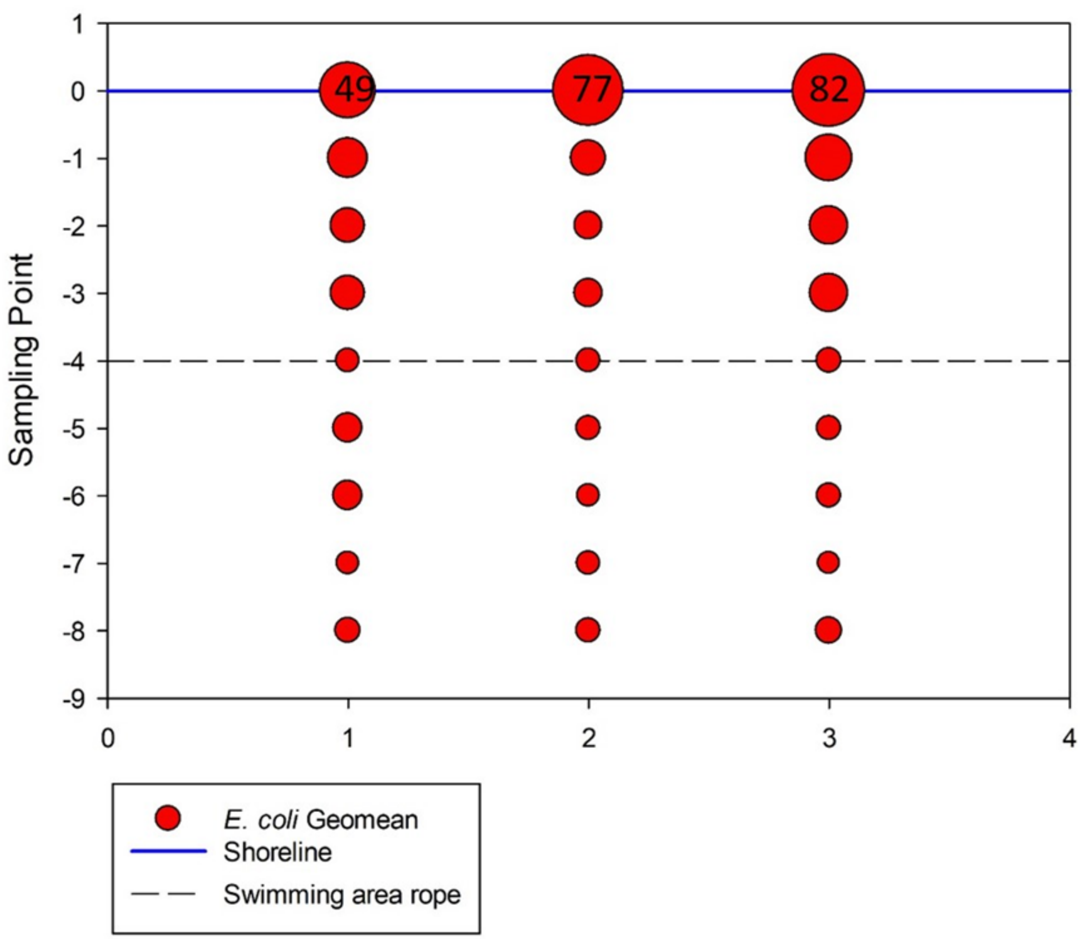

Figure 7-7. Bubble Plot of *E. coli* Sampling at Brushy Creek Beach Lake Transects Reported as MPN/ 100mL.

Table 7-4. Analysis Results from Brushy Creek 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

7.3. TMDL for Brushy Creek Lake Beach.

The 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 Brushy Creek State Park. Assessments conducted on the Brushy Creek beach and lake system (Section 7.2) 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

Brushy Creek Lake, IA 04-UDM-1276, was included on the 2012 303(d) impaired waters list for not fully supporting Class A1 (primary contact recreation) uses due to the presence of high levels of *E. coli*. Samples were collected during the recreational season (March 15 – November 15) between 2008 – 2020 as part of the state's ambient water quality monitoring and assessment program.

In 2017 and 2018 additional water quality samples were collected by the Iowa DNR to study and assess the relationships between the nearshore beach environment and open lake conditions. Results of this study are presented in Section 7.2

Applicable Water Quality Standards

The designated uses of Brushy Creek 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.
- 567-61.2(2)(c) Tier 2½ protection—outstanding Iowa waters. Where high quality waters constitute an outstanding state resource, such as waters of exceptional recreational or ecological significance, that water quality shall 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 7-8 shows the swimming and beach shed areas of Brushy Creek Lake. Table 7-5 is a summary of the NSBV data.

Figure 7-8. Swimming and Beach Shed Areas, Brushy Creek Lake.

Table 7-5. Brushy Creek NSBV Data.

Near Shore Beach Volume	1.61 acre-feet
Beach Front Length	649.8 feet
Radius from Shore at midpoint of beach	97.8 feet
Depth at Radius	4.9 feet (Elevation 1,049.1)
Beach Shed Area	6.5 Acres

Data Sources and Monitoring Sites

Table 7-6 lists the water quality monitoring locations used to develop the WQIP for Brushy Creek Lake. Figure 7-9 shows the monitoring locations used. In addition to these sites, samples were collected adjacent to the beach along three transects as shown in Figure 7-10. For a more detailed description of the samples collected along the transects see Section 7.2.

Table 7-6. WQ Data Monitoring Sites at Brushy Creek Lake.

Site Name	Site ID	Longitude	Latitude
Brushy Inlet 1(1)	14000195	94° 00' 14"	42° 25' 11"
Brushy Inlet 2 (1)	14000196	93° 59' 20"	42° 25' 11"
Brushy Inlet 4 (1)	14000198	93° 59' 06"	42° 23' 14"
Brushy Inlet 5 (1)	14000199	93° 58' 15"	42° 23' 18"
Brushy Creek Lake(2)	29940002	93° 58' 50"	42° 23' 21"
Brushy Creek Beach(1) (2)	21940001	93° 59' 04"	42° 23' 32"

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

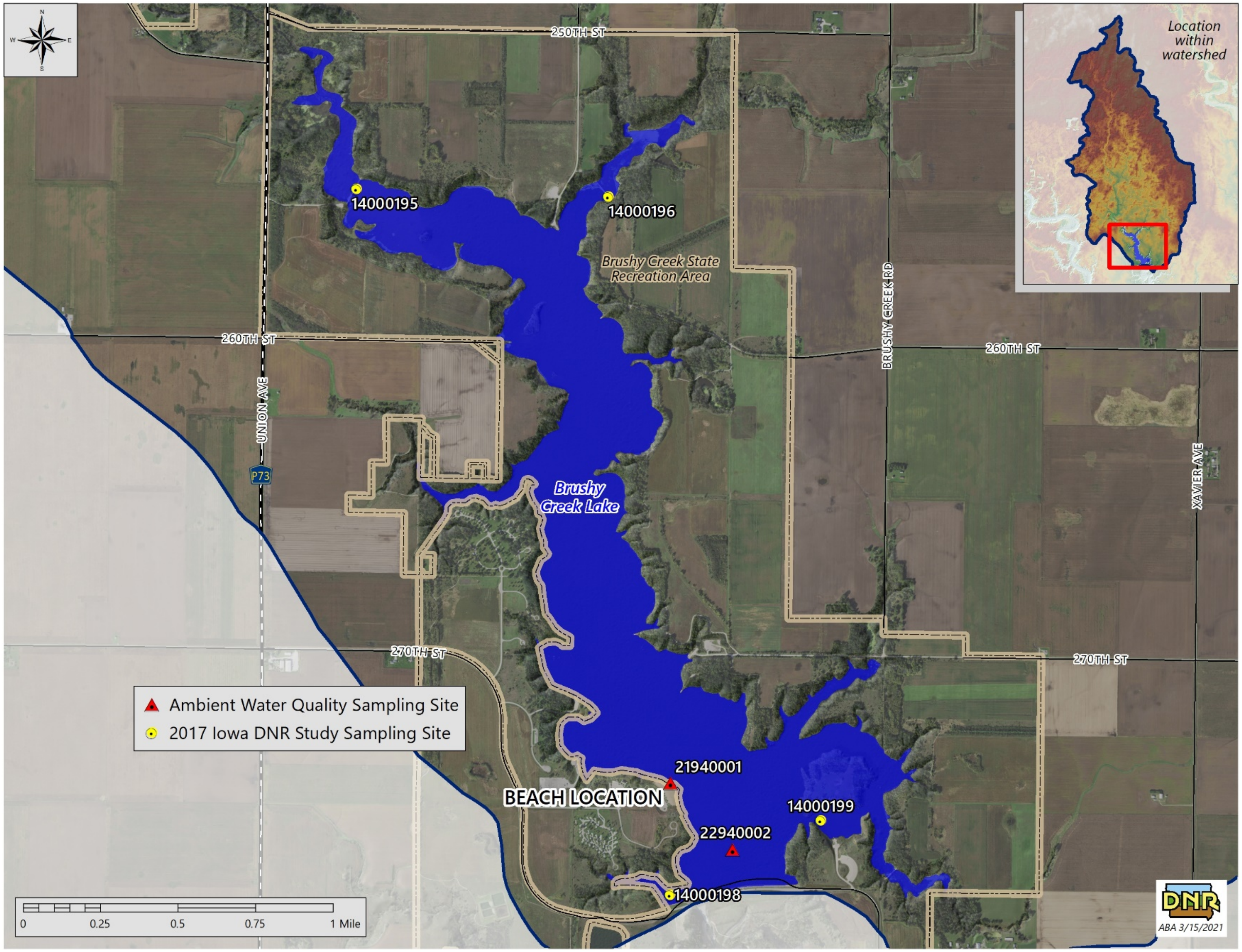

Figure 7-9. Sampling Locations, Brushy Creek Lake.

Figure 7-10. Nearshore Beach Sampling Locations, Brushy Creek Lake.

Interpretation of Data
Using data collected from 2008 – 2020, two box plots were developed. Figure 7-11 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 line representing the SSM concentration of 235 orgs/ 100 mL.

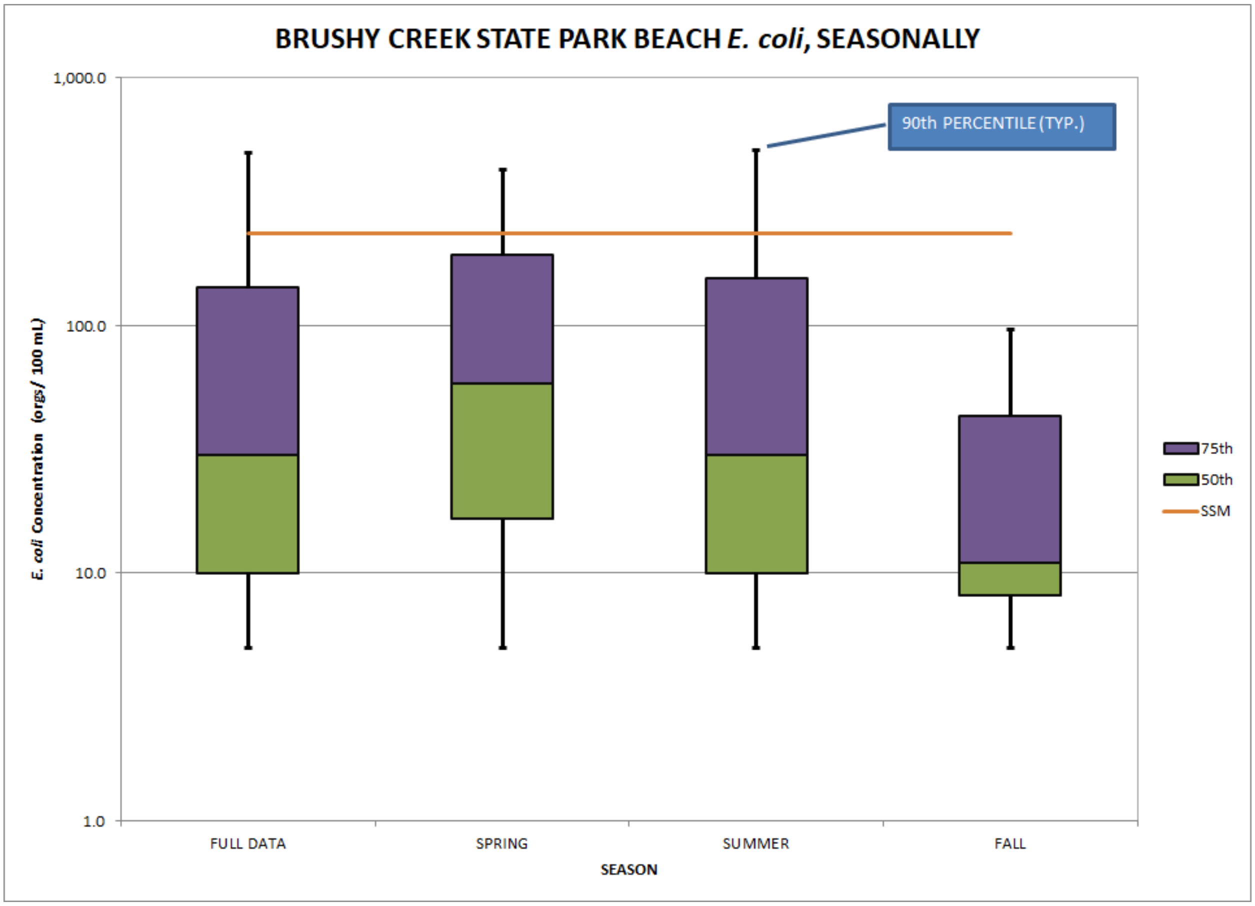

Figure 7-11. Seasonal Box Plot, Brushy Creek Lake.

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 20 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 7-11, there are elevated levels of bacteria during the spring and summer seasons at the Brushy Creek Lake beach.

In the second box plot graph, Figure 7-12, data is categorized by month. This box plot has the same format as previously described. This figure shows *E. coli* levels are elevated during the spring and summer months, decreases in September, and peaks in May. The elevated *E. coli* levels in the spring could be attributed to the large number of geese observed loafing on the beach in the spring.

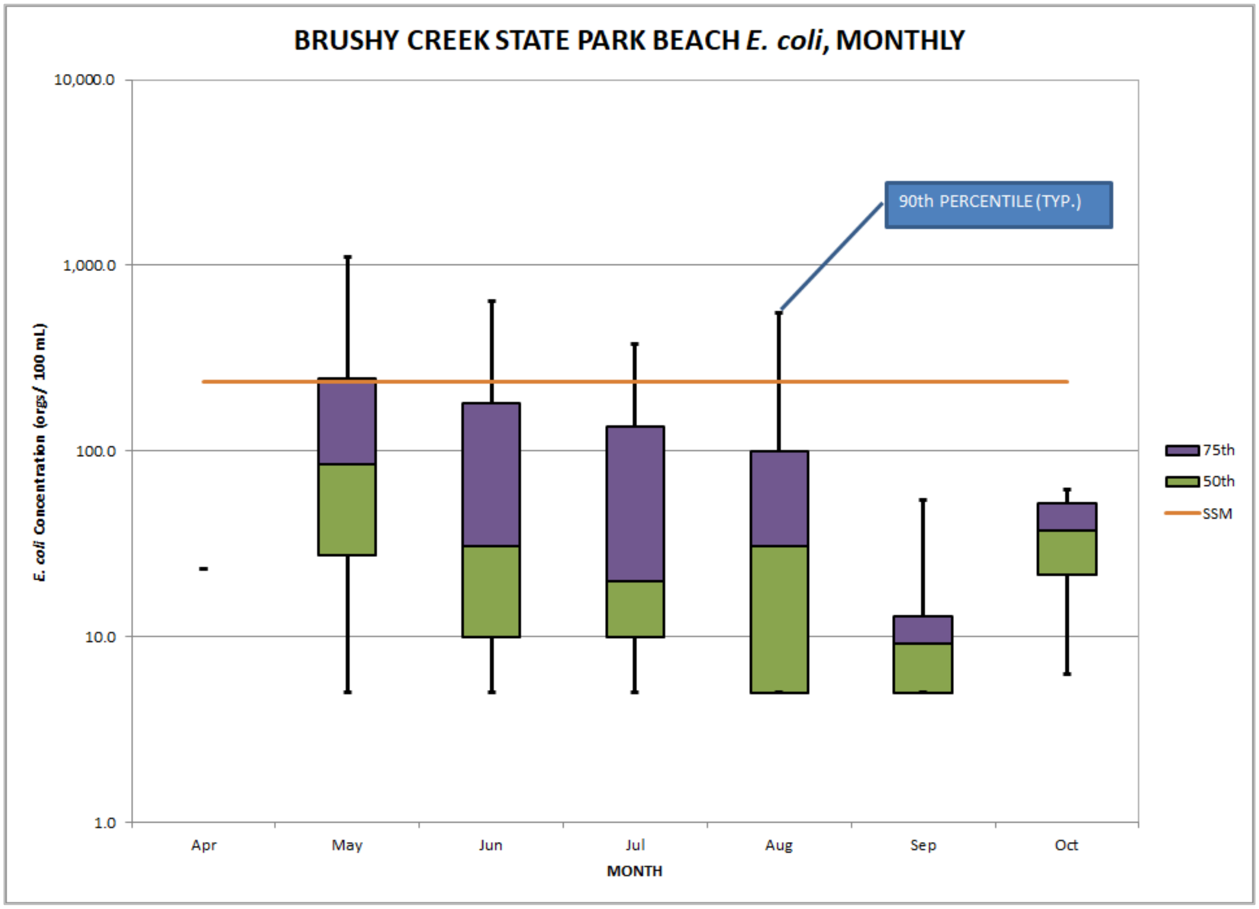

Figure 7-12. Monthly Box Plot, Brushy Creek Lake.

7.3.1. 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 to November 15. The critical volume is the NSBV, which is adjacent to the beach area.

Consideration of Seasonal Variation

These TMDL's were developed based on the Iowa WQS primary contact recreation season that runs from March 15 to 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 Brushy Creek Lake are based on the assumption 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 7-13 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.

7.3.2. Pollution Source Assessment

Departure from Load Capacity
The seasonal load curve and observed loads for the seasonal load conditions are plotted in Figure 7-13. 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.

7.3.3. Pollutant Allocations

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

Load Allocation (LA)
Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the stream. Specific examples of potential nonpoint sources of bacteria include animals directly depositing into streams, 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 2-year study presented in Chapter 2 and Section 7.2 of this WQIP the source of the impairment is from the near shore beach environment. The main source of *E. coli* is from waterfowl and shore birds loafing on the beach and 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 7-13 shows a seasonal load curve for the NSBV at Brushy Creek Lake. Table 7-7 and Table 7-8 are the existing load estimates and the TMDL summary, respectively for the NSBV at Brushy Creek Lake.

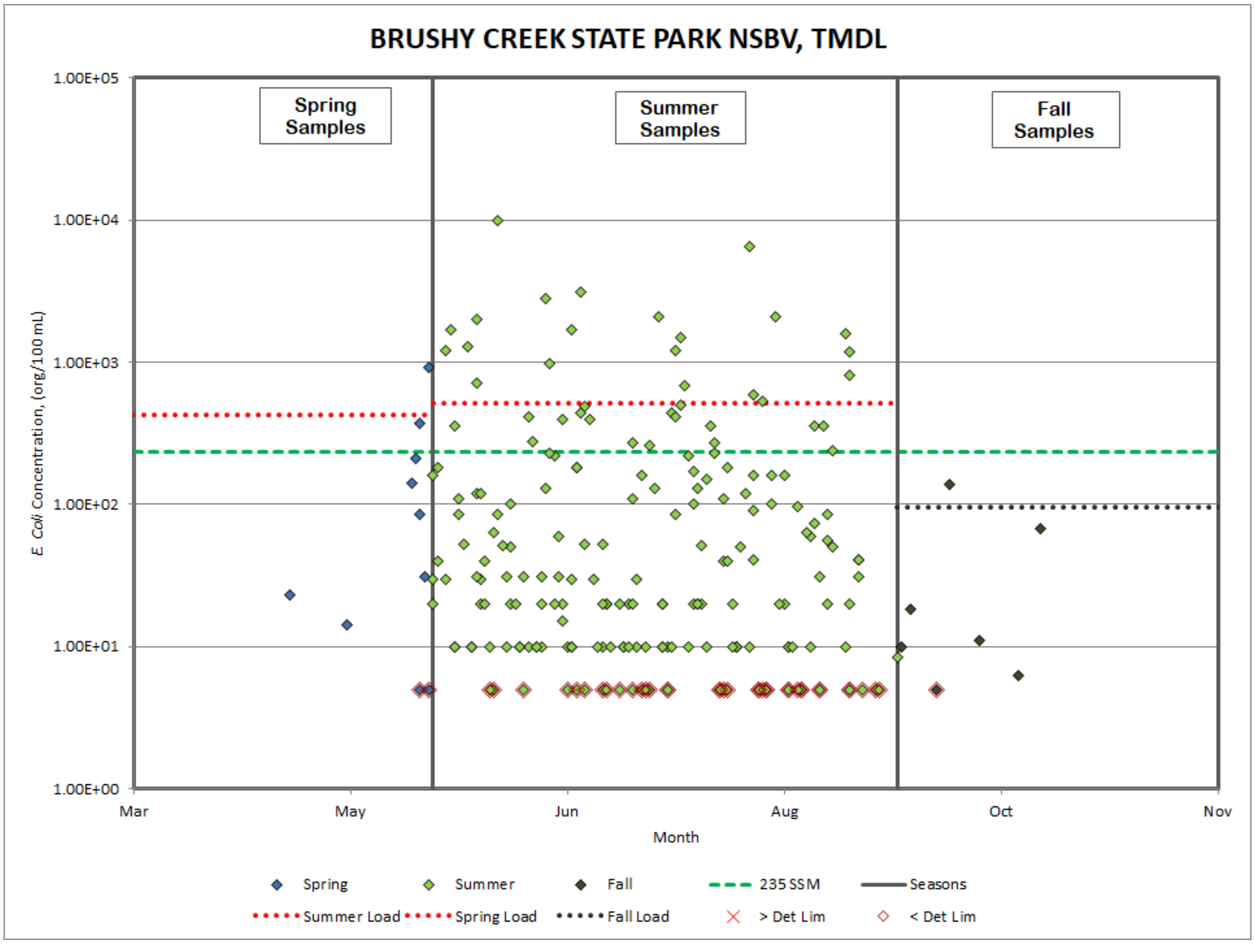

Figure 7-13. Seasonal Load Curve, Brushy Creek Lake, Near Shore Beach Volume.

Table 7-7. Existing Load Estimates for the NSBV at Brushy Creek Lake.

Load Summary	Seasonal Loads (org/ 100 mL)		
	Spring(1)	Summer	Fall
Observed Load(2)	424.4	512.0	96.5
Departure	189.4	277.0	N/A
(% Reduction)	(44.6)	(54.1)	(0)

(1) Not assessed as impaired. Number of samples did not exceed the significantly greater than 10% SSM criterion of 235 orgs/ 100 mL.
(2) Observed load is the 90th percentile of water quality samples.

Table 7-8 is a summary of the TMDL for the NSBV at Brushy Creek Lake. Because it is assumed that the NSVB is constant from year to year, the TMDL calculations do not change from season to season.

Table 7-8. TMDL Summary for the NSBV at Brushy Creek Lake.

	TMDL
TMDL (org/ 100 mL)	235.0
WLA (org/ 100 mL)	0.0
LA (org/ 100 mL)	211.5
MOS (org/ 100 mL))	23.5

7.3.4. TMDL Summary

This TMDL is based on meeting the water quality criteria for primary contact and children's recreation in Brushy Creek 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 7-8 and a NSBV of 1.6 acre-feet, the TMDL for Brushy Creek Lake as a mass loading is presented in Table 7-9.

Table 7-9. Summary of Brushy Creek Lake.

	TMDL
TMDL (orgs/day)	4.67E+09
WLA (orgs/day)	0.00E+00
LA (orgs/day)	4.20E+09
MOS (orgs/day)	4.67E+08

Appendix 7.A. Water Quality Data

Table 7.A-1. Water Quality Sampling Data, Beach Monitoring, Brushy Creek Lake, SITE ID 21940001.

Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)
5/20/2008	< 10[2]	7/8/2009	< 10[2]	7/26/2011	360
5/28/2008	10	7/14/2009	2,100	8/1/2011	10
6/3/2008	30	7/15/2009	10	8/9/2011	160
6/4/2008	40	7/21/2009	220	8/16/2011	< 10[2]
6/10/2008	100	7/23/2009	20	8/23/2011	240
6/18/2008	130	7/28/2009	< 10[2]	8/29/2011	31
6/24/2008	30	7/29/2009	< 10[2]	5/23/2012	30
6/25/2008	< 10[2]	8/4/2009	6,500	5/29/2012	85
7/1/2008	< 10[2]	8/5/2009	160	6/5/2012	10
7/2/2008	20	8/11/2009	20	6/12/2012	10
7/8/2008	270	8/13/2009	< 10[2]	6/19/2012	990
7/9/2008	30	8/18/2009	10	6/25/2012	180
7/15/2008	20	8/27/2009	20	7/2/2012	< 10[2]
7/16/2008	10	9/3/2009	< 10[2]	7/10/2012	< 10[2]
7/22/2008	100	5/24/2010	40	7/16/2012	< 10[2]
7/23/2008	130	6/2/2010	2,000	7/24/2012	51
7/29/2008	40	6/7/2010	10,000	7/31/2012	20
7/30/2008	40	6/14/2010	410	8/7/2012	< 10[2]
8/5/2008	90	6/21/2010	60	8/13/2012	10
8/6/2008	< 10[2]	6/28/2010	400	8/20/2012	< 10[2]
8/12/2008	20	7/6/2010	10	8/27/2012	< 10[2]
8/13/2008	10	7/8/2010	20	5/20/2013	86
8/18/2008	60	7/12/2010	< 10[2]	5/28/2013	360
8/26/2008	1,600	7/19/2010	500	6/3/2013	120
9/2/2008	< 10[2]	7/27/2010	230	6/10/2013	20
9/8/2008	10	8/2/2010	50	6/17/2013	31
9/16/2008	< 10[2]	8/9/2010	100	6/24/2013	1,700
5/20/2009	370	8/16/2010	< 10[2]	6/26/2013	3,100
5/27/2009	1,700	8/23/2010	50	7/1/2013	52
6/2/2009	120	8/30/2010	< 10[2]	7/8/2013	110
6/3/2009	20	5/24/2011	180	7/15/2013	20
6/9/2009	10	6/1/2011	10	7/17/2013	440
6/10/2009	50	6/7/2011	86	7/22/2013	20
6/16/2009	10	6/14/2011	10	7/29/2013	110
6/17/2009	10	6/21/2011	31	8/5/2013	41
6/23/2009	10	6/27/2011	490	8/12/2013	160
6/24/2009	10	7/5/2011	20	8/19/2013	74
7/1/2009	10	7/12/2011	260	8/26/2013	10
7/7/2009	20	7/19/2011	1,500	5/18/2015	140

Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)
5/26/2015	1,200	5/23/2017	160	9/10/2018	18(3)
6/1/2015	10	5/30/2017	52	9/19/2018	139(3)
6/8/2015	51	6/6/2017	< 10(2)	9/26/2018	11(3)
6/15/2015	280	6/13/2017	< 10(2)	10/10/2018	68(3)
6/17/2015	20	6/20/2017	20	5/21/2019	31
6/22/2015	400	6/22/2017	15(3)	5/28/2019	10
6/24/2015	10	6/27/2017	< 10(2)	6/4/2019	20
6/29/2015	30	7/3/2017	10	6/11/2019	20
7/6/2015	10	7/11/2017	< 10(2)	6/18/2019	2,800
7/13/2015	130	7/18/2017	411(3)	6/25/2019	180
7/20/2015	680	7/18/2017	1,200	7/1/2019	20
7/22/2015	170	7/25/2017	10	7/9/2019	10
7/27/2015	270	8/1/2017	10	7/16/2019	< 10(2)
7/30/2015	180	8/8/2017	< 10(2)	7/23/2019	20
8/3/2015	120	8/15/2017	< 10(2)	7/30/2019	< 10(2)
8/5/2015	590	8/22/2017	55(3)	8/6/2019	< 10(2)
8/10/2015	2,100	8/22/2017	20	8/13/2019	< 10(2)
8/17/2015	63	8/29/2017	41	8/20/2019	31
8/19/2015	360	9/7/2017	8(3)	8/27/2019	< 10(2)
5/23/2016	20	10/5/2017	6(3)	5/19/2020	210
5/31/2016	1,300	5/22/2018	914(3)	5/26/2020	30
6/2/2016	710	5/22/2018	< 10(2)	6/2/2020	31
6/6/2016	63	5/29/2018	110	6/9/2020	31
6/13/2016	31	6/5/2018	< 10(2)	6/16/2020	10
6/20/2016	220	6/12/2018	10	6/23/2020	< 10(2)
6/22/2016	20	6/19/2018	230	6/30/2020	10
6/27/2016	52	6/26/2018	440	7/7/2020	10
7/5/2016	< 10(2)	7/2/2018	20	7/15/2020	10
7/11/2016	10	7/10/2018	160	7/21/2020	10
7/18/2016	85	7/17/2018	10	7/28/2020	< 10(2)
7/25/2016	150	7/24/2018	20	8/4/2020	10
8/1/2016	10	7/31/2018	10		
8/8/2016	< 10(2)	8/7/2018	530	Min =	5
8/15/2016	97	8/14/2018	10	1st Quartile =	10
8/22/2016	85	8/20/2018	< 10(2)	Median =	30
8/29/2016	41	8/21/2018	360(3)	3rd Quartile =	143
4/20/2017	23(3)	8/27/2018	1,196(3)	Max =	10,000
5/3/2017	14(3)	8/27/2018	810	Mean =	267

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

Table 7.A-2. Sand Sampling Data from Transects, Brushy Creek Lake Beach.

		E. coli (MPN/cubic cm)				
Date	**Row/ Transect**	**A**	**B**	**C**	**D**	**E**
4/20/2017	1	1.2	< 0.1[1]	< 0.1[1]	0.1	< 0.1[1]
	2	1.3	4.5	0.68	< 0.1[1]	< 0.1[1]
	3	13.0	0.44	0.1	< 0.1[1]	< 0.1[1]
5/3/2017	1	1.4	0.11	< 0.1[1]	< 0.1[1]	< 0.1[1]
	2	4.0	25.0	52.0	< 0.12[1]	< 0.11[1]
	3	0.75	2.1	0.11	< 0.11[1]	< 0.11[1]
6/22/2017	1	14.0	60.0	4.4	320.0	< 0.1[1]
	2	30.0	170.0	6.5	7.7	210.0
	3	17.0	> 250[3]	8.3	0.1	< 0.1[1]
7/18/2017	1	210.0	87.0	0.5	< 0.1[1]	< 0.1[1]
	2	> 260[3]	2.4	22.0	2.5	2.1
	3	220.0	2.4	0.7	0.1	< 0.1[1]
8/22/2017	1	33.0	13.0	13.0	0.1	0.1
	2	19.0	< 0.1[1]	1.9	0.5	6.8
	3	> 270[3]	2.7	11.0	6.3	0.1
9/7/2017	1	0.7	1.2	0.1	0.1	< 0.1[1]
	2	0.8	0.5	0.1	< 0.1[1]	0.7
	3	6.9	3.5	< 0.1[1]	0.4	< 0.1[1]
5/22/2018	1	1.6	2.1	0.19	1.3	
	2	7.4	6.8	6.4	4.3	
	3	19.0	18.0	2.9	0.1	
8/21/2018	1	1.7	0.6	0.1	0.1	
	2	5.4	< 0.1[1]	0.1	< 0.1[1]	
	3	7.5	< 0.1[1]	0.1	< 0.1[1]	
8/27/2018	1	62.0	5.7	43.0	2.7	
	2	260.0	120.0	150.0	780.0	
	3	68.0	24.0	< 0.1[1]	< 0.1[1]	
9/10/2018	1	74.0	4.7	0.79	0.48	
	2	52.0	210.0	2100.0	870.0	
	3	3.2	3.6	< 0.1[1]	< 0.1[1]	
9/19/2018	1	24.0	6.0	< 10[1]	< 10[1]	
	2	59.0	13.0	370.0	170.0	
	3	66.0	110.0	22.0	3.1	
9/26/2018	1	8.1	1.6	0.19	4.2	
	2	3.0	26.0	200.0	8.7	
	3	31.0	48.0	5.9	4.8	

10/10/2018	1	12.0	4.1	0.1	1.2	
	2	4.2	1.8	< 0.1(1)	0.1	
	3	1.8	< 0.1(1)	0.1	0.1	

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

Table 7.A-3. Water Sampling Data from Transects, Brushy Creek Lake Beach.

		E. coli (MPN/100 ml)								
Date	**Row/ Transect**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
4/20/2017	1	31	41	10	10	10	10	< 10[(1)]	< 10[(1)]	< 10[(1)]
	2	52	31	20	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]
	3	52	10	10	< 10[(1)]	10	< 10[(1)]	< 10[(1)]	< 10[(1)]	10
5/3/2017	1	10	10	20	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	10	< 10[(1)]
	2	52	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	10	< 10[(1)]	< 10[(1)]	10
	3	20	20	10	10	10	< 10[(1)]	< 10[(1)]	< 10[(1)]	20
6/22/2017	1	< 10[(1)]	10	< 10[(1)]	10	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]
	2	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	10	< 10[(1)]	< 10[(1)]	< 10[(1)]
	3	98	10	20	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]
7/18/2017	1	320	75	86	86	< 10[(1)]	86	86	< 10[(1)]	< 10[(1)]
	2	74	10	< 10[(1)]	30	10	< 10[(1)]	< 10[(1)]	10	< 10[(1)]
	3	3900	63	120	160	20	30	20	10	< 10[(1)]
8/22/2017	1	160	20	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	31	< 10[(1)]	< 10[(1)]
	2	130	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	10	< 10[(1)]	< 10[(1)]	< 10[(1)]
	3	170	110	20	30	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	10
9/7/2017	1	< 10[(1)]	10	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]
	2	41	< 10[(1)]	< 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)]
10/5/2017	1	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]					
	2	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]					
	3	20	< 10[(1)]	< 10[(1)]	< 10[(1)]					
5/22/2018	1	760	< 10[(1)]	10	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]
	2	10000	110	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]
	3	41	< 10[(1)]	20	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]	< 10[(1)]

8/21/2018	1	160	74	41	63	20	30	63	41	85
	2	110	62	10	10	20	31	20	63	52
	3	290	3100	230	170	41	20	51	31	51
8/27/2018	1	390	470	610	300	52	52	52	20	52
	2	2700	1000	400	380	41	20	31	41	41
	3	3100	1600	2200	1200	41	52	10	20	20
9/10/2018	1	31	< 10(1)	< 10(1)	10	< 10(1)	10	20	< 10(1)	< 10(1)
	2	< 10(1)	< 10(1)	31	20	< 10(1)	10	10	< 10(1)	< 10(1)
	3	52	20	< 10(1)	31	< 10(1)	< 10(1)	20	< 10(1)	20
9/19/2018	1	110	200	170	260	20	41	< 10(1)	< 10(1)	30
	2	350	63	130	96	31	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	3	220	63	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)
9/26/2018	1	20	10	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	2	20	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10
	3	20	10	10	41	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
10/10/2018	1	74	74	74	74	52	130	86	63	86
	2	86	130	31	63	73	74	160	74	120
	3	10	63	52	85	75	97	96	63	85

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

8. Lake Ahquabi TMDL

8.1. Description and History of Lake Ahquabi

Lake Ahquabi, IA 04-LDM-1080, is located in White Oak Township, Warren County, Iowa approximately 4 miles southwest of the City of Indianola. Lake Ahquabi was constructed in the 1930's by the Civilian Conservation Corps (CCC). The lake is located within the 787-acre Lake Ahquabi 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 3,288 acres, a maximum depth of 21 feet, a shore length of approximately 4.35 miles, and an approximate volume of 1,244 acre-feet. Figure 8-1 is an aerial photograph with the boundaries of the watershed. Table 8-1 is a summary of the lake and watershed properties.

Table 8-1. Lake Ahquabi Watershed and Lake Information.

Waterbody Name	Lake Ahquabi
Waterbody ID	IA 04-LDM-1080
12 Digit Hydrologic Unit Code (HUC)	071000080804
HUC-12 Name	Lower Squaw Creek
Location (Ambient Monitoring Site)	Section 14, T75N, R24W, Warren 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
Antidegredation Protection Level	Tier 1
Tributaries	Unnamed Stream
Receiving Waterbody	Unnamed Tributary to Squaw Creek
Watershed Area	3,288 acres
Lake Surface Area(1)	116 acres
Maximum Depth(1)	21 feet
Volume(1)	1,244 ac-feet
Length of Shoreline	4.35 miles
Watershed/Lake Area Ratio	27.3:1

(1) Per February 2017 Bathymetric Survey.

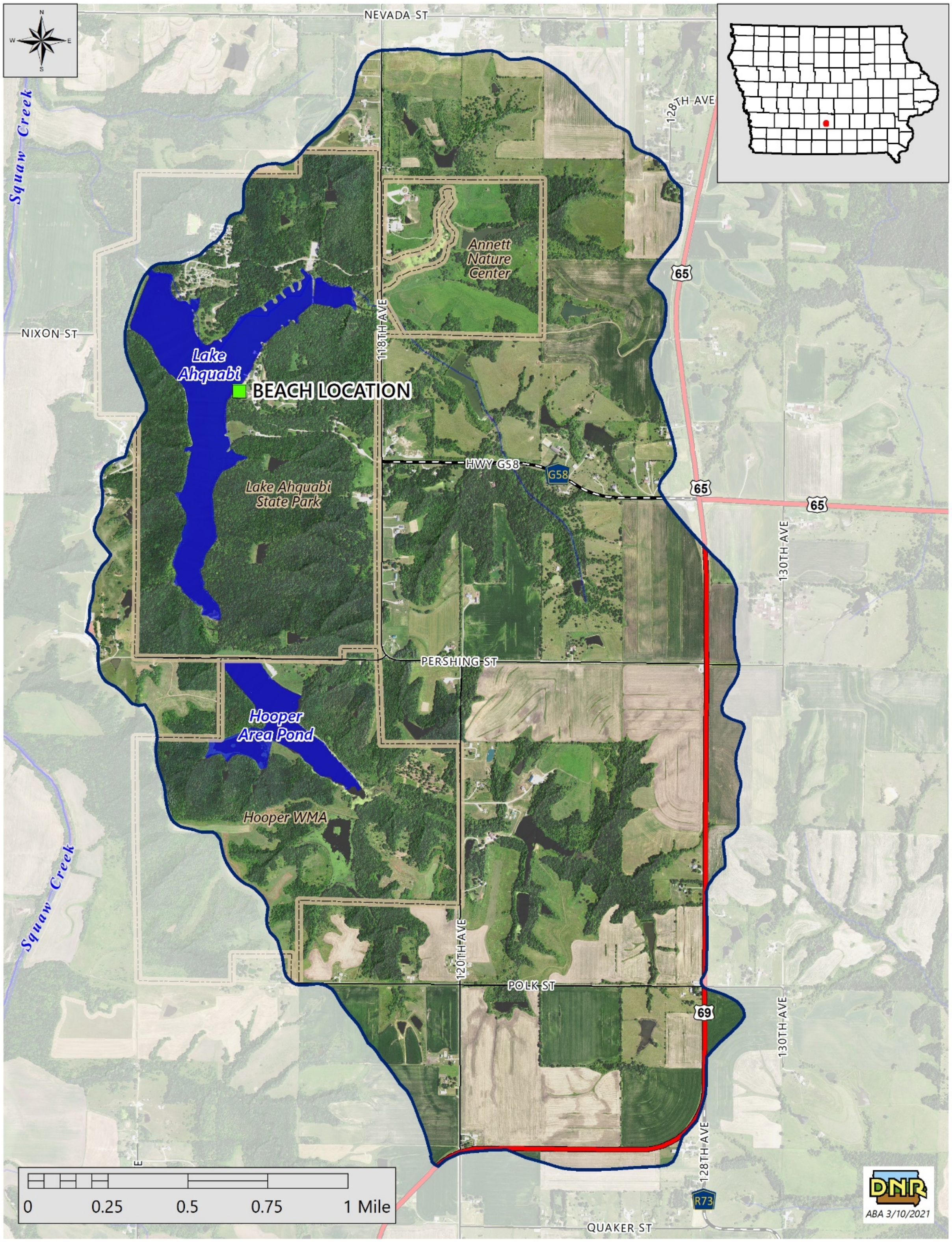

Figure 8-1. Lake Ahquabi Watershed.

Land Use
A Geographic Information System (GIS) coverage of land use information was developed using the 2014 USDA Cropland Data Layer (USDA, National Agricultural Statistics Service). The three dominate land uses are forest (38%), grassland (21%), and row crop (24%) (Table 8-2). The eight land uses shown in Table 8-2 were aggregated from the fourteen land uses in the cropland data layer as shown in the description column. Figure 8-2 shows the distribution of the various land uses throughout the Lake Ahquabi watershed in a pie-chart.

Table 8-2. Lake Ahquabi Watershed Land Uses.

Land Use	Description	Area (AC)	Percent of Total
Water/Wetland	Water and Wetlands	255	7.8%
Forested	Bottomland, Coniferous, Deciduous	1,249	38.0%
Grassland	Ungrazed, Grazed, & CRP-	705	21.4%
Alfalfa/Hay	Perennial Hay Crop-	57	1.7%
Row Crop	Corn, Soybeans, & other	784	23.8%
Roads	Roads Lightly Developed Urban	197	6.0%
Urban	Intensively Developed Urban	41	1.3%
Total		3,288	100.0%

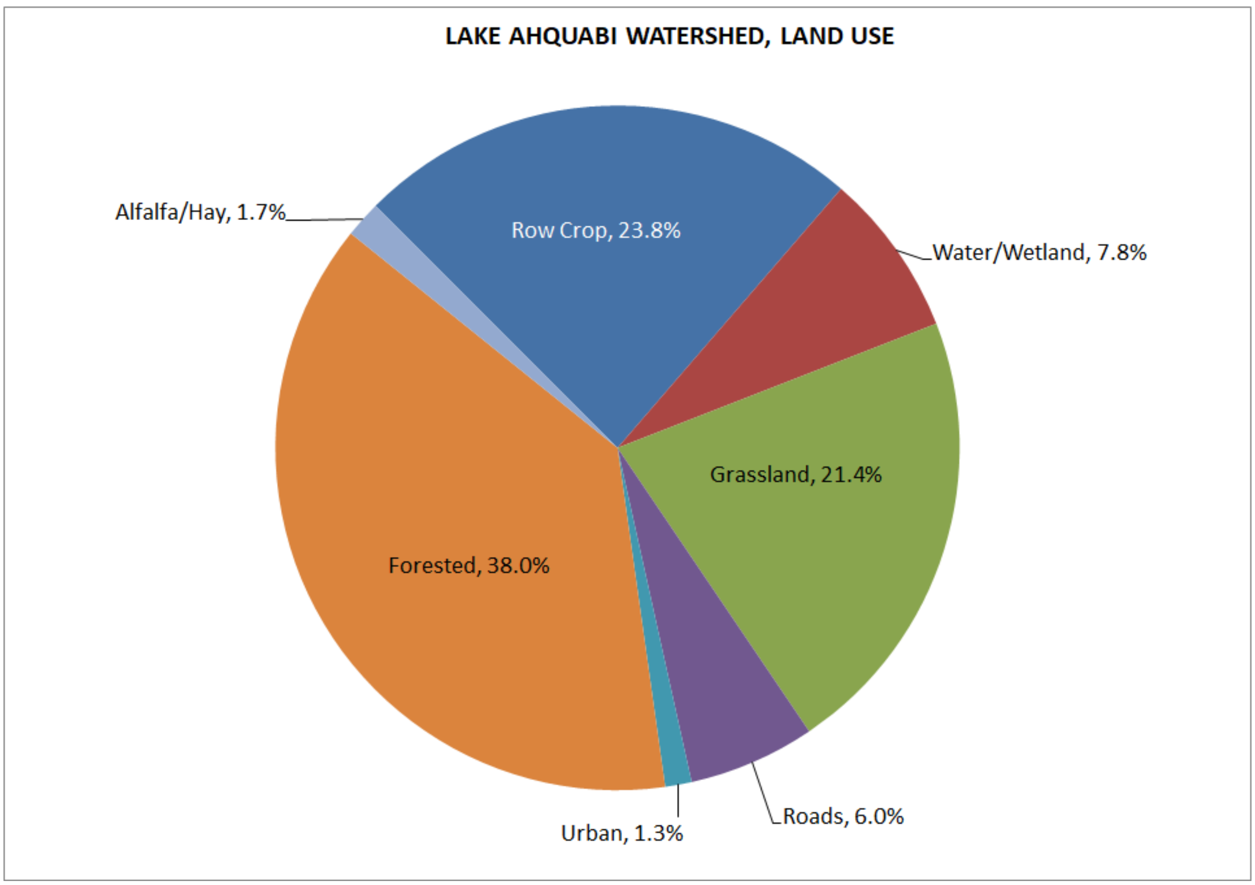

Figure 8-2. Land Use Composition of the Lake Ahquabi Watershed.

Hydrology, Soils, Climate, Topography
From data obtained from the NRCS, there are 28 soil types in this watershed. No soil type makes up a majority in the area. The top three soil types in the watershed are the Ladoga, Gosport, and Macksburg

soils, which make up 38% of the soil types in the watershed. Hydrologic soil types B and C make up the majority of the soils in the watershed at 95%. The topography for the Lake Ahquabi watershed consists of rolling hills of Wisconsin-age loess on Illinoisan till. 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 Ahquabi watershed from 2008 through 2020 is 41.1 inches with the majority (73%) falling between April 1st and September 30th. Lake evapotranspiration averages 42.8 inches per year, with more occurring in dryer years. Figure 8-3 shows the annual rainfall and reference evapotranspiration from 2008 to 2020. Figure 8-4 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.

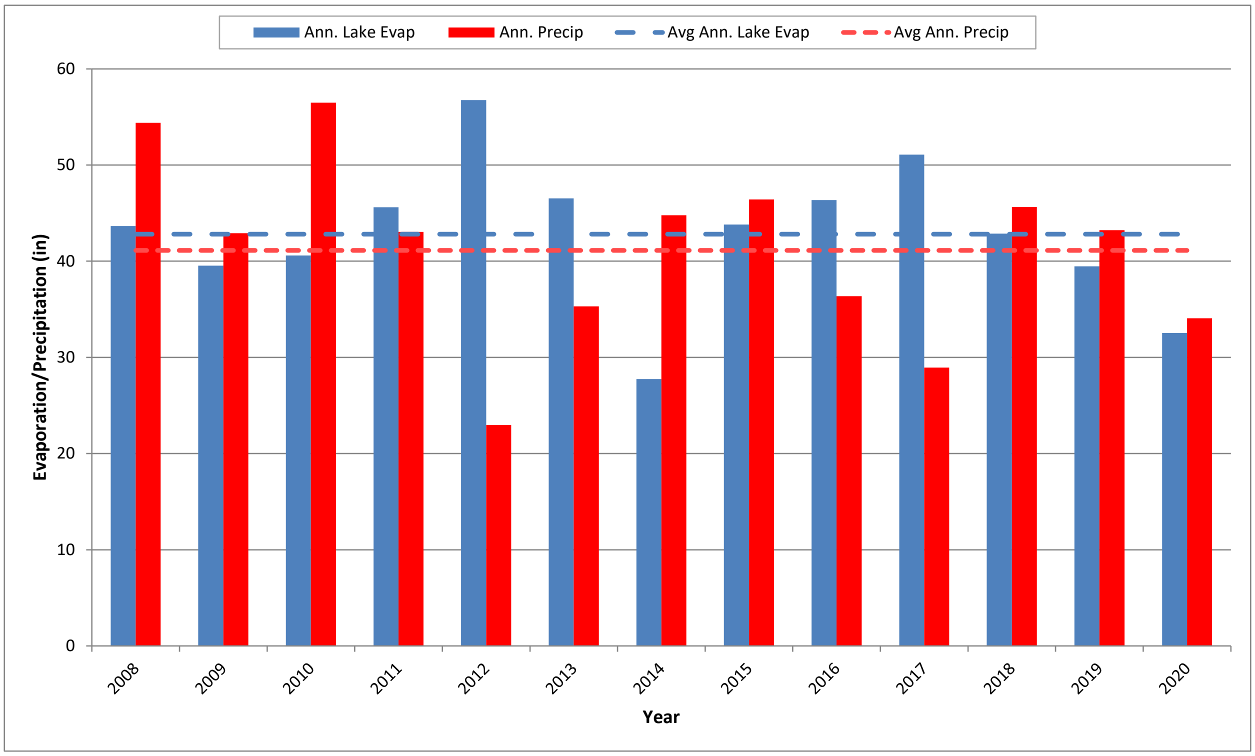

Figure 8-3. Annual Rainfall and Estimated Evapotranspiration Totals, Lake Ahquabi Watershed.

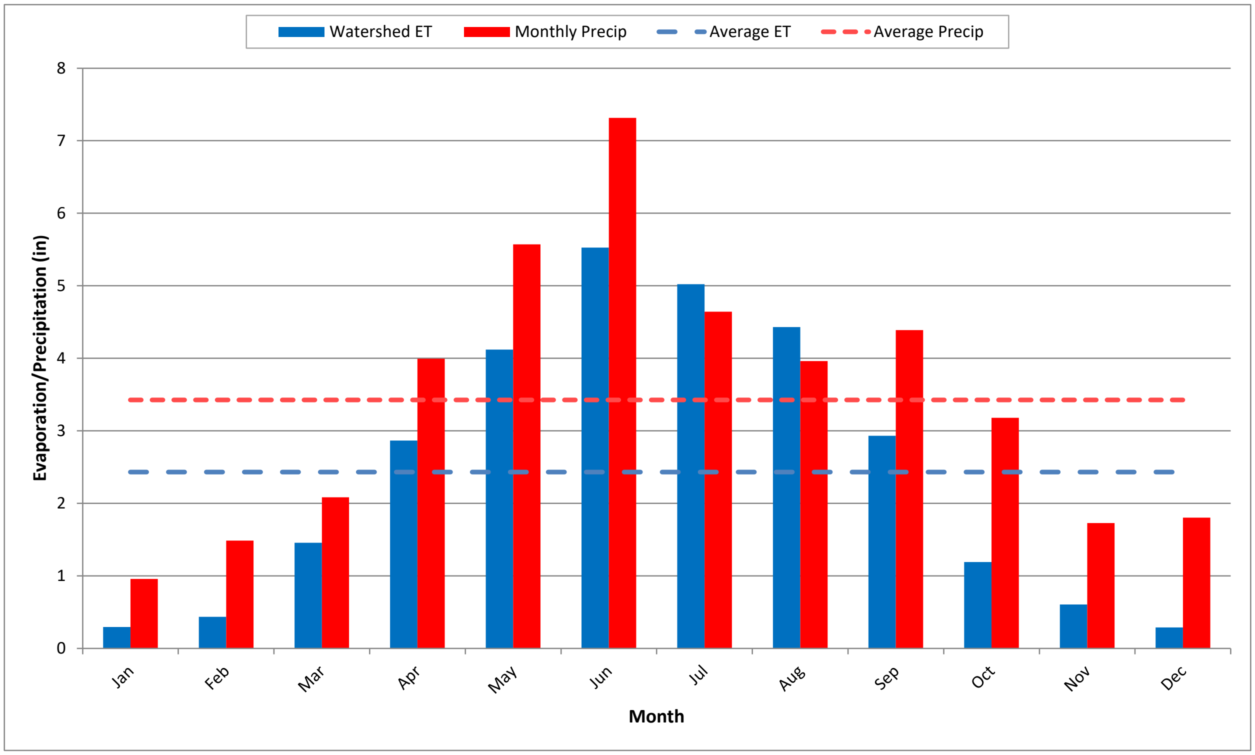

Figure 8-4. Monthly Rainfall and Estimated Evapotranspiration Totals, Lake Ahquabi Watershed.

8.2. 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 based impairments result in whole lake waterbodies being listed as impaired on the states 303(d) list each cycle. 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 (Section 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 Ahquabi Beach on Lake Ahquabi (IA 04-LDM-1080).

Sampling and Data Collection

Beach, open lake and alternate transects as well as open lake sampling points were sampled seasonally and in response to wet weather events from spring 2017 through the fall of 2017 and again from the spring of 2019 through the fall of 2019 (Figure 8-5). All water and sand sample collection and laboratory analysis was conducted following protocols highlighted in Section 2.3.

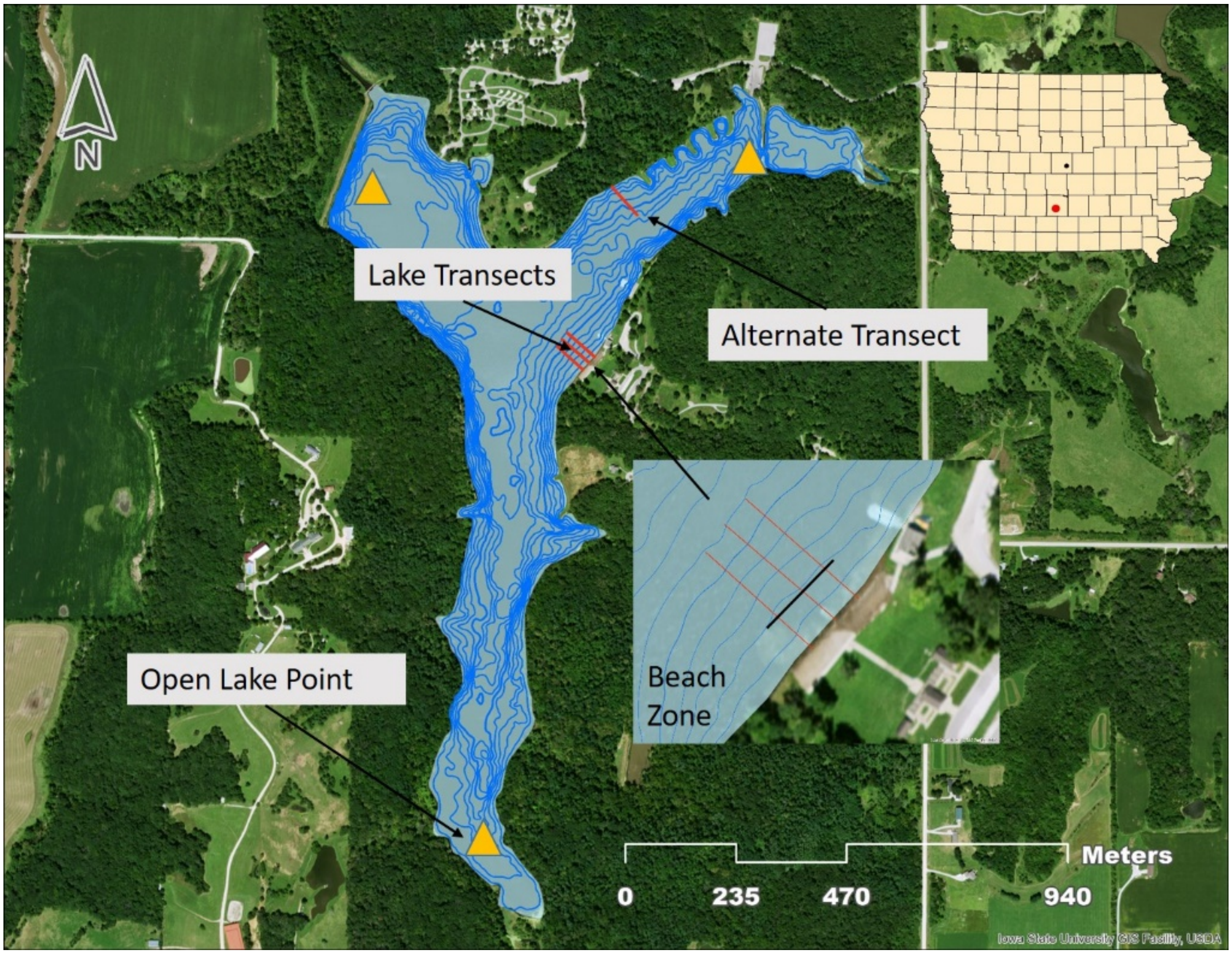

Figure 8-5. Overview of Monitoring Locations on Lake Ahquabi.

Sampling Results and Analysis

Data collected from the beach sand environment during both seasons showed a wide range of variability (Table 8-3). However, median sample *E. coli* concentrations were well above detection limits of (0.1 MPN/gram). This trend is conistant with analysis conducted on other systems in Iowa (Section 2.4).

Table 8-3. Basic Statistics from Bacteria Sampling at Lake Ahquabi.

Sampling Dataset	N	Mean	Median	St. Dev.	25th %	75th %
Lake Ahquabi Swimming Zone	120	168	10	843	5	75
Lake Ahquabi Transects	120	17	5	31	5	10
Lake Ahquabi Open Lake	30	37	5	74	5	20
Lake Ahquabi Beach Sand	135	66	0.9	230	0.05	21

Water results reported as MPN/ 100mL and sand results reported as MPN/dry wt. gram

Water sample collection in the nearshore swimming zone showed a high degree of variability. Sample results commonly varied by hundreds of MPN/ 100mL, 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 very low *E. coli* concentrations as median dataset concentrations were only slightly above the detection limit of 10 MPN/ 100mL (Table 8-

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 year sampling effort at Lake Ahquabi the swimming area met recreational standards (235 MPN/ 100mL) during seven of the ten 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/ 100mL and relatively low standard deviations, indicating overall low concentrations in these environments.

Beach sand sampling conducted at Lake Ahquabi Beach revealed trends consistent with prior surveys (Section 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 were significantly higher in *E. coli* concentrations than C or D (P<0.05). As with prior surveys, the sands on Lake Ahquabi Beach had *E. coli* concentrations many times higher than observed in adjacent swimming waters (Figure 8-6). Beach sand *E. coli* concentrations averaged about 800 times higher than those observed in adjacent swimming areas during the two-year sampling period. 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 Section 2.

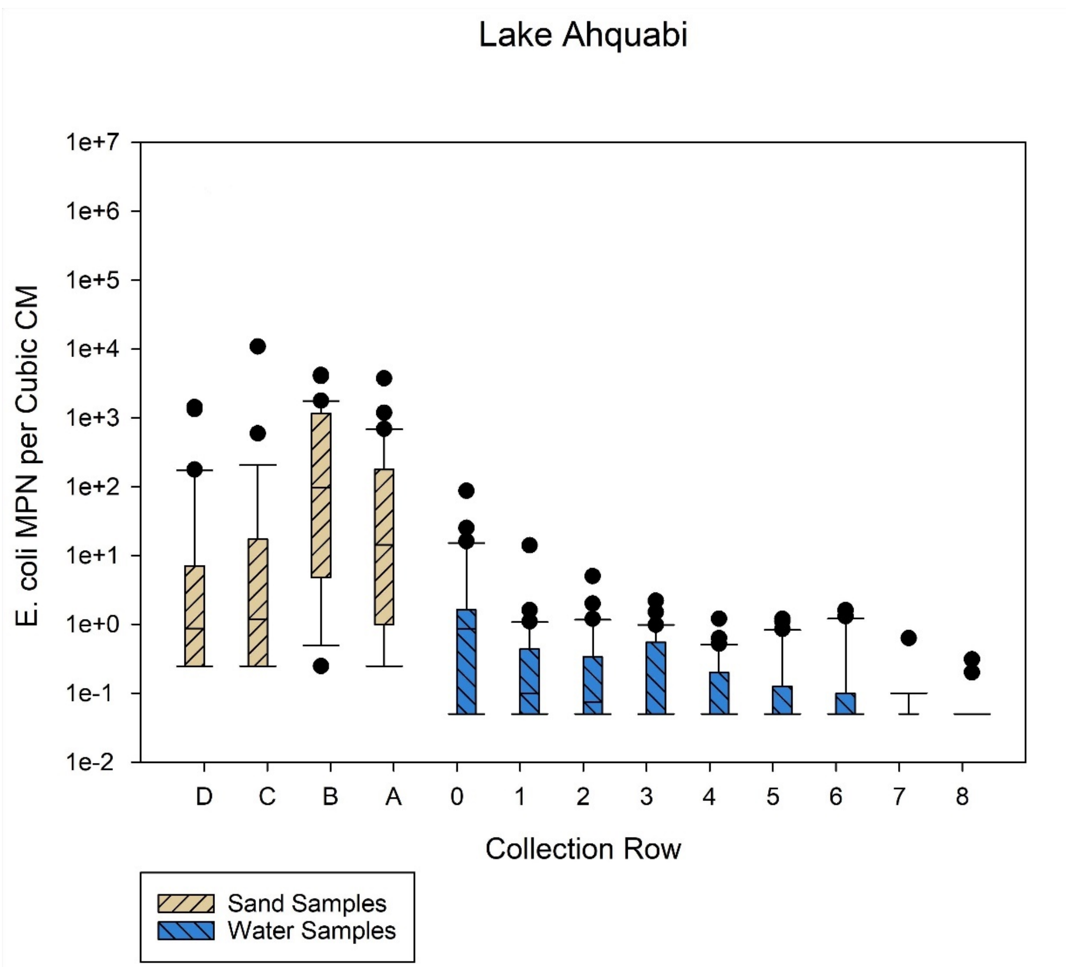

Figure 8-6. Box Plots of Sand and Water Sampling from Transects along Lake Ahquabi Beach. Reported in MPN/per cubic cm. Sampling points in figure correspond to following locations in relation to shoreline: A=shoreline, B (+2.5 m), C (+5m), D (+10M), 0 (Ankle deep), 1 (Knee deep), 2 (waist deep), 3 (chest 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 8-7) 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 Ahquabi monitoring network uncovered trends and associations that closely mimicked findings of previous beach investigations (Section 2). Results highlighted in Table 8-4 demonstrate the dissassociation 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 (Section 2). The findings from this analysis validate the decision to address the *E. coli* bacteria impairments at Lake Ahquabi Beach with a framework that directly addresses beach specific sources.

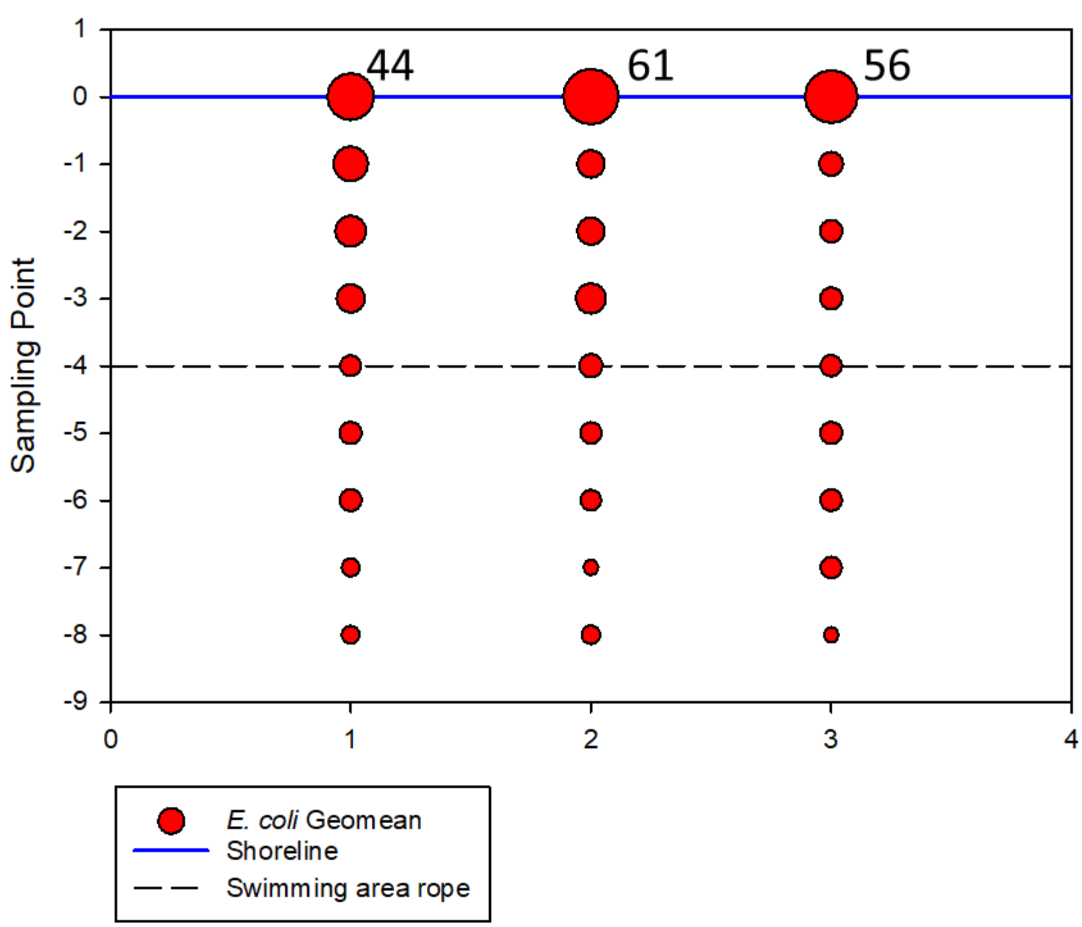

Figure 8-7. Bubble Plot of *E. coli* Sampling at Lake Ahquabi Beach Lake Transects Reported as MPN/ 100mL.

Table 8-4. Analysis Results from Lake Ahquabi 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

8.3. TMDL for Lake Ahquabi Beach.

The 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 Ahquabi State Park. Assessments conducted on the Lake Ahquabi beach and lake system (Section 8.2) 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 Ahquabi, IA 04-UDM-1276, was included on the 2012 303(d) impaired waters list for not fully supporting Class A1 (primary contact recreation) uses due to the presence of high levels of *E. coli*. Samples were collected during the recreational season (March 15 – November 15) between 2008 – 2020 as part of the state's ambient water quality monitoring and assessment program.

In 2017 and 2019, additional water quality samples were collected by the Iowa DNR to study and assess the relationships between the nearshore beach environment and open lake conditions. Results of this study are presented in Section 8.2

Applicable Water Quality Standards

The designated uses of Lake Ahquabi are: primary contact recreational use (Class A1); lakes and wetlands (Class B(LW)); human health (Class HH); and drinking water (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.
- 567-61.2(2)(c) Tier 2½ protection—outstanding Iowa waters. Where high quality waters constitute an outstanding state resource, such as waters of exceptional recreational or ecological significance, that water quality shall 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 8-8 shows the swimming and beach shed areas of Lake Ahquabi. Table 8-5 is a summary of the NSBV data.

Figure 8-8. Swimming and Beach Shed Areas, Lake Ahquabi.

Table 8-5. Lake Ahquabi NSBV Data.

Near Shore Beach Volume	1.10 acre-feet
Beach Front Length	806.4 feet
Radius from Shore at midpoint of beach	102.3 feet
Depth at Radius	4.2 feet (Elevation 853.8)
Beach Shed Area	11.6 Acres

Data Sources and Monitoring Sites

Table 8-6 lists the water quality monitoring locations used to develop the WQIP for Lake Ahquabi. Figure 8-9 shows the monitoring locations used. In addition to these sites, samples were collected adjacent to the beach along three transects as shown in Figure 8-10. See Section 8.2 for a more detailed description of the samples collected along the transects.

Table 8-6. WQ Data Monitoring Sites at Lake Ahquabi.

Site Name	Site ID	Longitude	Latitude
Ahquabi Inlet 1(1)	14000201	93° 35' 12"	41° 17' 40"
Ahquabi Inlet 2 (1)	14000202	93° 35' 34"	41° 16' 50"
Lake Ahquabi(2	22910002	93° 35' 47"	41° 17' 36"
Lake Ahquabi Beach (Lake Ahquabi State Park)(1) (2)	21910001	93° 35' 27"	41° 17' 25"

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

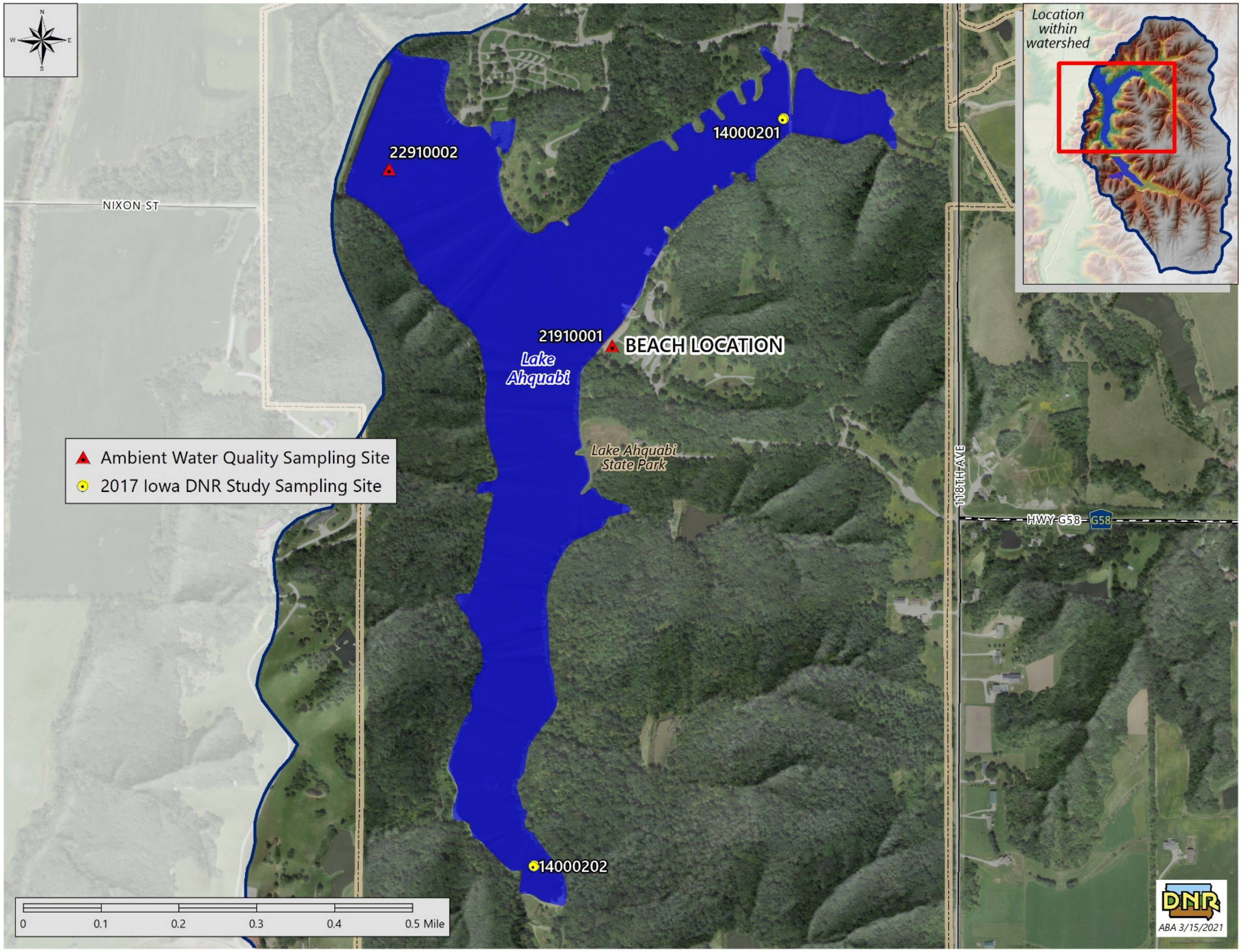

Figure 8-9. Sampling Locations, Lake Ahquabi.

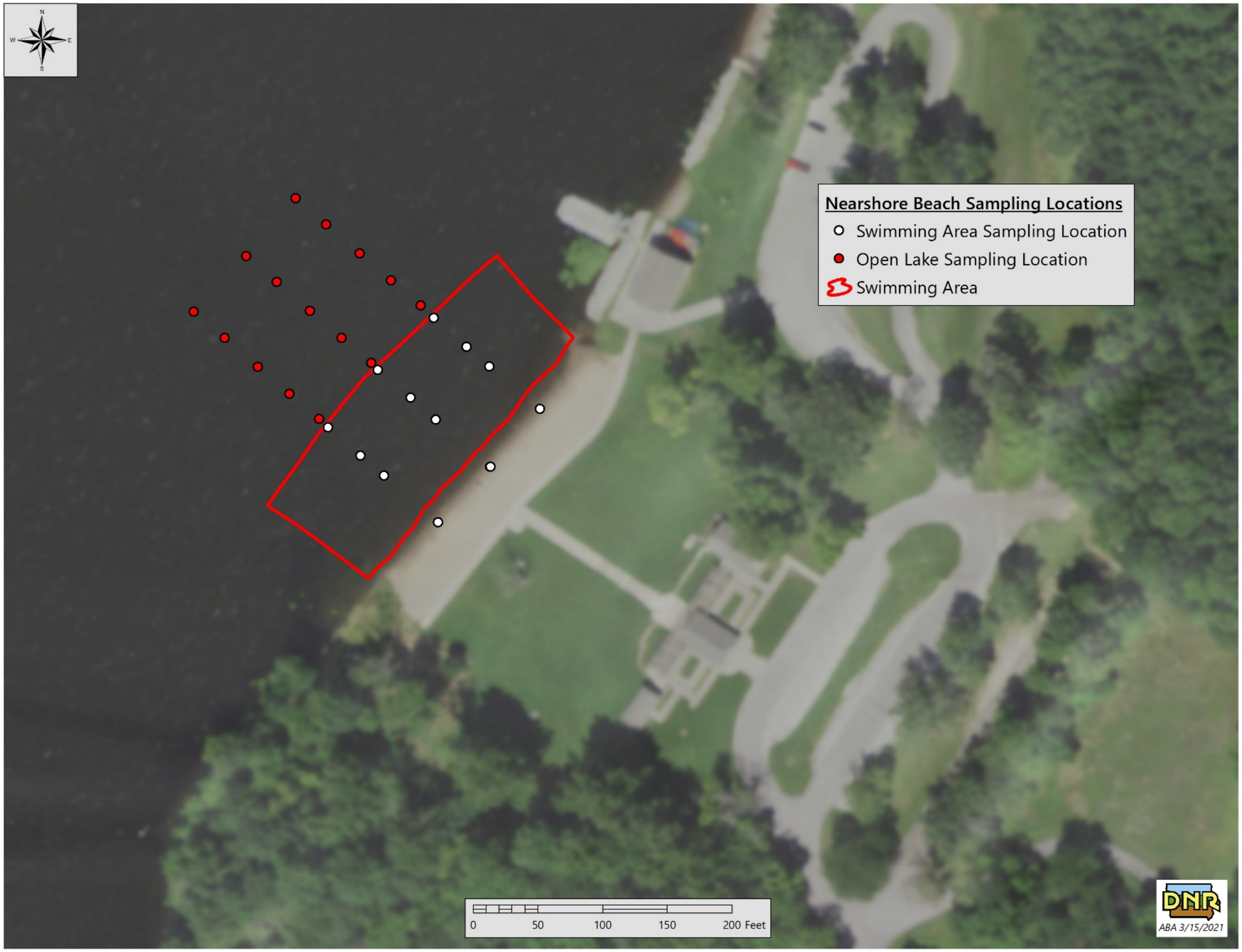

Figure 8-10. Nearshore Beach Sampling Locations, Lake Ahquabi.

Interpretation of Data
Using data collected from 2008 – 2020, two box plots were developed. Figure 8-11 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 line representing the SSM concentration of 235 orgs/ 100 mL.

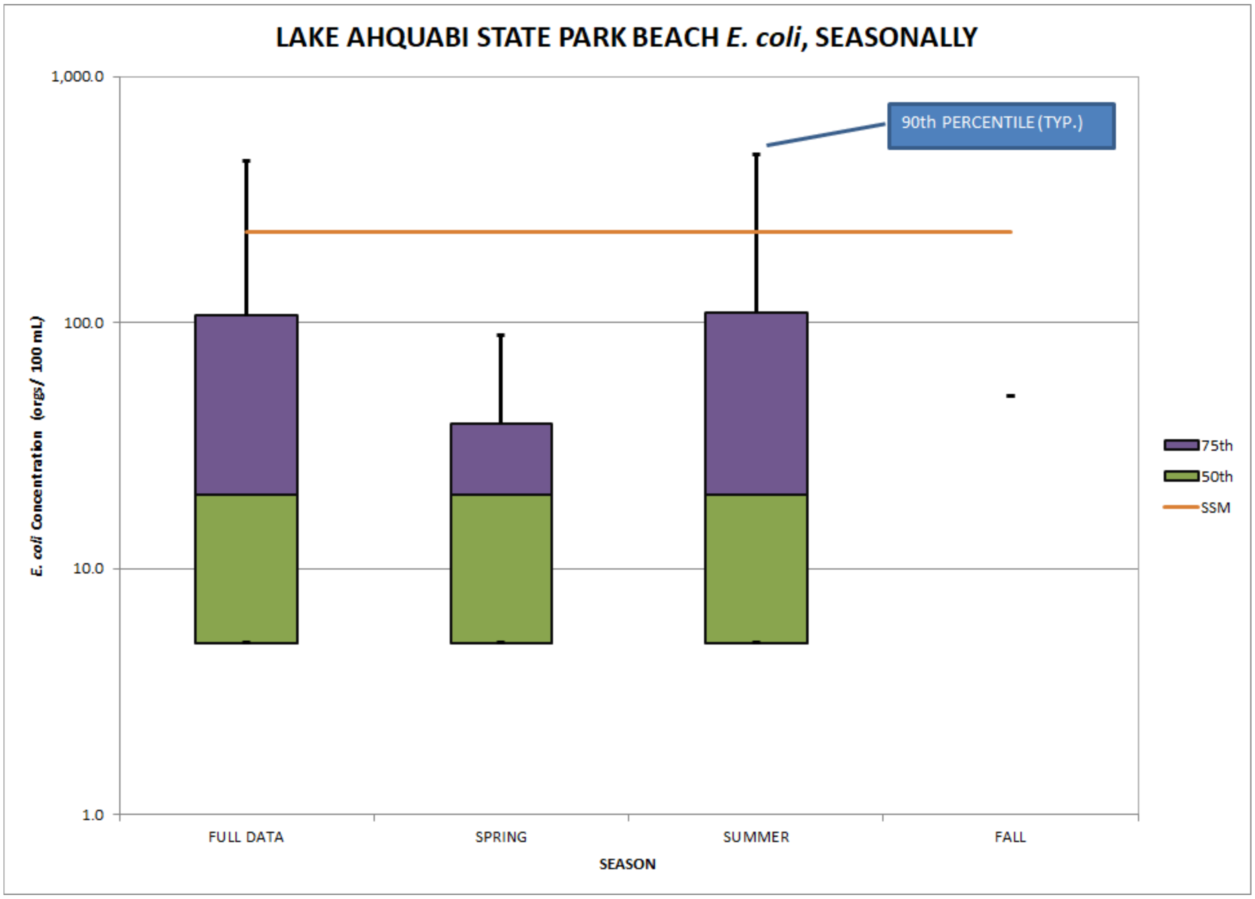

Figure 8-11. Seasonal Box Plot, Lake Ahquabi.

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. 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 8-11 illustrates that the summer season is the critical season for bacteria at the Lake Ahquabi State Park beach. An insufficient number of samples were collected during the fall season to make an evaluation on the concentration of *E. coli* present at the beach during this season.

In the second box plot graph, Figure 8-12, data is categorized by month. This box plot has the same format as previously described. This figure shows that *E. coli* levels are low in the spring, increase during the summer months, and decrease in the fall. The general trend is for bacteria levels to increase from spring into summer and decrease in the fall, peaking in July.

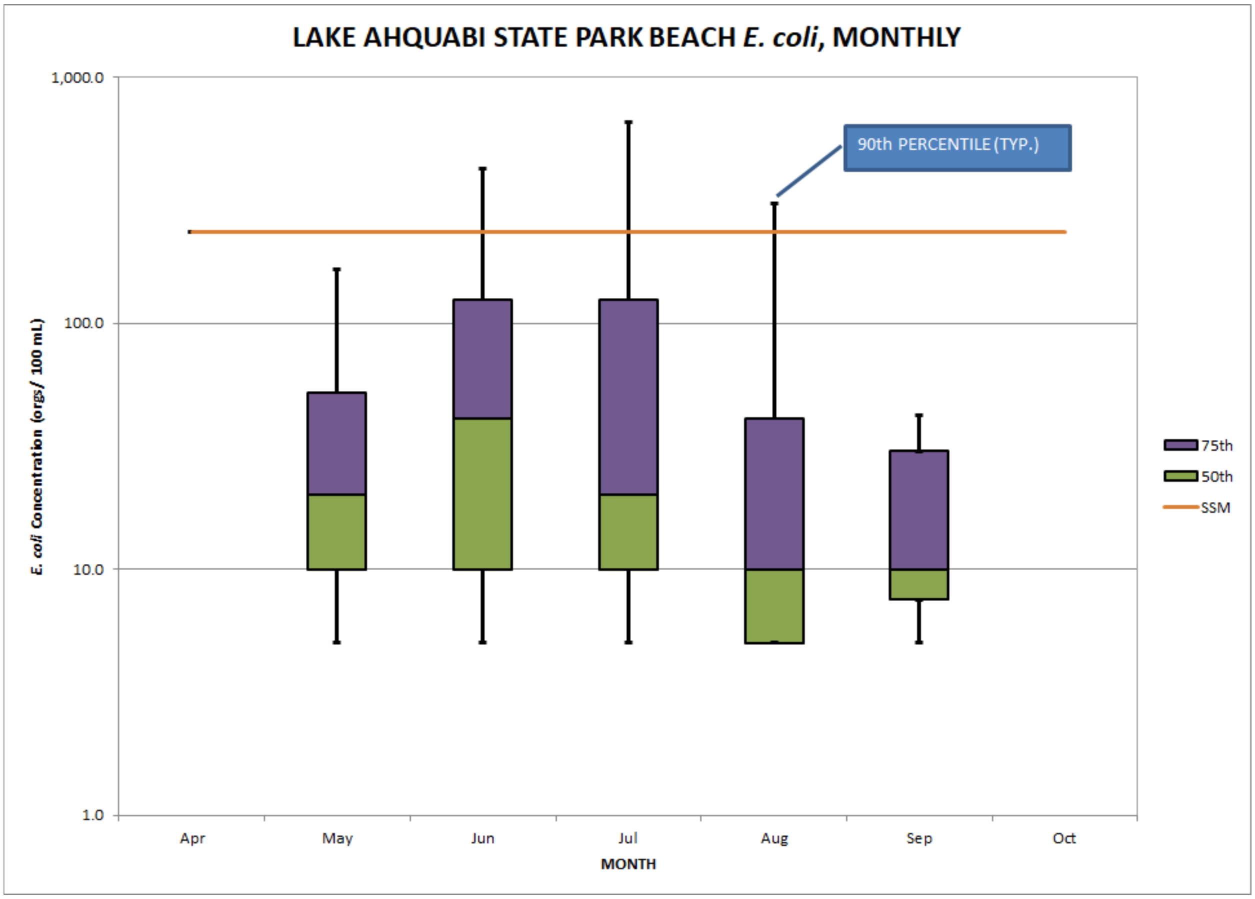

Figure 8-12. Monthly Box Plot, Lake Ahquabi.

8.3.1. 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 to November 15. The critical volume is the NSBV, which is adjacent to the beach area.

Consideration of Seasonal Variation

These TMDL's were developed based on the Iowa WQS primary contact recreation season that runs from March 15 to 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 Lake Ahquabi are based on the assumption 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 8-13 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.

8.3.2. Pollution Source Assessment

Departure from Load Capacity
The seasonal load curve and observed loads for the seasonal load conditions are plotted in Figure 8-13. 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.

8.3.3. Pollutant Allocations

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

Load Allocation (LA)
Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the stream. Specific examples of potential nonpoint sources of bacteria include animals directly depositing into streams, 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 2-year study presented in Chapter 2 and Section 8.2 of this WQIP the source of the impairment is from the near shore beach environment. The main source of *E. coli* is from waterfowl and shore birds loafing on the beach and 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 8-13 shows a seasonal load curve for the NSBV at Lake Ahquabi. Table 8-7 and Table 8-8 are the existing load estimates and the TMDL summary, respectively for the NSBV at Lake Ahquabi.

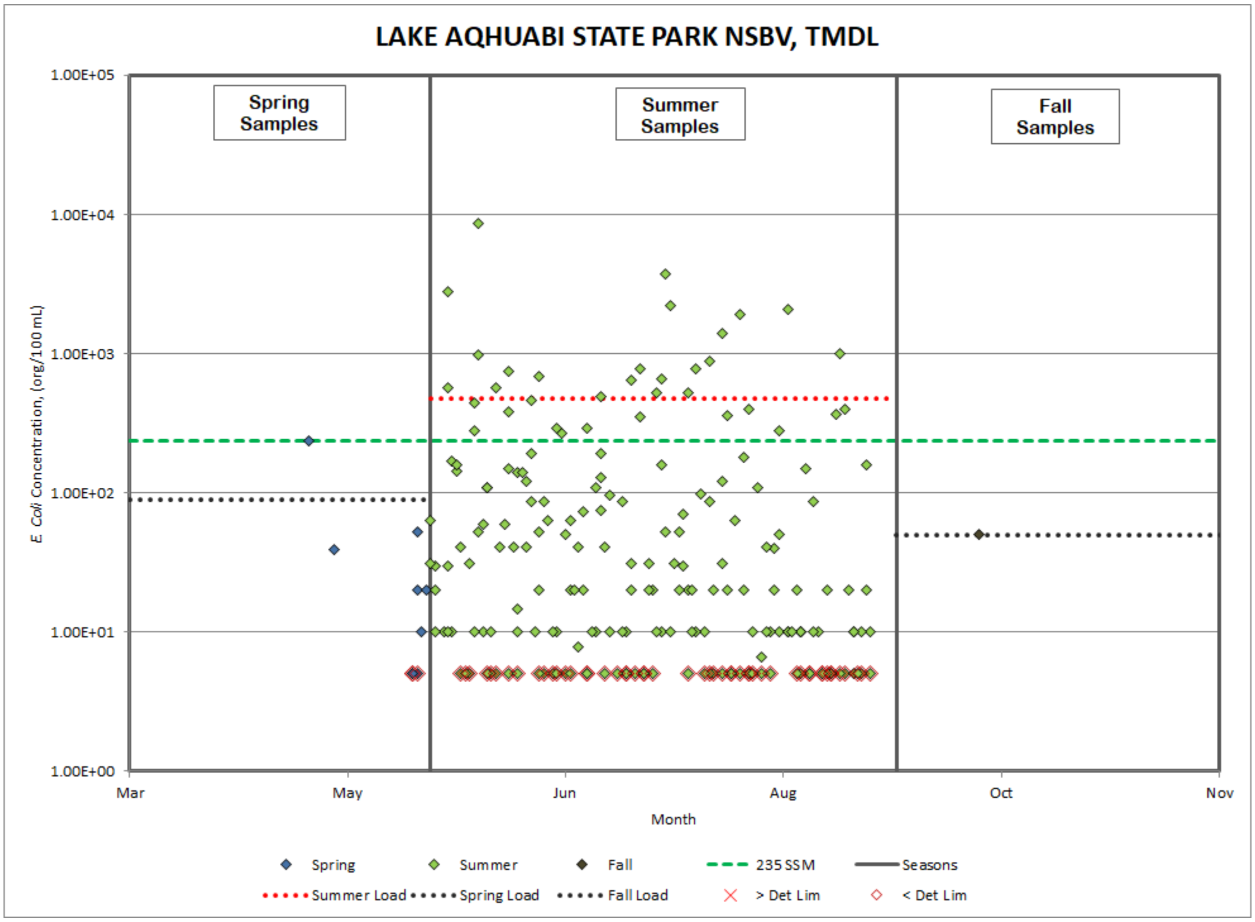

Figure 8-13. Seasonal Load Curve, Lake Ahquabi, Near Shore Beach Volume.

Table 8-7. Existing Load Estimates for the NSBV at Lake Ahquabi.

Load Summary	Seasonal Loads (org/ 100 mL)		
	Spring	Summer	Fall
Observed Load[(1)]	88.8	481.0	50.1
Departure	N/A	246.0	N/A
(% Reduction)	(0)	(51.1)	(0)

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

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

Table 8-8. TMDL Summary for the NSBV at Lake Ahquabi.

	TMDL
TMDL (org/ 100 mL)	235.0
WLA (org/ 100 mL)	0.0
LA (org/ 100 mL)	211.5
MOS (org/ 100 mL))	23.5

8.3.4. TMDL Summary

This TMDL is based on meeting the water quality criteria for primary contact and children's recreation in Lake Ahquabi. 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 8-8 and a NSBV of 1.1 acre-feet the TMDL for Lake Ahquabi as a mass loading is presented in Table 8-9.

Table 8-9. Summary of Lake Ahquabi.

	TMDL
TMDL (orgs/day)	3.18+09
WLA (orgs/day)	0.00E+00
LA (orgs/day)	2.86E+09
MOS (orgs/day)	3.18E+08

Appendix 8.A. Water Quality Data

Table 8.A- 1. Water Quality Sampling Data, Beach Monitoring, Lake Ahquabi, SITE ID 21910001.

Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)
5/19/2008	< 10[2]	7/7/2010	10	8/28/2012	10
5/27/2008	570	7/13/2010	< 10[2]	5/21/2013	10
6/3/2008	990	7/20/2010	70	5/28/2013	170
6/4/2008	60	7/26/2010	880	6/4/2013	10
6/10/2008	150	8/3/2010	180	6/11/2013	41
6/17/2008	20	8/10/2010	40	6/18/2013	< 10[2]
6/24/2008	20	8/16/2010	< 10[2]	6/25/2013	20
7/1/2008	130	8/24/2010	370	7/2/2013	< 10[2]
7/8/2008	640	8/31/2010	20	7/9/2013	< 10[2]
7/15/2008	10	5/24/2011	30	7/16/2013	52
7/21/2008	20	6/1/2011	31	7/23/2013	10
7/29/2008	120	6/8/2011	41	7/30/2013	20
8/4/2008	< 10[2]	6/15/2011	86	8/6/2013	110
8/11/2008	10	6/21/2011	290	8/13/2013	10
8/18/2008	< 10[2]	6/28/2011	290	8/20/2013	10
8/26/2008	< 10[2]	7/6/2011	10	8/27/2013	20
5/20/2009	< 10[2]	7/12/2011	31	5/20/2014	20
5/27/2009	30	7/20/2011	30	5/28/2014	10
6/2/2009	440	7/27/2011	20	6/3/2014	8,700
6/9/2009	60	8/3/2011	20	6/5/2014	110
6/16/2009	10	8/10/2011	20	6/10/2014	380
6/23/2009	50	8/16/2011	10	6/12/2014	140
6/30/2009	10	8/22/2011	20	6/17/2014	690
7/7/2009	< 10[2]	8/31/2011	160	6/18/2014	86
7/14/2009	10	5/23/2012	63	6/24/2014	63
7/21/2009	< 10[2]	5/30/2012	< 10[2]	7/1/2014	490
7/27/2009	< 10[2]	6/5/2012	110	7/8/2014	31
8/4/2009	< 10[2]	6/12/2012	10	7/15/2014	160
8/11/2009	50	6/20/2012	< 10[2]	7/22/2014	10
8/18/2009	< 10[2]	6/27/2012	20	7/29/2014	31
8/25/2009	< 10[2]	7/3/2012	97	8/5/2014	10
9/1/2009	< 10[2]	7/11/2012	< 10[2]	8/13/2014	10
5/26/2010	10	7/17/2012	10	8/19/2014	10
6/2/2010	280	7/25/2012	10	8/26/2014	400
6/7/2010	570	7/31/2012	< 10[2]	5/19/2015	< 10[2]
6/15/2010	190	8/8/2012	41	5/27/2015	10
6/22/2010	270	8/13/2012	2100	6/2/2015	10
6/29/2010	10	8/15/2012	20	6/10/2015	< 10[2]
7/1/2010	190	8/21/2012	< 10[2]	6/15/2015	460

Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)
6/17/2015	52	6/14/2017	41	6/12/2019	< 10(2)
6/23/2015	< 10(2)	6/21/2017	< 10(2)	6/19/2019	63
6/30/2015	110	6/26/2017	8(3)	6/26/2019	41
7/7/2015	< 10(2)	6/28/2017	< 10(2)	7/2/2019	41
7/14/2015	520	7/5/2017	< 10(2)	7/10/2019	350(3)
7/16/2015	3,700	7/12/2017	20	7/10/2019	780
7/21/2015	520	7/19/2017	52	7/17/2019	2200
7/29/2015	1,400	7/26/2017	< 10(2)	7/23/2019	772(3)
7/30/2015	360	8/2/2017	< 10(2)	7/24/2019	98
8/4/2015	400	8/9/2017	< 10(2)	7/31/2019	< 10(2)
8/11/2015	280	8/16/2017	10	8/7/2019	7(3)
8/17/2015	150	8/23/2017	< 10(2)	8/7/2019	< 10(2)
8/19/2015	86	8/28/2017	5(3)	8/14/2019	10
8/25/2015	1,000	8/30/2017	< 10(2)	8/21/2019	< 10(2)
9/1/2015	10	9/26/2017	50(3)	8/28/2019	10
5/24/2016	10	5/23/2018	31	5/20/2020	52
6/1/2016	< 10(2)	5/30/2018	41	5/27/2020	,2800
6/6/2016	10	6/6/2018	< 10(2)	6/3/2020	52
6/14/2016	120	6/13/2018	140	6/10/2020	750
6/21/2016	10	6/20/2018	10	6/17/2020	< 10(2)
6/28/2016	< 10(2)	6/27/2018	74	6/24/2020	< 10(2)
7/6/2016	86	7/3/2018	10	7/1/2020	75
7/13/2016	20	7/11/2018	< 10(2)	7/8/2020	20
7/19/2016	20	7/18/2018	31	7/15/2020	660
7/26/2016	86	7/25/2018	< 10(2)	7/22/2020	20
8/2/2016	1900	8/1/2018	63	7/29/2020	< 10(2)
8/9/2016	10	8/8/2018	10	8/5/2020	< 10(2)
8/16/2016	10	8/15/2018	< 10(2)		
8/23/2016	< 10(2)	8/22/2018	< 10(2)		
8/30/2016	10	8/29/2018	< 10(2)	Min =	5
4/25/2017	236(3)	5/22/2019	20	1st Quartile =	5
5/1/2017	39(3)	5/29/2019	143(3)	Median =	20
5/24/2017	20	5/29/2019	160	3rd Quartile =	107
5/31/2017	< 10(2)	6/5/2019	< 10(2)	Max =	8,700
6/7/2017	< 10(2)	6/12/2019	15(3)	Mean =	204

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

Table 8.A-2. Sand Sampling Data from Transects, Lake Ahquabi Beach.

		E. coli (MPN/cubic cm)				
Date	**Row/ Transect**	**A**	**B**	**C**	**D**	**E**
4/25/2017	1	< 0.1(1)	< 0.1(1)	< 0.1(1)	< 0.1(1)	0.1
	2	0.3	1.4	< 0.1(1)	< 0.1(1)	< 1.0(1)
	3	< 0.1(1)	0.1	< 0.1(1)	< 0.1(1)	1.0
5/1/2017	1	2.3	21.0	11.0	24.0	0.2
	2	2.1	0.88	< 0.1(1)	< 0.1(1)	< 0.1(1)
	3	< 0.1(1)	< 0.1(1)	< 0.1(1)	< 0.1(1)	< 0.1(1)
6/26/2017	1	0.2	360.0	< 0.1(1)	< 0.1(1)	< 1.0(1)
	2	0.2	340.0	0.4	1.4	< 1.0(1)
	3	0.4	7.3	3.0	< 0.1(1)	195.6
8/28/2017	1	< 0.1(1)	1.0	0.4	< 0.1(1)	2.8
	2	0.4	34.0	< 0.1(1)	< 0.1(1)	< 0.1(1)
	3	0.2	4.4	0.2	< 0.1(1)	< 0.1(1)
9/26/2017	1	3.5	0.1	< 0.1(1)	< 0.1(1)	1.0
	2	26.0	4.1	< 0.1(1)	< 0.1(1)	< 0.1(1)
	3	760.0	1.2	0.1	< 0.1(1)	3.1
5/29/2019	1	0.1	0.65	1.3	1.5	
	2	7.4	0.86	0.2	0.31	
	3	45.0	18.0	0.1	0.3	
6/12/2019	1	140.0	24.0	0.59	< 0.1(1)	
	2	12.3	4.1	< 0.1(1)	36.0	
	3	49.0	150.0	< 0.1(1)	< 0.1(1)	
7/10/2019	1	31.0	40.0	3.0	1.0	
	2	88.0	280.0	42.0	1.1	
	3	19.0	230.0	>2200(2)	6.4	
7/23/2019	1	33.0	820.0	< 10(1)	290.0	
	2	130.0	850.0	42.0	21.0	
	3	240.0	280.0	21.0	270.0	
8/7/2019	1	0.91	110.0	120.0	0.68	
	2	14.0	250.0	0.28	0.4	
	3	0.11	130.0	0.9	0.69	

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

Table 8.A-3. Water Sampling Data from Transects, Lake Ahquabi Beach.

		E. coli (MPN/100 ml)								
Date	**Row/ Transect**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
4/25/2017	1	470	1400	500	98	< 10(1)	< 10(1)	10	10	< 10(1)
	2	< 10(1)	< 10(1)	41	63	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	3	98	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
5/1/2017	1	86	52	20	52	30	110	41	10	20
	2	86	41	20	74	31	20	20	< 10(1)	31
	3	700	52	20	20	41	52	41	63	< 10(1)
6/26/2017	1	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	2	10	20	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	3	< 10(1)	10	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	10	< 10(1)
8/28/2017	1	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	2	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	< 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)
9/26/2017	1	98	31	31	20	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)
	2	41	41	75	63	10	10	< 10(1)	< 10(1)	< 10(1)
	3	97	86	52	52	20	20	10	10	< 10(1)
5/29/2019	1	150	160	120	220	63	120	160		
	2	200	110	85	97	120	85	160		
	3	150	75	200	150	52	63	130		
6/12/2019	1	110	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)		
	2	10	10	< 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)		
7/10/2019	1	31	10	10	< 10(1)	20	10	10		
	2	2500	< 10(1)	20	< 10(1)	20	< 10(1)	10		

	3	1600	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)		
7/23/2019	1	98	20	31	10	< 10(1)	< 10(1)	< 10(1)		
	2	8700	31	10	52	10	10	< 10(1)		
	3	300	< 10(1)	< 10(1)	< 10(1)	< 10(1)	< 10(1)	10		
8/7/2019	1	< 10(1)	< 10(1)	< 10(1)	10	< 10(1)	< 10(1)	< 10(1)		
	2	20	< 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)		

(1) *E. coli* for the sample was not detectable. The non-detectable limit recorded was divided in half for calculation purposes.

9. Lake Macbride TMDL

9.1. Description and History of Lake Macbride

Lake Macbride, IA 02-IOW-629, is located in Big Grove Township, Johnson County, Iowa approximately four miles west of Solon. The lake was constructed in the 1930's and is located within the 1,995 acre Lake Macbride State Park, which is owned and operated by the Iowa DNR. 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 17,033 acres, a maximum depth of 45 feet, a shore length of approximately 16.0 miles, and an approximate volume of 13,528 acre-feet. Figure 9-1 is an aerial photograph with the boundaries of the watershed. Table 9-1 is a summary of the lake and watershed properties.

Table 9-1. Lake Macbride Watershed and Lake Information.

Waterbody Name	Lake Macbride
Waterbody ID	IA 02-IOW-629
12 Digit Hydrologic Unit Code (HUC)	070802081008
HUC-12 Name	Lake Macbride-Mill Creek
Location (Ambient Monitoring Site)	Section 29, T81N, R06W, Johnson County, Iowa
Water Quality Standard Designated Uses	Class A1 Primary Contact Recreation Class B(LW) Aquatic Life Class HH Human Health
Antidegredation Protection Level	Tier 1
Tributaries	Mill Creek and Jordan Creek
Receiving Waterbody	Coralville Reservoir
Watershed Area	17,033 acres
Lake Surface Area(1)	888.9 acres
Maximum Depth(1)	45.0 feet
Volume(1)	13,528 ac-feet
Length of Shoreline	16.0 miles
Watershed/Lake Area Ratio	18.2:1

(1) Per July 2003 Bathymetric Survey.

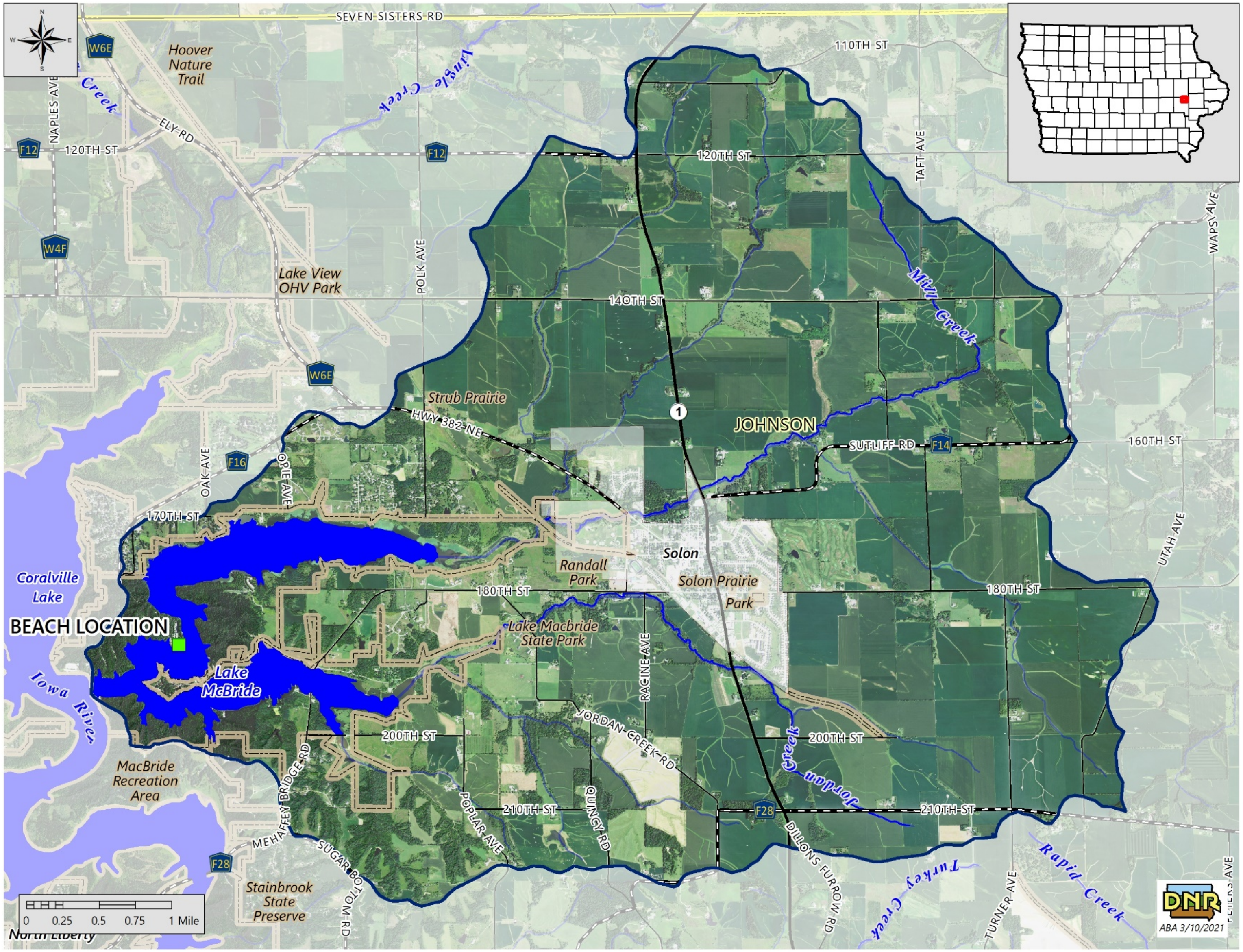

Figure 9-1. Lake Macbride Watershed.

Land Use

A Geographic Information System (GIS) coverage of land use information was developed using the 2014 USDA Cropland Data Layer (USDA, National Agricultural Statistics Service). The dominate land use is row crops (corn and soybeans rotations) making up approximately 50% (Table 9-2). The eight land uses shown in Table 9-2 were aggregated from the fourteen land uses in the cropland data layer as shown in the description column. Figure 9-2 shows the distribution of the various land uses throughout the Lake Macbride watershed in a pie-chart.

Table 9-2. Lake Macbride Watershed Land Uses.

Land Use	Description	Area (AC)	Percent of Total
Water/Wetland	Water and Wetlands	914	5.4%
Forested	Bottomland, Coniferous, Deciduous	2,158	12.7%
Grassland	Ungrazed, Grazed, & CRP-	3,282	19.3%
Alfalfa/Hay	Perennial Hay Crop-	319	1.8%
Row Crop	Corn, Soybeans, & other	8,590	50.4%
Roads	Roads Lightly Developed Urban	1,138	6.7%
Urban	Intensively Developed Urban	632	3.7%
Total		**17,033**	**100.0%**

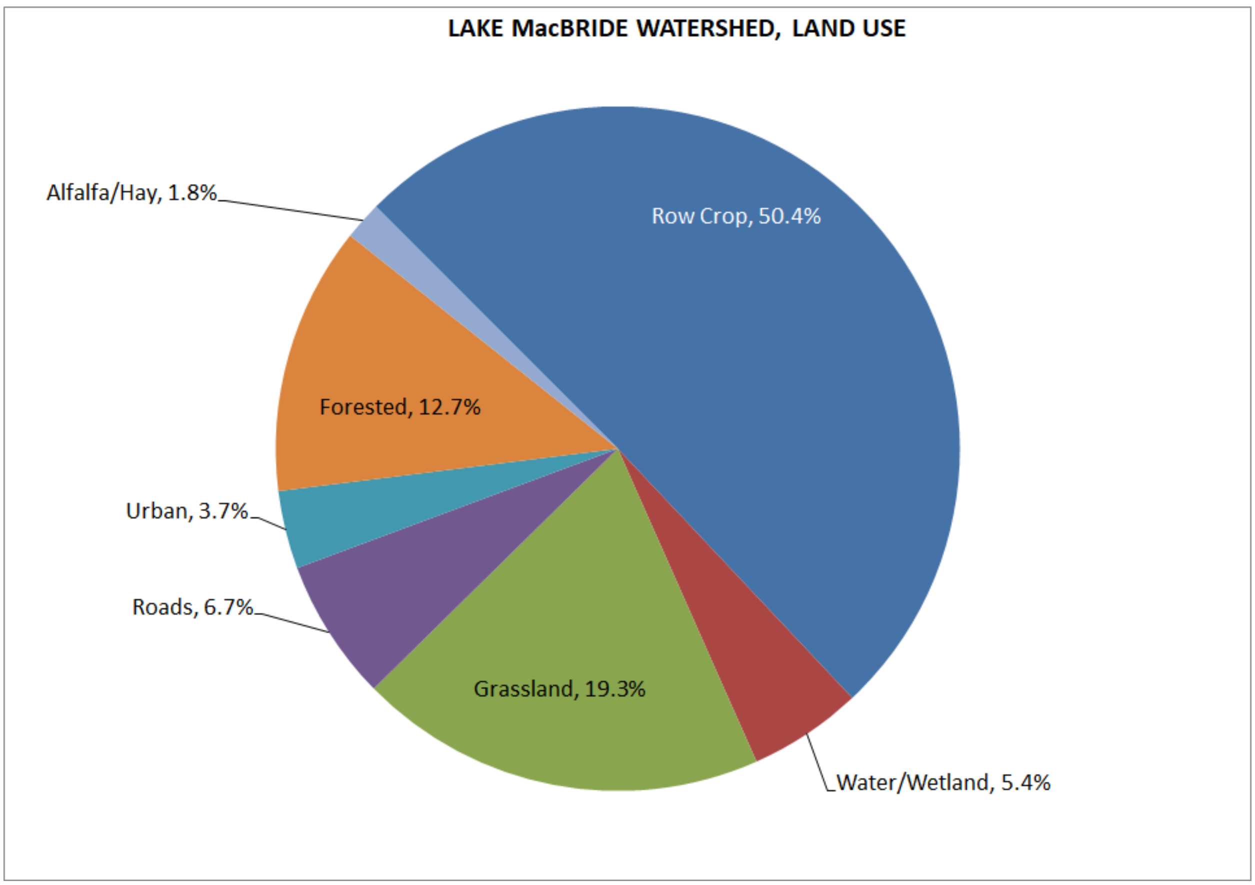

Figure 9-2. Land Use Composition of the Lake Macbride Watershed.

Hydrology, Soils, Climate, Topography

From data obtained from the NRCS, the two most common soils types are the Fayette and Tama soils, which makes up 35% of the soil types in the watershed. No other soil type makes up more than 10%

soils in the watershed. Of the four hydrologic soil types, hydrologic soil type B makes up the majority of the soils in the watershed at approximately 83%. The majority of the Lake Macbride watershed lies within the Iowan Surface landform, which usually appears slightly inclined to gently rolling with long slopes, low relief and open views to the horizon (Prior, 1991).

The average rainfall for the Lake Macbride watershed from 2002 through 2020 is 36.2 inches with the majority (69%) falling between April 1st and September 30th. Lake evapotranspiration averages 42.0 inches per year with more occurring in dryer years on average. Figure 9-3 shows the annual rainfall and reference evapotranspiration from 2002 to 2020. Figure 9-4 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.

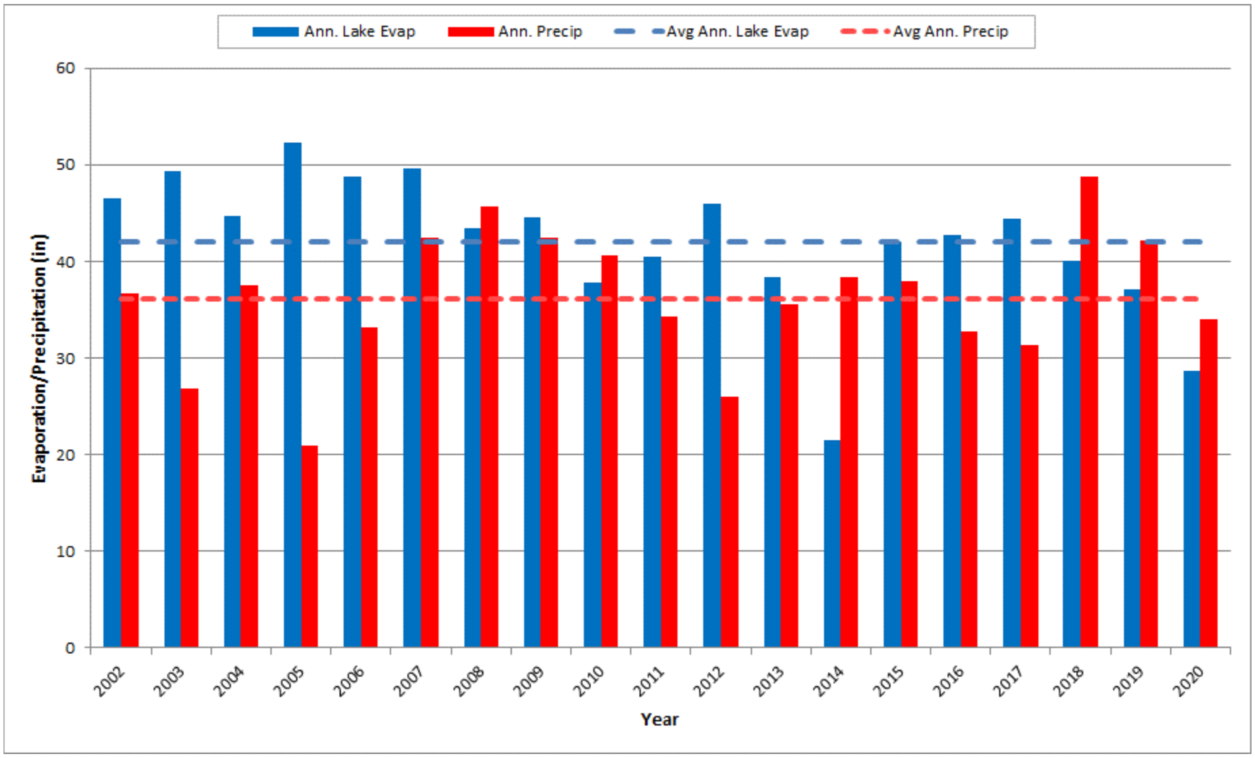

Figure 9-3. Annual Rainfall and Estimated Evapotranspiration Totals, Lake Macbride Watershed.

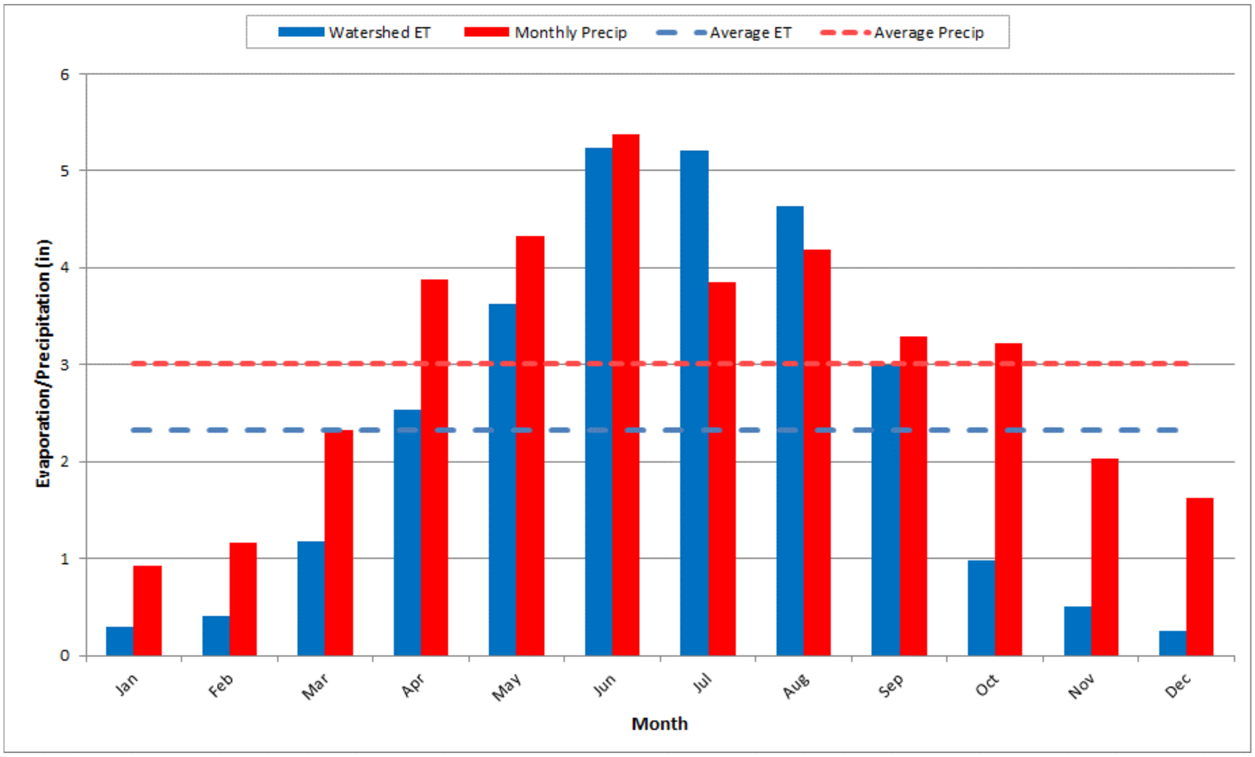

Figure 9-4. Monthly Rainfall and Estimated Evapotranspiration Totals, Lake Macbride Watershed.

9.2. 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 based impairments result in whole lake waterbodies being listed as impaired on the states 303(d) list each cycle. 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 (Section 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 Macbride Beach on Lake Macbride (IA 02-IOW-629).

Sampling and Data Collection

Beach, open lake and alternate transects as well as open lake sampling points were sampled seasonally and in response to wet weather events from spring 2017 through the fall of 2017 and again from the spring of 2018 through the fall of 2018 (Figure 9-5). All water and sand sample collection and laboratory analysis was conducted following protocols highlighted in Section 2.3.

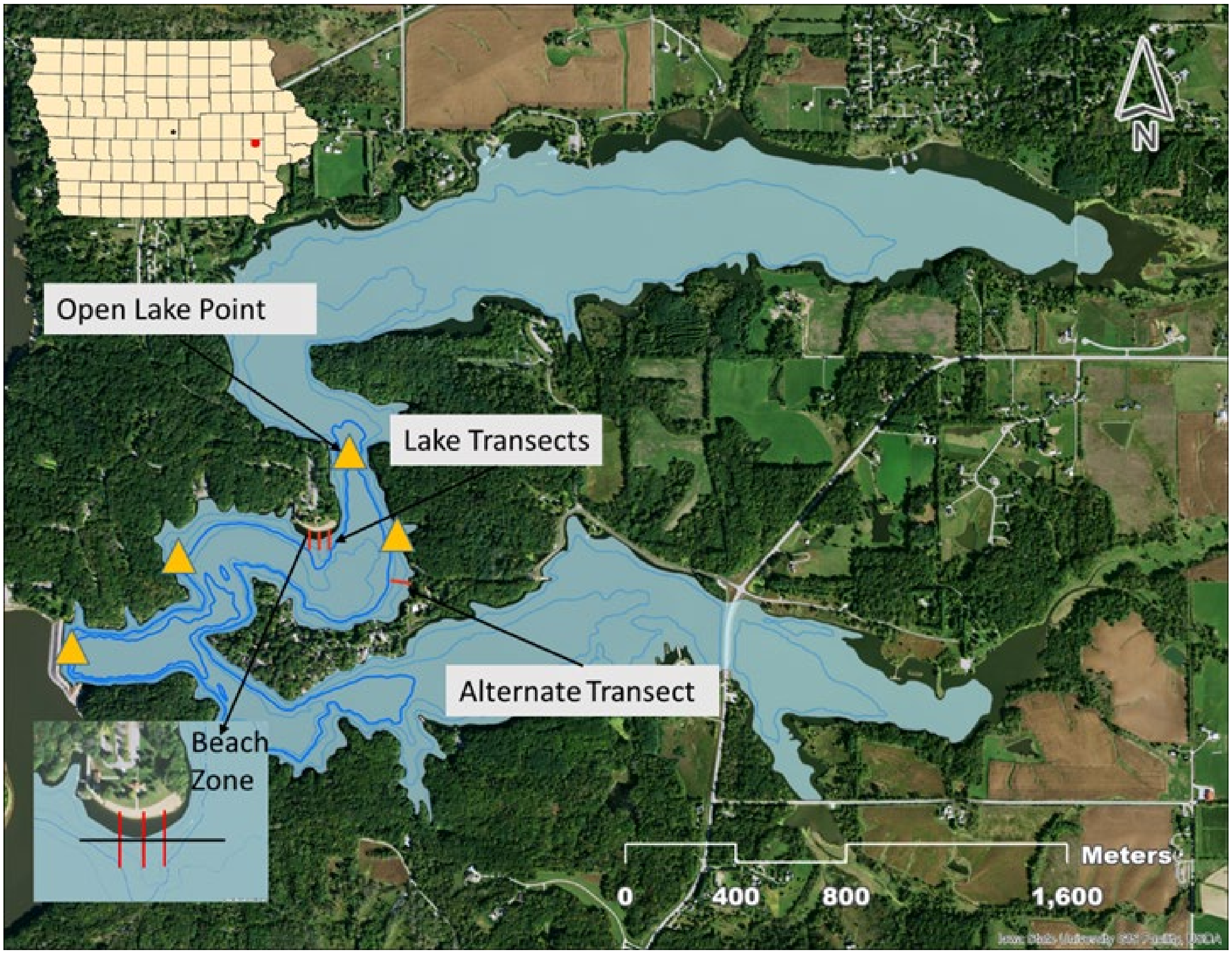

Figure 9-5. Overview of Monitoring Locations on Lake Macbride.

Sampling Results and Analysis
Data collected from the beach sand environment during both seasons showed a wide range of variability (Table 9-3). However, median sample *E. coli* concentrations were well above detection limits of (0.1 MPN/gram). This trend is conistant with analysis conducted on other systems in Iowa (Section 2.4).

Table 9-3. Basic Statistics from Bacteria Sampling at Lake Macbride.

Sampling Dataset	N	Mean	Median	St. Dev.	25th %	75th %
Lake Macbride Swimming Zone	155	620	20	2,064	5	200
Lake Macbride Transects	195	11	5	13	5	10
Lake Macbride Open Lake	46	14	5	27	5	10
Lake Macbride Beach Sand	174	1,202	96	4,266	10	453

Water results reported as MPN/ 100mL and sand results reported as MPN/dry wt. gram

Water sample collection in the nearshore swimming zone showed a high degree of variability. Sample results commonly varied by hundreds of MPN/ 100mL, 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 very low *E. coli* concentrations as median dataset concentrations were right at the detection limit of 10 MPN/ 100mL (Table 9-3). 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 2017 sampling year at Lake Macbride the swimming area met recreational standards (235 MPN/ 100mL) five of the 6 sampling trips. However, in 2018 the beach failed the recreational standard six of the seven trips, showing a high degree of inter annual variability. Sampling at the alternate transect and open lake locations had a two year median value below the *E. coli* detection limit of 10 MPN/ 100mL and relatively low standard deviations, indicating overall low concentrations in these environments.

Beach sand sampling conducted at Lake Macbride Beach revealed trends consistent with prior surveys (Section 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 were significantly higher in *E. coli* concentrations than C or D (P<0.05). As with prior surveys, the sands on Lake Macbride Beach had *E. coli* concentrations many times higher than observed in adjacent swimming waters (Figure 9-6). Beach sand *E. coli* concentrations averaged over 2,800 times higher than those observed in adjacent swimming areas during the two-year sampling period. 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 Section 2.

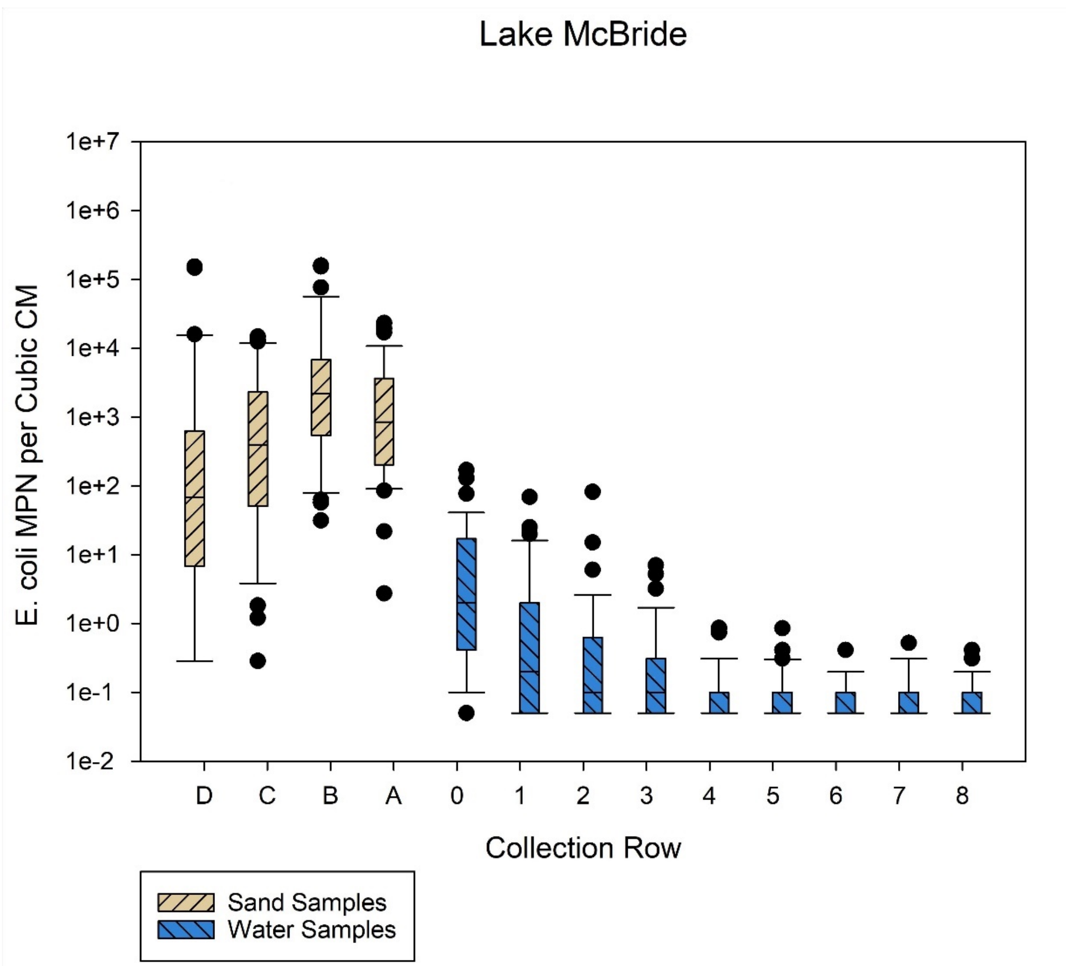

Figure 9-6. Box Plots of Sand and Water Sampling from Transects along Lake Macbride Beach. Reported in MPN/per cubic cm. Sampling points in figure correspond to following locations in relation to shoreline: A=shoreline, B (+2.5 m), C (+5m), D (+10M), 0 (Ankle deep), 1 (Knee deep), 2 (waist deep), 3 (chest 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 9-7) 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 Macbride monitoring network uncovered trends and associations which closely mimiced findings of previous beach investigations (Section 2). Results highlighted in Table 9-4 demonstrate the dissassociation 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 (Section 2). The findings from this analysis validate the decision to address the *E. coli* bacteria impairments at Lake Macbride Beach with a framework that directly addresses beach specific sources of *E. coli*.

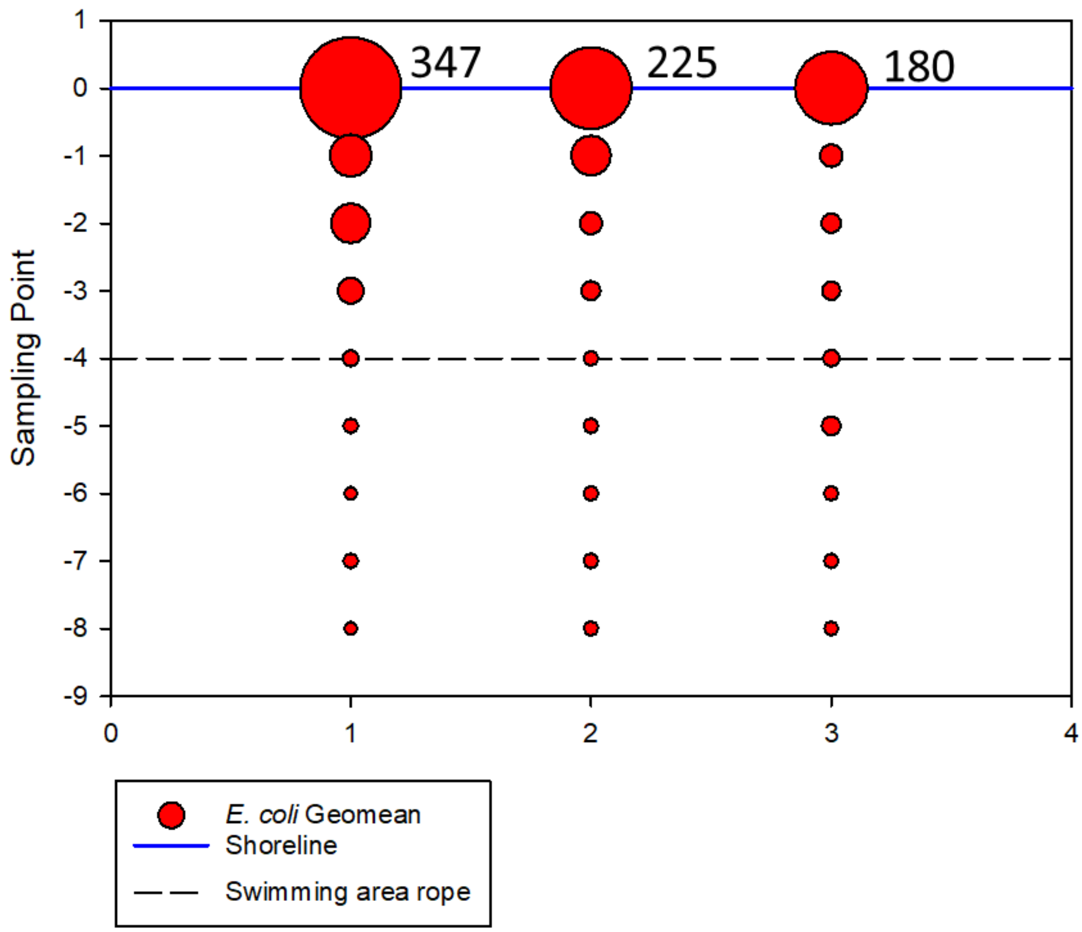

Figure 9-7. Bubble Plot of *E. coli* Sampling at Lake Macbride Beach Lake Transects Reported as MPN/ 100mL.

Table 9-4. Analysis Results from Lake Macbride 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

9.3. TMDL for Lake Macbride Beach.

The 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 beach at Lake Macbride State Park. Assessments conducted on the Lake Macbride beach and lake system (Section 9.2) 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 Macbride, IA 02-IOW-629, was included on the 2006 303(d) impaired waters list for not fully supporting Class A1 (primary contact recreation) uses due to the presence of high levels of *E. coli*. Samples were collected during the recreational season (March 15 – November 15) between 2002 – 2020 as part of the state's ambient water quality monitoring and assessment program.

In 2017 and 2018 additional water quality samples were collected by the Iowa DNR to study and assess the relationships between the nearshore beach environment and open lake conditions. Results of this study are presented in Section 9.2

Applicable Water Quality Standards

The designated uses of Lake Macbride 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.
- 567-61.2(2)(c) Tier 2½ protection—outstanding Iowa waters. Where high quality waters constitute an outstanding state resource, such as waters of exceptional recreational or ecological significance, that water quality shall 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 9-8 shows the swimming and beach shed areas of Lake Macbride. Table 9-5 is a summary of the NSBV data.

Figure 9-8. Swimming and Beach Shed Areas, Lake Macbride.

Table 9-5. Lake Macbride NSBV Data.

Near Shore Beach Volume	1.51 acre-feet
Beach Front Length	523.1 feet
Radius from Shore at midpoint of beach	81.9 feet
Depth at Radius	4.3 feet (Elevation 707.7)
Beach Shed Area	3.1 Acres

Data Sources and Monitoring Sites

Table 9-6 lists the water quality monitoring locations used to develop the WQIP for Lake Macbride. Figure 9-9 shows the monitoring locations used. In addition to these sites, samples were collected adjacent to the beach along three transects as shown in Figure 9-10. See Section 9.2 for a more detailed description of the samples collected along the transects.

Table 9-6. WQ Data Monitoring Sites at Lake Macbride.

Site Name	Site ID	Longitude	Latitude
McBride bac 1[(1)]	14000212	91° 33’ 44”	41° 47’ 58”
Lake Macbride[(2]	22520001	91° 34’ 22”	41° 47’ 37”
Lake Macbride near Cottage Grove[(1) (2]	22520006	91° 33’ 38”	41° 47’ 50”
Lake Macbride near Campground[(1) (2]	22520007	91° 34’ 07”	41° 47’ 46”
Lake Macbride Beach (Lake Macbride State Park)[(1) (2)]	21520001	91° 33’ 49”	41° 47’ 52”

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

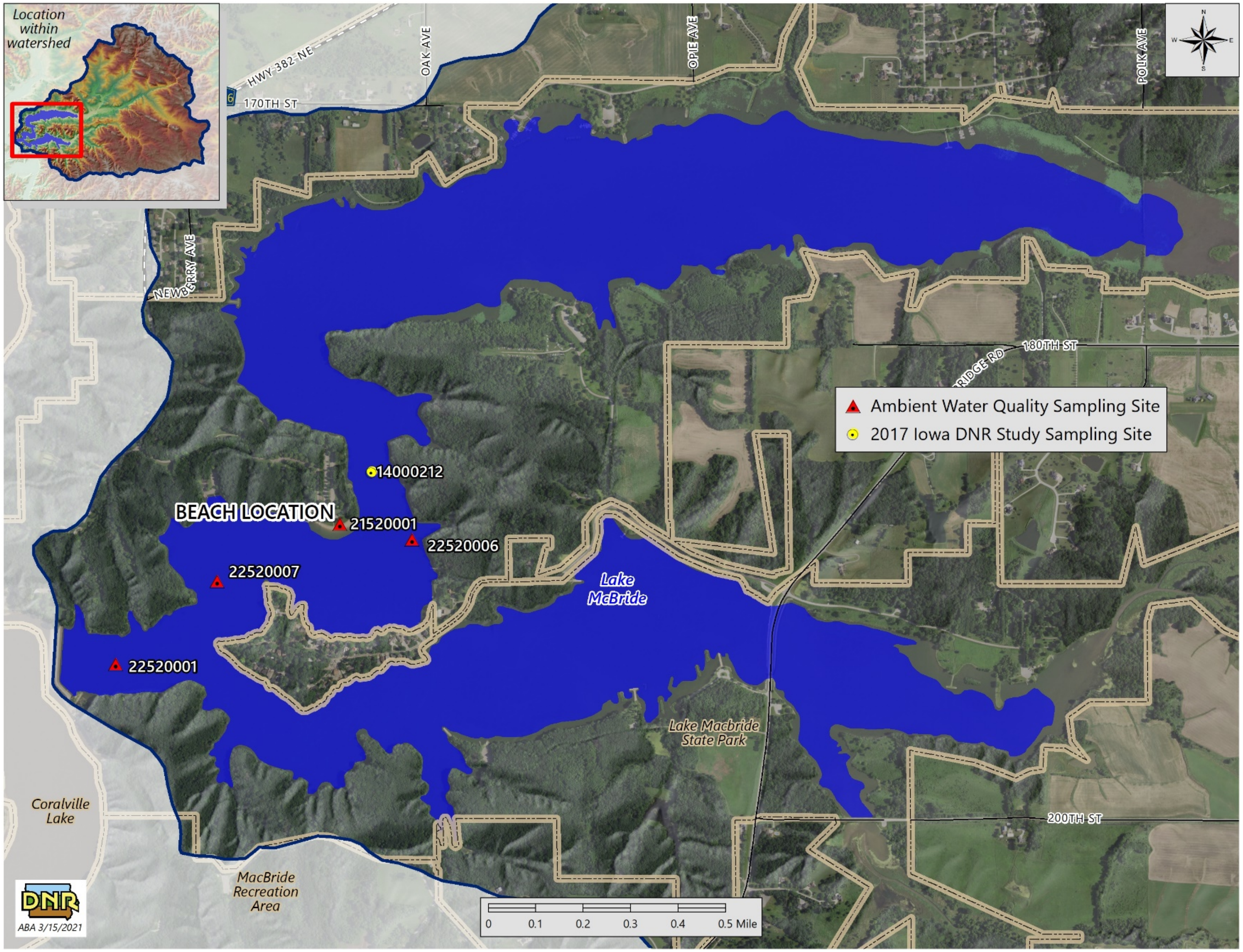

Figure 9-9. Sampling Locations, Lake Macbride.

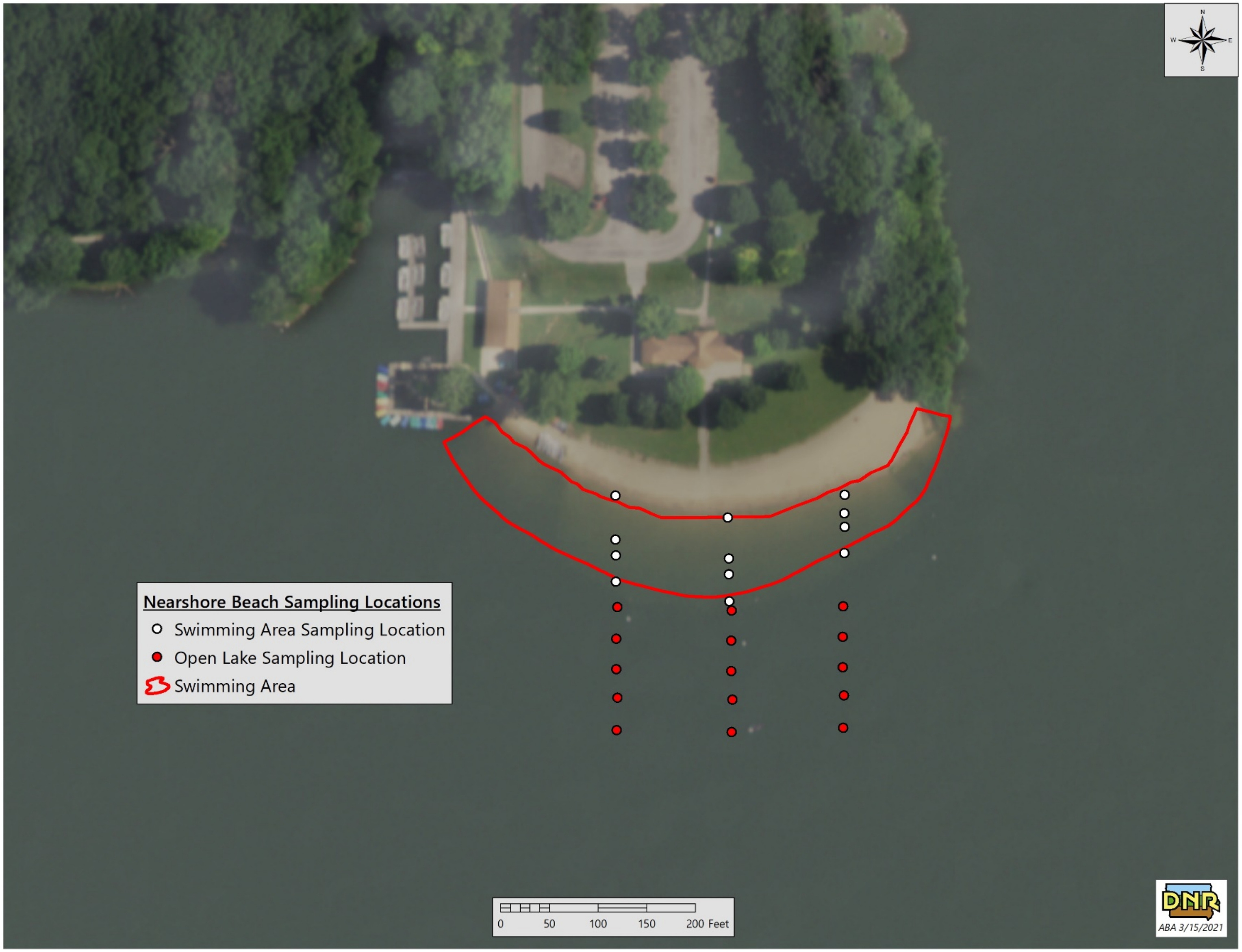

Figure 9-10. Nearshore Beach Sampling Locations, Lake Macbride.

Interpretation of Data

Using data collected from 2002 – 2020, two box plots were developed. Figure 9-11 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 line representing the SSM concentration of 235 orgs/ 100 mL.

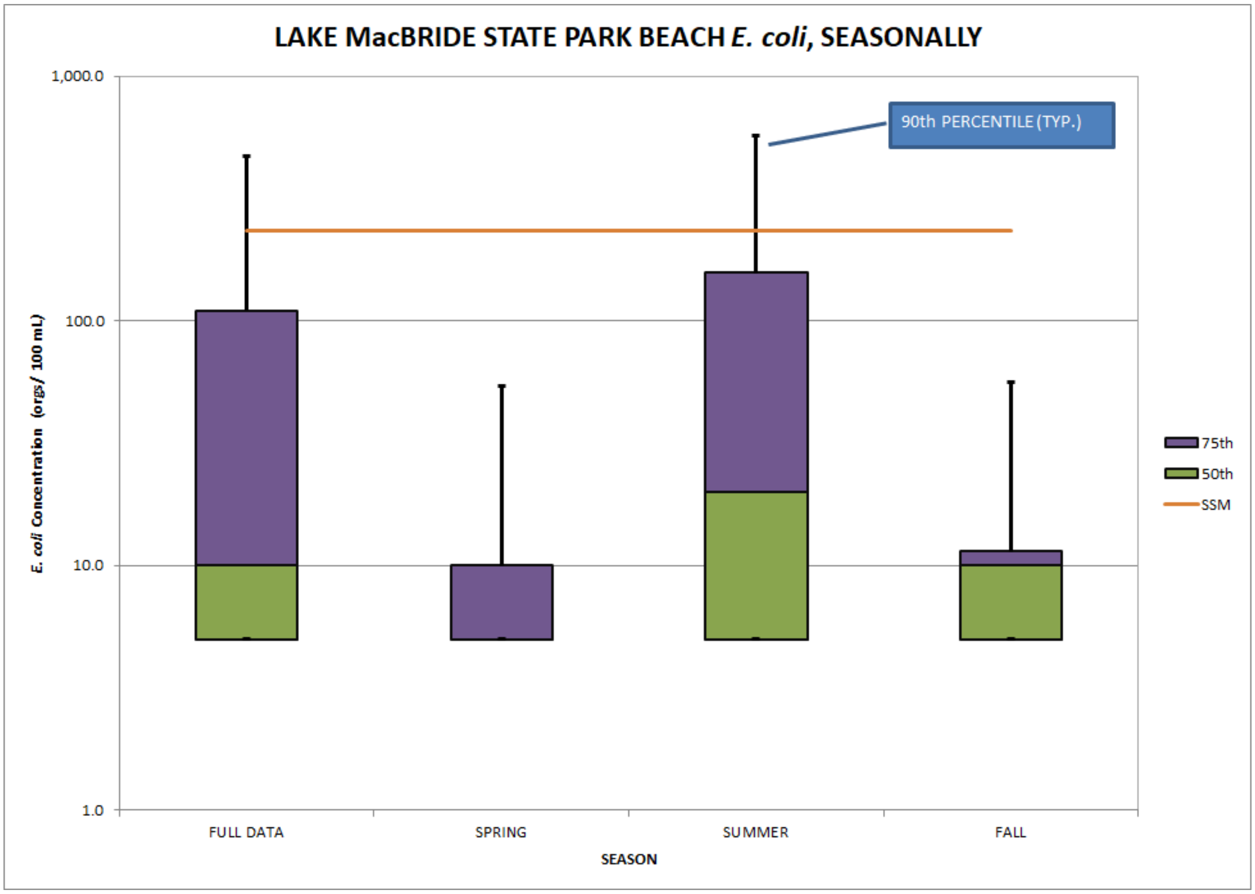

Figure 9-11. Seasonal Box Plot, Lake Macbride.

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. Moderate 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 9-11 it can be seen that there is elevated levels of bacteria during the summer season at the Lake Macbride beach.

In the second box plot graph, Figure 9-12, 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 rise during the spring months, exceed WQS during June and July, and decease in late summer and fall with July being the peak month.

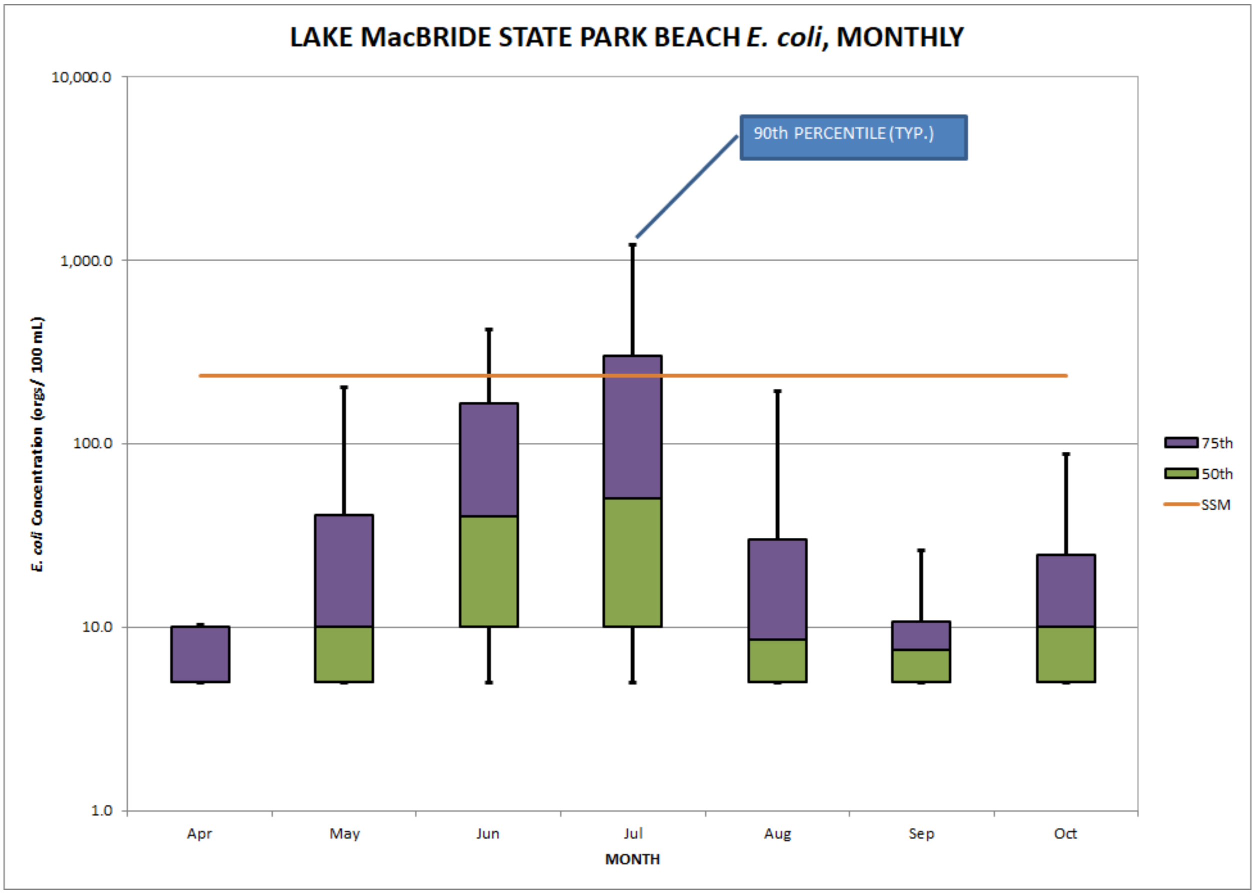

Figure 9-12. Monthly Box Plot, Lake Macbride.

9.3.1. 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 to November 15. The critical volume is the NSBV, which is adjacent to the beach area.

Consideration of Seasonal Variation

These TMDL's were developed based on the Iowa WQS primary contact recreation season that runs from March 15 to 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 Lake Macbride are based on the assumption 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 9-13 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.

9.3.2. Pollution Source Assessment

Departure from Load Capacity
The seasonal load curve and observed loads for the seasonal load conditions are plotted in Figure 9-13. 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.

9.3.3. Pollutant Allocations

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

Load Allocation (LA)
Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the stream. Specific examples of potential nonpoint sources of bacteria include animals directly depositing into streams, 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 2-year study presented in Chapter 2 and Section 9.2 of this WQIP the source of the impairment is from the near shore beach environment. The main source of *E. coli* is from waterfowl and shore birds loafing on the beach and 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 9-13 shows a seasonal load curve for the NSBV at Lake Macbride. Table 9-7 and Table 9-8 are the existing load estimates and the TMDL summary, respectively for the NSBV at Lake Macbride.

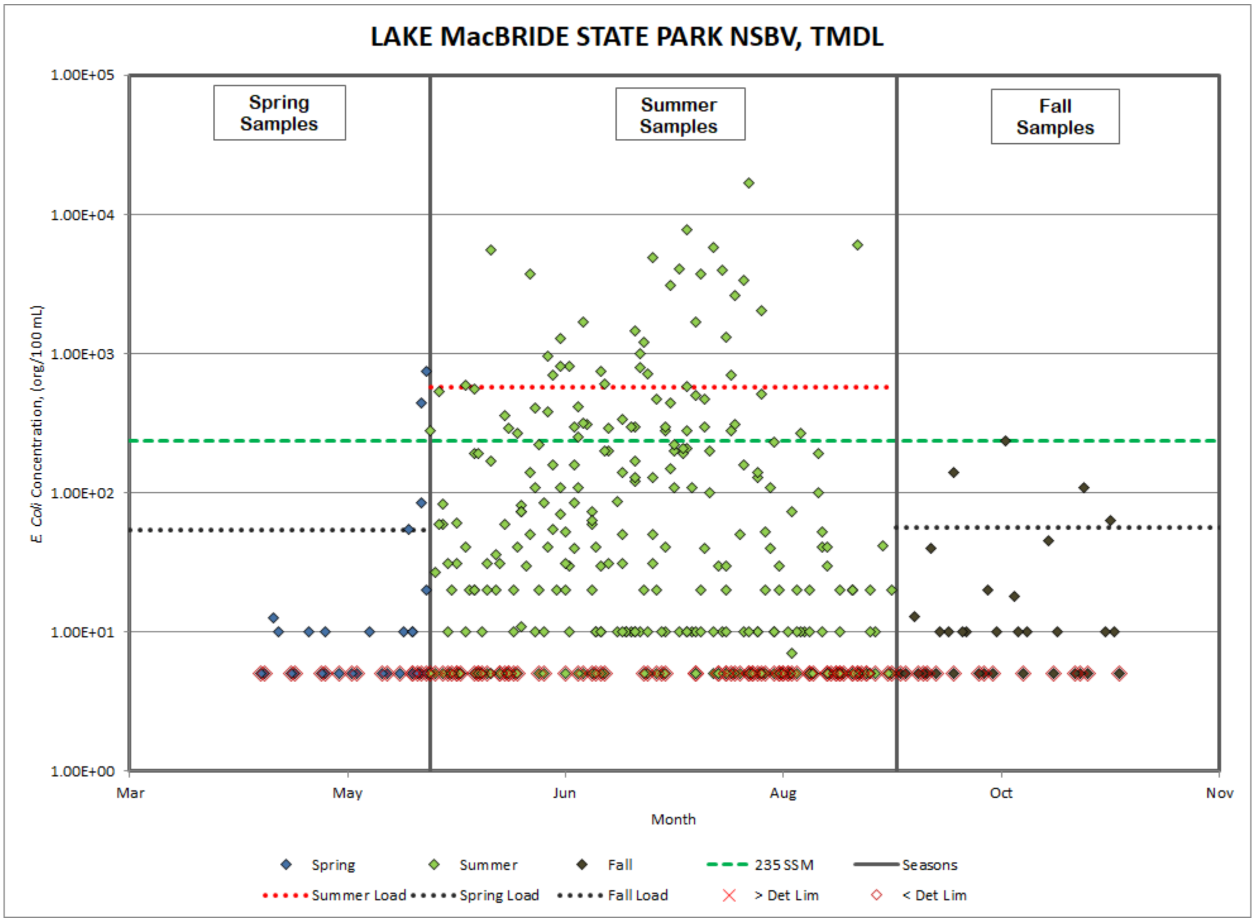

Figure 9-13. Seasonal Load Curve, Lake Macbride, Near Shore Beach Volume.

Table 9-7. Existing Load Estimates for the NSBV at Lake Macbride.

Load Summary	Seasonal Loads (org/ 100 mL)		
	Spring	Summer	Fall
Observed Load(1)	54.3	574.0	56.4
Departure	N/A	339.0	N/A
(% Reduction)	(0)	(59.1)	(0)

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

Table 9-8 is a summary of the TMDL for the NSBV at Lake Macbride. Because it is assumed that the NSVB is constant from year to year the TMDL calculations do not change from season to season.

Table 9-8. TMDL Summary for the NSBV at Lake Macbride.

	TMDL
TMDL (org/ 100 mL)	235.0
WLA (org/ 100 mL)	0.0
LA (org/ 100 mL)	211.5
MOS (org/ 100 mL))	23.5

9.3.4. TMDL Summary

This TMDL is based on meeting the water quality criteria for primary contact and children's recreation in Lake Macbride. 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 9-8 and a NSBV of 1.5 acre-feet the TMDL for Lake Macbride as a mass loading is presented in Table 9-9.

Table 9-9. Summary of Lake Macbride.

	TMDL
TMDL (orgs/day)	4.37E+09
WLA (orgs/day)	0.00E+00
LA (orgs/day)	3.94E+09
MOS (orgs/day)	4.37E+08

Appendix 9.A. Water Quality Data

Table 9.A-1. Water Quality Sampling Data, Beach Monitoring, Lake Macbride, SITE ID 21520001.

Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)
4/15/2002	< 10[(2)]	6/23/2003	< 10[(2)]	10/12/2004	45
4/22/2002	< 10[(2)]	6/30/2003	10	10/19/2004	< 10[(2)]
4/29/2002	10	7/7/2003	10	10/26/2004	64
4/29/2002	< 10[(2)]	7/14/2003	< 10[(2)]	5/17/2005	10
5/6/2002	< 10[(2)]	7/21/2003	210	5/24/2005	< 10[(2)]
5/13/2002	< 10[(2)]	7/28/2003	30	5/31/2005	10
5/20/2002	< 10[(2)]	8/4/2003	< 10[(2)]	6/7/2005	36
5/27/2002	< 10[(2)]	8/11/2003	< 10[(2)]	6/14/2005	30
6/3/2002	< 10[(2)]	8/18/2003	< 10[(2)]	6/21/2005	20
6/10/2002	< 10[(2)]	8/25/2003	< 10[(2)]	6/28/2005	310
6/17/2002	< 10[(2)]	9/1/2003	10	7/5/2005	10
6/24/2002	10	9/8/2003	< 10[(2)]	7/12/2005	< 10[(2)]
7/1/2002	10	9/15/2003	40	7/19/2005	10
7/8/2002	10	9/22/2003	10	7/26/2005	100
7/15/2002	< 10[(2)]	9/29/2003	< 10[(2)]	8/2/2005	< 10[(2)]
7/22/2002	10	10/6/2003	< 10[(2)]	8/9/2005	40
7/29/2002	10	10/13/2003	< 10[(2)]	8/16/2005	10
8/5/2002	< 10[(2)]	10/20/2003	110	8/23/2005	< 10[(2)]
8/12/2002	< 10[(2)]	10/27/2003	10	8/30/2005	< 10[(2)]
8/19/2002	< 10[(2)]	5/24/2004	27	9/6/2005	< 10[(2)]
8/26/2002	< 10[(2)]	5/31/2004	590	9/13/2005	< 10[(2)]
9/2/2002	10	6/8/2004	< 10[(2)]	9/20/2005	140
9/16/2002	< 10[(2)]	6/15/2004	140	9/27/2005	< 10[(2)]
9/23/2002	10	6/22/2004	1,300	10/4/2005	18
9/30/2002	10	6/29/2004	73	10/18/2005	< 10[(2)]
10/7/2002	10	7/6/2004	50	10/25/2005	10
10/14/2002	10	7/13/2004	130	4/18/2006	10
10/21/2002	< 10[(2)]	7/20/2004	190	4/25/2006	10
10/28/2002	< 10[(2)]	7/27/2004	5,800	5/2/2006	< 10[(2)]
4/14/2003	< 10[(2)]	8/3/2004	160	5/9/2006	10
4/21/2003	< 10[(2)]	8/10/2004	< 10[(2)]	5/16/2006	< 10[(2)]
4/28/2003	< 10[(2)]	8/17/2004	10	5/23/2006	< 10[(2)]
5/5/2003	< 10[(2)]	8/24/2004	< 10[(2)]	5/30/2006	< 10[(2)]
5/12/2003	< 10[(2)]	8/31/2004	< 10[(2)]	6/6/2006	5,600
5/19/2003	< 10[(2)]	9/6/2004	20	6/13/2006	82
5/26/2003	< 10[(2)]	9/14/2004	< 10[(2)]	6/20/2006	55
6/2/2003	< 10[(2)]	9/20/2004	< 10[(2)]	6/27/2006	< 10[(2)]
6/9/2003	< 10[(2)]	9/28/2004	20	7/3/2006	200
6/16/2003	10	10/5/2004	10	7/11/2006	< 10[(2)]

Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)
7/18/2006	110	8/4/2008	< 10[2]	7/14/2010	470
7/25/2006	40	8/6/2008	10	7/16/2010	280
8/1/2006	< 10[2]	8/11/2008	30	7/19/2010	4,100
8/8/2006	< 10[2]	8/13/2008	< 10[2]	7/21/2010	280
8/15/2006	20	8/20/2008	100	7/26/2010	200
8/22/2006	30	8/25/2008	20	8/2/2010	50
8/29/2006	< 10[2]	9/2/2008	< 10[2]	8/6/2010	10
9/5/2006	< 10[2]	9/9/2008	< 10[2]	8/9/2010	110
9/12/2006	< 10[2]	9/17/2008	10	8/18/2010	< 10[2]
9/19/2006	10	5/19/2009	< 10[2]	8/24/2010	< 10[2]
9/26/2006	< 10[2]	5/26/2009	60	8/31/2010	< 10[2]
5/21/2007	< 10[2]	6/1/2009	20	5/23/2011	280
5/29/2007	< 10[2]	6/3/2009	< 10[2]	5/31/2011	41
6/4/2007	10	6/8/2009	< 10[2]	6/6/2011	170
6/11/2007	< 10[2]	6/10/2009	< 10[2]	6/13/2011	74
6/18/2007	< 10[2]	6/15/2009	50	6/20/2011	700
6/25/2007	160	6/17/2009	220	6/23/2011	52
7/2/2007	< 10[2]	6/22/2009	110	6/27/2011	320
7/9/2007	120	6/24/2009	30	6/29/2011	63
7/16/2007	< 10[2]	6/29/2009	< 10[2]	6/30/2011	41
7/23/2007	< 10[2]	7/6/2009	10	7/5/2011	86
7/30/2007	< 10[2]	7/9/2009	130	7/11/2011	20
8/6/2007	< 10[2]	7/13/2009	50	7/18/2011	200
8/13/2007	< 10[2]	7/15/2009	10	7/25/2011	300
8/21/2007	10	7/21/2009	580	8/1/2011	2,600
8/28/2007	< 10[2]	7/22/2009	110	8/3/2011	3,400
5/19/2008	10	7/27/2009	10	8/8/2011	52
5/27/2008	10	7/30/2009	30	8/11/2011	< 10[2]
6/2/2008	20	8/6/2009	130	8/15/2011	10
6/9/2008	60	8/10/2009	10	8/22/2011	< 10[2]
6/23/2008	20	8/12/2009	< 10[2]	8/29/2011	< 10[2]
6/25/2008	40	8/18/2009	10	5/22/2012	20
6/30/2008	10	8/25/2009	< 10[2]	5/29/2012	31
7/1/2008	30	9/1/2009	20	6/5/2012	< 10[2]
7/7/2008	10	5/25/2010	60	6/12/2012	< 10[2]
7/9/2008	10	6/2/2010	190	6/19/2012	41
7/14/2008	20	6/7/2010	20	6/26/2012	< 10[2]
7/16/2008	10	6/16/2010	110	7/3/2012	31
7/21/2008	10	6/22/2010	70	7/10/2012	10
7/23/2008	10	6/29/2010	60	7/17/2012	440
7/28/2008	< 10[2]	7/6/2010	340	7/24/2012	20
7/30/2008	10	7/12/2010	710	7/31/2012	< 10[2]

Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)
8/7/2012	< 10[2]	7/13/2015	4,900	8/15/2017	< 10[2]
8/14/2012	< 10[2]	7/21/2015	7,700	8/22/2017	41
8/22/2012	< 10[2]	7/29/2015	4,000	8/29/2017	6,100
8/28/2012	20	8/4/2015	17,000	9/11/2017	13[3]
5/22/2013	< 10[2]	8/10/2015	230	5/22/2018	750
5/29/2013	< 10[2]	8/12/2015	< 10[2]	5/29/2018	61
6/5/2013	31	8/18/2015	< 10[2]	6/5/2018	20
6/12/2013	41	8/19/2015	< 10[2]	6/12/2018	270
6/19/2013	380	8/25/2015	< 10[2]	6/19/2018	960
6/26/2013	250	9/1/2015	< 10[2]	6/26/2018	419[3]
7/1/2013	< 10[2]	5/25/2016	540	6/26/2018	110
7/9/2013	10	6/2/2016	20	7/2/2018	600
7/17/2013	150	6/8/2016	31	7/9/2018	1,454[3]
7/24/2013	10	6/15/2016	3,700	7/10/2018	1,000
7/31/2013	700	6/22/2016	820	7/17/2018	3,100
8/7/2013	< 10[2]	6/29/2016	20	7/23/2018	1,703[3]
8/14/2013	< 10[2]	7/6/2016	31	7/24/2018	3,700
8/21/2013	41	7/12/2016	10	7/30/2018	,1313[3]
8/28/2013	20	7/20/2016	210	7/31/2018	280
5/21/2014	440	7/27/2016	< 10[2]	8/7/2018	2,058[3]
5/27/2014	31	8/3/2016	10	8/7/2018	510
6/4/2014	< 10[2]	8/10/2016	10	8/14/2018	74
6/11/2014	20	8/16/2016	270	8/21/2018	52
6/18/2014	85	8/22/2016	< 10[2]	8/28/2018	20
6/25/2014	85	8/29/2016	< 10[2]	9/4/2018	42[3]
7/2/2014	200	4/17/2017	13[3]	10/2/2018	238[3]
7/9/2014	300	5/18/2017	54[3]	5/21/2019	85
7/16/2014	41	5/23/2017	< 10[2]	5/28/2019	< 10[2]
7/23/2014	500	5/30/2017	< 10[2]	6/4/2019	< 10[2]
7/30/2014	20	6/6/2017	< 10[2]	6/11/2019	10
8/6/2014	140	6/13/2017	11[3]	6/18/2019	10
8/11/2014	20	6/13/2017	73	6/25/2019	300
8/18/2014	20	6/20/2017	160	7/1/2019	10
8/25/2014	10	6/27/2017	1,700	7/9/2019	170
5/20/2015	< 10[2]	7/3/2017	290	7/16/2019	300
5/28/2015	20	7/10/2017	792[3]	7/23/2019	< 10[2]
6/3/2015	190	7/11/2017	1,200	7/30/2019	< 10[2]
6/10/2015	290	7/18/2017	220	8/5/2019	< 10[2]
6/17/2015	20	7/25/2017	470	8/13/2019	10
6/24/2015	810	8/1/2017	310	8/20/2019	190
7/1/2015	750	8/8/2017	20	8/28/2019	< 10[2]
7/8/2015	300	8/14/2017	7[3]	5/19/2020	10

Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)	Date	*E. coli* (orgs/ 100 mL)
5/26/2020	84	7/28/2020	< 10(2)	8/4/2020	10
6/2/2020	560				
6/9/2020	360				
6/16/2020	410			Min =	5
6/23/2020	31			1st Quartile =	5
6/30/2020	< 10(2)			Median =	10
7/6/2020	140			3rd Quartile =	110
7/13/2020	31			Max =	17,000
7/21/2020	10			Mean =	299

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

Table 9.A-2. Sand Sampling Data from Transects, Lake Macbride Beach.

		E. coli (MPN/cubic cm)				
Date	Row/ Transect	A	B	C	D	E
4/17/2017	1	240	8900	11	< 0.10(1)	< 0.11(1)
	2	60	> 27000(2)	8.9	260	1.4
	3	0.48	16	< 0.11(1)	< 0.10(1)	< .10
5/18/2017	1	16	220	2200	41	280
	2	1400	62	200	1300	120
	3	360	430	440	800	1300
6/13/2017	1	39	640	410	13	< 0.10(1)
	2	120	14	490	4	< 1(1)
	3	77	1300	0.21	95	1.6
7/10/2017	1	4100	> 28000	1800	> 26000	270
	2	890	780	280	27000	80
	3	1900	1600	140	2800	1800
8/14/2017	1	37	97	2.2	1.1	29
	2	17	1200	12	1.1	13
	3	20	10000	12	21	5.6
9/11/2017	1	15	10	0.32	19	0.1
	2	140	51	0.67	1.2	0.2
	3	3.8	31	1	0.53	6.2
6/26/2018	1	1800	150	1100	92	
	2	640	390	2100	71	
	3	430	980	2300	240	

7/9/2018	1	300	28	10	6.4	
	2	410	140	2600	< 0.1[(1)]	
	3	200	13500	13	< 0.1[(1)]	
7/23/2018	1	200	270	2.3	0.1	
	2	140	510	720	0.11	
	3	1400	830	6.1	2.7	
7/30/2018	1	150	1300	260	200	
	2	160	620	230	12	
	3	43	610	100	110	
8/7/2018	1	3400	240	230	6.6	
	2	3000	96	100	30	
	3	28	2300	140	2700	
9/4/2018	1	36	11	< 11[(1)]	< 10[(1)]	
	2	1800	440	11	< 11[(1)]	
	3	260	< 11[(1)]	22	22	
10/2/2018	1	36	190	11	< 10[(1)]	
	2	36	230	70	< 11[(1)]	
	3	48	160	45	< 11[(1)]	

(3) *E. coli* for the sample was not detectable. The non-detectable limit recorded was divided in half for calculation purposes.

(4) Individual *E. coli* sampling point was greater than quantification value. In these cases, the value listed was used for calculation purposes.

Table 9.A-3. Water Sampling Data from Transects, Lake Macbride Beach.

		E. coli (MPN/100 ml)								
Date	**Row/ Transect**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
4/17/2017	1	41	10	10	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]
	2	30	10	10	< 10[1]	< 10[1]	10	10	< 10[1]	< 10[1]
	3	10	10	< 10[1]	< 10[1]	< 10[1]	10	< 10[1]	10	< 10[1]
5/18/2017	1	200	51	31	31	10	31	10	10	10
	2	< 10[1]	75	20	31	31	< 10[1]	20	31	41
	3	85	41	41	41	20	10	< 10[1]	10	10
6/13/2017	1	52	10	< 10[1]	< 10[1]	< 10[1]	10	< 10[1]	< 10[1]	< 10[1]
	2	10	10	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]
	3	10	< 10[1]	< 10[1]	10	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]
7/10/2017	1	3400	290	250	85	85	20	20	52	10
	2	1100	360	260	320	20	20	10	31	41
	3	1700	440	600	700	86	41	41	31	31
8/14/2017	1	10	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]
	2	20	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]
	3	< 10[1]	< 10[1]	10	< 10[1]	10	< 10[1]	< 10[1]	< 10[1]	< 10[1]
9/11/2017	1	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]
	2	52	< 10[1]	< 10[1]	< 10[1]	< 10[1]	10	< 10[1]	< 10[1]	< 10[1]
	3	52	< 10[1]	< 10[1]	< 10[1]	< 10[1]	10	< 10[1]	< 10[1]	20
6/26/2018	1	730	160	98	170	20	< 10[1]	< 10[1]	20	10
	2	800	84	31	10	< 10[1]	10	10	10	< 10[1]
	3	2900	10	10	20	10	30	< 10[1]	< 10[1]	10
7/9/2018	1	13000	200	86	63	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]
	2	2700	130	20	20	< 10[1]	10	10	20	< 10[1]
	3	1200	< 10[1]	10	10	< 10[1]	10	10	< 10[1]	< 10[1]

	1	7700	6900	1500	520	10	20	< 10[1]	< 10[1]	< 10[1]
7/23/2018	2	2600	390	41	10	< 10[1]	< 10[1]	20	< 10[1]	< 10[1]
	3	740	20	< 10[1]	< 10[1]	< 10[1]	< 10[1]	10	20	20
	1	140	63	8200	31	< 10[1]	< 10[1]	10	10	10
7/30/2018	2	640	2000	200	30	20	10	< 10[1]	< 10[1]	< 10[1]
	3	1400	1600	140		74	85	< 10[1]	10	10
	1	4100	260	52	63	< 10[1]	10	< 10[1]	10	10
8/7/2018	2	17000	2500	< 10[1]	20	10	< 10[1]	< 10[1]	< 10[1]	10
	3	660	20	10	10	< 10[1]	20	10	< 10[1]	< 10[1]
	1	160	10	10	10	10	< 10[1]	< 10[1]	10	10
9/4/2018	2	150	< 10[1]	< 10[1]	< 10[1]	10	10	10	< 10[1]	< 10[1]
	3	130	< 10[1]	< 10[1]	< 10[1]	< 10[1]	10	< 10[1]	< 10[1]	< 10[1]
	1	2200	130	63	< 10[1]	20	< 10[1]	< 10[1]	< 10[1]	< 10[1]
10/2/2018	2	240	< 10[1]	10	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]
	3	180	< 10[1]	< 10[1]	< 10[1]	< 10[1]	< 10[1]	10	< 10[1]	< 10[1]

(1) *E. coli* was not detectable. 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 Iowa DNR's YouTube channel for public viewing on September 2, 2021. A link to the presentation can be located on the Iowa DNR;'s website at https://www.iowadnr.gov/environmental-protection/water-quality/watershed-improvement/water-improvement-plans. The presentation will be available for viewing through the public comment period.

Table E-1 is a listing of past and current public meetings and presentations. The Iowa 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

E.2. Written Comments

A press release was issued on September 2, 2021 to begin a 30-day public comment period that ended on October 4, 2021. During the public comment period the Iowa DNR received one (1) public comment. The public comment and the corresponding official response from the Iowa DNR are contained in Section E.3.

E.3. Public Comments

The public comment and Iowa DNRs response are attached.

iowa.gov

Hallmark, James <james.hallmark@dnr.iowa.gov>

Water quality issues

1 message

Mary Maher <irishmaher4@gmail.com> Fri, Sep 10, 2021 at 12:39 PM
To: james.hallmark@dnr.iowa.gov

Dear Mr. Hallmark,

One of the things we need to do in the state of Iowa is to put restrictions on CAFO's. There really are no restrictions that are enforced when someone applies to build one or continues to operate one.

Until we get a handle on these facilities there needs to be a moratorium on the building of new CAFO's, and the state of Iowa needs to enact laws to regulate these facilities. Case in point there are 6 hogs per each Iowan. That is a lot of hog excrement everyday.

Respectfully,
Mary M. Maher
irishmaher4@gmail.com

October 27, 2021

Ms. Maher,

Thank you for your comment dated September 10, 2021 on Addendum #1 of the Statewide Beach Bacteria Water Quality Improvement Plan (WQIP).

Two purposes of a WQIP are to identify the pollutant of concern and potential sources of the pollutant. In this particular WQIP the pollutant of concern is *E. coli* and the main source of the pollutant is isolated to the near shore beach environment as related to regeneration and attenuation of *E. coli* in the sand environment as discussed in Chapter 2 of the original WQIP and Sections 7.2, 8.2, and 9.2 of this addendum.

The watershed area impacting these beaches was limited to a very small area referred to in the WQIP as the beach shed area, which is described as the area that drains to the swimming zone at each of these recreational beaches. The beach shed area for each of the three beaches in this WQIP are shown in Figures 7-8, 8-8, and 9-8 and Tables 7-5, 8-5, and 9-5 describe the size of the beach shed area. Due to the size and location of the beach shed areas it was determined that this area did not contain any CAFO's or other agricultural sources.

Sampling and data collection for this WQIP, as discussed in Chapter 2 of the original WQIP and Sections 7.2, 8.2, and 9.2, demonstrate that the impairment for these beaches comes from the near shore beach environment and not from the open lake environment, which if CAFO's were a source of concern in this WQIP there would have been much higher *E. coli* levels in the samples collected from lake inlets and in the open lake environment.

Given the small beach shed area and sampling data collected for each of the lakes in this WQIP it was determined that CAFO's did not play a part in the impairment of these specific beaches.

Links to the original WQIP and Addendum #1 to the WQIP are provided below.

https://www.iowadnr.gov/Portals/idnr/uploads/water/watershed/tmdl/Statewide_Beach_FINAL_06102020_with%20comments.pdf

https://www.iowadnr.gov/Portals/idnr/uploads/water/watershed/tmdl/Statewide%20Beach%20Bacteria_Addendum1%20Draft%2008-16-2021.pdf.

Thank you again for taking the time to comment on the Statewide Beach Bacteria WQIP.

Sincerely,

Roger Bruner Digitally signed by Roger Bruner
Date: 2021.10.28 07:44:01 -05'00'

Roger Bruner, Section Supervisor
Water Quality Monitoring and Assessment Section