UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
901 NORTH 5TH STREET
KANSAS CITY, KANSAS 66101

AUG 30 2012

Mr. Chuck Gipp
Director
Iowa Department of Natural Resources
Henry A. Wallace Building
502 East 9th Street
Des Moines, Iowa 50319

Dear Mr. Gipp:

RE: Approval of TMDLs for Briggs Woods Lake

This letter responds to the submission from the Iowa Department of Natural Resources originally received by the U.S. Environmental Protection Agency, Region 7, on September 27, 2011, for a Total Maximum Daily Load document that contained TMDLs for organic enrichment, low dissolved oxygen and algae. Briggs Woods Lake was identified on the 2010 Iowa Section 303(d) List as impaired. This submission fulfills the Clean Water Act statutory requirement to develop TMDLs for impairments listed on a state's § 303(d) List. The specific impairments (water body segment and pollutants) are:

Water Body Name	WBID	Pollutants
Briggs Woods Lake	IA 04-UDM-01880-L_0	Organic Enrichment Low Dissolved Oxygen Algae

The EPA has completed its review of the TMDLs with supporting documentation and information. By this letter, the EPA approves the submitted TMDL document. Enclosed with this letter is the Region 7 TMDL Decision Document which summarizes the rationale for the EPA's approval of the TMDLs. The EPA believes the separate elements of the TMDLs described in the enclosed form adequately address the pollutants of concern, taking into consideration seasonal variation and a margin of safety. 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 a TMDL and determine if future revisions are necessary or appropriate to meet applicable water quality standards.

The EPA is currently in consultation under Section 7 of the Endangered Species Act with the U. S. Fish and Wildlife Service regarding this TMDL document. While we are approving these TMDLs at the present time, we may decide that changes to the TMDL document are warranted based upon the results of the consultation when it is completed.

The EPA appreciates the thoughtful effort that the IDNR has put into these TMDLs. We will continue to cooperate with and assist, as appropriate, in future efforts by the IDNR to develop remaining TMDLs.

Sincerely,

Karen A. Flournoy
Director
Water, Wetlands and Pesticides Division

Enclosure

cc: Mr. William Ehm, Administrator, Division of Environmental Services, IDNR
Mr. Allen Bonini, Supervisor, Watershed Improvement Program, IDNR
Mr. Mike Coffey, U.S. Fish and Wildlife Service

EPA Region 7 TMDL Review

TMDL ID: IA 04-UDM-01880-L_0 **State:** IA

Document Name: BRIGGS WOODS LAKE

Basin(s): DES MOINES RIVER
HUC(s): 07100005
Water body(ies): BRIGGS WOODS LAKE
Tributary(ies):
Pollutant(s): ALGAE, LOW DISSOLVED OXYGEN, ORGANIC ENRICHMENT, TOTAL PHOSPHORUS

Submittal Date: 9/27/2011 **Approved:** Yes

Submittal Letter

State submittal letter indicates final Total Maximum Daily Load(s) (TMDL) for specific pollutant(s)/water(s) were adopted by the state, and submitted to 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 EPA, date of receipt of any revisions, and the date of original approval if submittal is a phase II TMDL.

This TMDL document was formally submitted by the Iowa Department of Natural Resources to the U.S. Environmental Protection Agency on September 27, 2011. Revisions to this TMDL document were submitted by email on July 2, 2012.

Water Quality Standards Attainment

The water body's loading capacity (LC) 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. TMDL and associated allocations are set at levels adequate to result in attainment of applicable water quality standards (WQS) [40 CFR § 130.7(c)(1)]. A statement that WQS will be attained is made.

The 2010 Section 305(b) Water Quality Assessment Report states that primary contact recreation was assessed "partially supported" due to increased levels of algae (chlorophyll-a). This is an excursion to the state of Iowa's narrative water quality standard protection against "aesthetically objectionable conditions." The aquatic life use for this lake was also assessed as "partially supported" due to a fish kill that occurred in 2005. Low dissolved oxygen related to excessive growth of aquatic vegetation was the suspected cause of the fish kill. According to the IDNR assessment methodology, this constituted the need for development of a TMDL document for organic enrichment/low DO impairment.

The 2010 assessment is included in Appendix H of the TMDL document and can also be accessed at http://programs.iowadnr.gov/adbnet/assessment.aspx?aid=11452.

The current load is 8,515 pounds per year, or 93 pounds per day total phosphorus. The target strategy is based on in-lake chlorophyll-a targets that will be achieved by reductions in phosphorus loading. Phosphorus reductions are also accompanied by a reduction of nitrogen loads. If phosphorus targets are met and the algae still persists, more formal nitrogen reductions will be considered. To meet target loads, a reduction of 15 percent of the TP load is required.

The allowable in-lake chlorophyll-a target was translated to the total phosphorus loading capacity by performing water quality simulations using the BATHTUB model. The Spreadsheet Tool for Estimating Pollutant Load predicted sediment and nutrient loads from various land use and animal sources, as well as estimated potential sediment and nutrient reductions resulting from best management practices.

The narrative criteria in the water quality standards require that Briggs Woods Lake be free from "aesthetically objectionable conditions." There are no numeric criteria associated with water clarity, therefore the attainment of the standard is based on maintaining relatively good water clarity in comparison to other Iowa lakes.

In order to delist a lake impaired by algae from the 303(d) list, the median growing season chlorophyll-a trophic state index must not exceed 63 in two consecutive listing cycles, per the IDNR delisting methodology. This TSI value is equivalent to a median summer chlorophyll-a concentration of 27 micrograms per liter. If this goal is met, WQS attainment will be achieved.

Numeric Target(s)

Submittal describes applicable WQS, including beneficial uses, applicable numeric and/or narrative criteria. If the TMDL 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.

Designated uses for Briggs Woods Lake are primary contact recreation (A1), aquatic life (B(LW)) and human health fish consumption (HH).

The TMDL states that the state of Iowa Water Quality Standards are published in the Iowa Administrative Code, Environmental Protection Rule 567, Chapter 61. Although the IDNR does not have a numeric criteria for sediment, nutrients or algae (chlorophyll-a), narrative WQS do apply. Chapter 61.3(2)(c)(e) of the Iowa WQS contains the general criteria that is applicable to all surface waters. The narrative criteria reads that:

- "waters shall be from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor, or other aesthetically objectionable conditions"
- "waters shall be free from substances, attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance aquatic life."

As stated in the TMDL document, with respect to the fish kill and organic enrichment/low dissolved oxygen impairment, there was not sufficient data to compare the DO in Briggs Woods Lake to the numeric standard of not less than 5 milligrams per liter in the upper layer of stratification. Despite the absence of data showing an excursion of numeric criteria, the aquatic life use was impaired because of the fish kill, which provided evidence that this designated use was not supported. Chapter 61.3(.3)(b)(1) of the Iowa WQS contains the general criteria that is applicable to all surface waters. The narrative criteria reads that, "Dissolved oxygen shall not be less than the values shown in Table 2 of this subrule."

The water quality standards can be accessed on the web at
http://www.iowadnr.gov/InsideDNR/RegulatoryWater/WaterQualityStandards/Rules.aspx.

For 303(d) listing purposes, aesthetically objectionable conditions are present in a water body when the median summer chlorophyll-a or Secchi depth trophic state index exceeds 65. In order to delist a lake impaired by algae, the media growing season chlorophyll-a TSI must not exceed 63 in two consecutive listing cycles. To avoid the exceedance of 63, the median summer chlorophyll-a concentration must not exceed 27 micrograms per liter.

With respect to the fish kill and organic enrichment/low DO impairment, there was not sufficient data to determine that a specific WQS was exceeded. The excessive growth of aquatic vegetation was suspected to be caused by nutrient enrichment. The aquatic life use was judged to be impaired because of the fish kill, which is direct evidence that the designated use was not supported.

The loading capacity for Briggs Woods Lake is 8,515 pounds per year, or 93 pounds per day total phosphorus. To meet target loads, a 15 percent reduction from the current load is required.

The narrative criteria in the water quality standards require that Briggs Woods Lake be free from "aesthetically objectionable conditions." There are no numeric criteria associated with water clarity, therefore the attainment of the standard is based on maintaining relatively good water clarity in comparison to other Iowa lakes.

Pollutant(s) of concern

An explanation and analytical basis for expressing the TMDL through surrogate measures (e.g., parameters such as percent fines and turbidity for sediment impairments, or chlorophyll-a and phosphorus loadings for excess algae) is provided, if applicable. For each identified pollutant, the submittal describes analytical basis for conclusions, allocations and margin of safety (MOS) that do not exceed the LC. If submittal is a phase II TMDL *there are refined relationships linking the load to WQS attainment. If there is an increase in the TMDL there is a refined relationship specified to validate the increase in TMDL (either load allocation (LA) or waste load allocation (WLA)). This section will compare and validate the change in targeted load between the versions.*

The TMDL was written for organic enrichment, low DO and algae. Dissolved oxygen is a basic requirement for a healthy ecosystem. Some fish and aquatic organisms (such as carp and sludge worms) are adapted to low oxygen conditions, but most desirable fish species (such as trout and salmon) suffer if dissolved oxygen concentrations fall below 3 to 4 milligrams per liter (3 to 4 milligrams of oxygen dissolved in 1 liter of water, or 3 to 4 parts of oxygen per million parts of water). Depleted oxygen levels, especially in colder bottom waters where dead organic matter tends to accumulate, can reduce the quality of fish habitat and encourage the propagation of fish that are adapted to less oxygen or to warmer surface waters. The lack of oxygen increases the amount of phosphorus present in the water. The added phosphorus (organic enrichment) encourages increased plant and algae growth followed by increased populations of bacteria. The bacterial decomposition of dead plant material lowers dissolved oxygen levels and can eventually result in the death of fish and invertebrates. Algae (bacteria) produces oxygen during daylight hours but use up oxygen during the night and again when they die and decay. Decomposition of algae also causes the release of nutrients (total phosphorus) to the lake, which may allow more algae to grow. Targets to achieve water quality standards are for chlorophyll-a, with reductions to total phosphorus levels.

Water quality data collected by State Hygienic Laboratory in 2007 and 2008 was grouped with data collected by Iowa State University in 2009 and 2010 for statistical analysis of existing (baseline) conditions, water quality modeling and development of in-lake water quality targets.

Carlson's trophic state index was used to evaluate the relationships between total phosphorus, algae (chlorophyll-a) and transparency (Secchi depth) in Briggs Woods Lake. If the TSI values for the three parameters are the same, the relationships between the three are strong. If the TP TSI values are higher than chlorophyll-a TSI, it suggests there are limitations to algal growth besides phosphorus. Figure 3-1 within the TMDL document illustrates each of the individual TSI values throughout the sampling period, and Table 3-1 within the TMDL document reports mean and median TSI values calculated using the ambient lake monitoring data. The general trend is that chlorophyll-a TSI values are significantly higher than those for Secchi depth, and TSI values for TP are slightly higher than those for chlorophyll-a. Total phosphorus is targeted because of the blue-green algae's ability to fix atmospheric nitrogen and the overabundance of phosphorus inputs.

The loading capacity for Briggs Woods Lake is 8,515 pounds per year, or 93 pounds per day total phosphorus. To meet target loads, a 15 percent reduction from the current load is required.

The narrative criteria in the water quality standards require that Briggs Woods Lake be free from "aesthetically objectionable conditions." There are no numeric criteria associated with water clarity, therefore the attainment of the standard is based on maintaining relatively good water clarity in comparison to other Iowa lakes.

In order to delist a lake impaired by algae from the 303(d) list, the median growing season chlorophyll-a trophic state index must not exceed 63 in two consecutive listing cycles, per the IDNR delisting methodology. This TSI value is equivalent to a median summer chlorophyll-a concentration of 27 micrograms per liter. If this goal is met, WQS attainment will be achieved.

Source Analysis

Important assumptions made in developing the TMDL, 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. Submittal demonstrates all significant sources have been considered. If this is a phase II TMDL any new sources or removed sources will be specified and explained.

Briggs Woods Lake is a man-made impoundment located one mile south of Webster City in Hamilton County in central Iowa. Briggs Woods Park, which encompasses 550 acres surrounding the 61-acre lake, is operated and maintained by the Hamilton County Conservation Board. The lake provides 300,000 Iowa citizens opportunities to canoe, swim and fish. It is estimated that Briggs Woods Lake averages over 240,000 visitors annually.

This man made reservoir lies within the Boone River hydrological unit code 8 and Drainage Ditch 206 HUC 12. This reservoir was formed in 1966 with the construction of two earthen dams and outlet structures. A 900 foot long, 43 foot high earthen dam and primary outlet structure, is located at the south end of the lake. The primary outlet includes a concrete riser with small weir, as a drawdown pipe and valve that can be used to drain the lake. At the northwest corner of the lake, there is a 2,200 foot long, 26 foot high earthen dam with a 40 foot wide ogee spillway, in addition to a 600 foot wide emergency spillway. The majority of the flow to the lake discharges through the ogee spillway to the Boone River under high flow conditions (flows greater than 4-6 cubic feet per second). This configuration bypasses high flows around the lake in an attempt to minimize negative impacts of sediment and nutrient-laden runoff on lake water quality. A berm was constructed in 2006 across the north end of the lake that further limits sediment-laden high flows from negatively impacting the main body of the lake. North of the berm is expected to evolve into a shallow wetland area as it retains sediment and nutrients. Low flows pass through the berm via a concrete box culvert and stop log structure.

Land use composition of Briggs Woods Lake consists of 47 percent corn, 35.4 percent soybeans, 10.3 percent grasslands/hay, 3.4 percent roads and 1.3 percent farmsteads. Other land uses include a small golf course that is 0.4 percent, timbered areas accounting for <0.1 percent and commercial property that is 1.3 percent.

The Briggs Woods Lake watershed has four general soil series: Bode, Browton, Kossuth and Ottosen. Of these, Bode and Browton soils comprise the largest portion of the watershed, by 37 percent and 24 percent, respectively. Bode soils consist of well drained, moderately permeable soils on knobs, ridges and convex side slopes in upland areas. Browton soils are poorly drained, calcareous soils often found in flats, swales and drainage ways surrounding depressions. Both soils were formed in glacial or lacustrine sediments and were heavily vegetated with prairie grasses in their native state. Over the years, many of the natural wetlands that were common in the watershed pre-settlement have been lost or drastically altered. With the draining of depressional "pothole" wetlands, remnants of these wetland soils create adverse affects to crop yields. This results in the disconnection of these potholes from the primary drainage course of the watershed and the contribution of surface runoff. This also increases subsurface flows through the tile drain network. This modification may decrease sediment and attached phosphorus transport, but could increase transport of nitrate and other dissolved nutrients. Tile drainage and loss of wetlands has a direct affect on the water quality of Briggs Woods Lake.

There are eleven National Weather Service Continuity of Operations Plan stations within 25 miles of the watershed with daily precipitation data available through the Iowa Environmental Mesonet. The three nearest stations are Webster City which is 4 miles northeast of the watershed centroid, Jewell (10 miles) and Williams (12 miles). The Thiessen polygon method was used to develop an area-weighted precipitation data set for the watershed using the closest weather stations. However, the use of this method resulted in a polygon that included only the Webster City station. Therefore, rainfall data from the NWS COOP station at Webster City was used for modeling purposes.

The Spreadsheet Tool for Estimating Pollutant Load was used to estimate average annual inflow. A BATHTUB model, developed by the Army Corps of Engineers, was developed to describe water quality conditions and estimate the assimilative capacity in water bodies was used calculate the water balance of Briggs Woods Lake. Calculations from BATHTUB includes inflows from STEPL, direct precipitation, evapotranspiration estimates and lake morphometry.

Nonpoint sources are the sole contributor to phosphorus loading into Briggs Woods Lake. Watershed runoff and groundwater, including agricultural tile drainage, from land in row crop production are the predominant sources. Phosphorus transport is increased by the application of commercial and organic fertilizers. Internal recycling of phosphorus contributes about 2 percent of the annual average load.

Other relatively insignificant sources, each comprising 2 percent or less of the total load, include background sources such as wildlife and atmospheric deposition, privately owned on-site wastewater treatment systems (e.g., septic systems), ungrazed grasslands and hay, farmsteads, a small golf course and runoff from roads and right-of-way areas.

There are over 8,900 hogs raised in or near the watershed. Manure production from these hogs account for nutrient loading into the watershed. There are no significant beef, dairy or poultry operations. There are no significant livestock grazing operations in the watershed; there are also no open feedlots. The estimated deer density in Hamilton County, based on road kills, is approximately two deer per square mile. Pollutant contributions from waterfowl included nutrients and bacteria contained in feces deposited in and near the lake by Canada geese. On an annual average basis, there are 69 geese residing at the lake. The estimated geese population consider the changes in goose population throughout the year due to migratory patterns, nesting season and the number of resident geese.

There are no point sources operating under an NPDES permit or regulated by other Clean Water Act programs.

There are several small animal feeding operations in the Briggs Woods Lake watershed. However, none of them are regulated under NPDES permits or other CWA programs. No regulated municipal or industrial point sources are located in the watershed. Therefore, all sediment and nutrients in the lake are attributed to nonpoint sources including wildlife, particles carried by dust and wind (i.e., atmospheric deposition), livestock, cropland, pets and humans that live, work and play in and around the lake.

In the absence of an NPDES permit, the discharges associated with sources were applied to the load allocation, as opposed to the wasteload allocation 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 TMDLs 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. Any WLA in addition to that allocated here is not available.

Any concentrated animal feeding operation that does not obtain an NPDES permit must operate as a no discharge operation. Any discharge from an unpermitted CAFO is a violation of Section 301. It is the EPA's position that all CAFOs should obtain an NPDES permit because it provides clarity of compliance requirements, authorization to discharge when the discharges are the result of large precipitation events (e.g., in excess of 25-year and 24-hour frequency/duration) or are from a man-made conveyance. However, many large CAFOs (mostly the poultry and swine sectors) contend that they do not discharge nor propose to discharge therefore are not required to obtain an NPDES permit. It is the EPA's opinion that many of the "no discharge" CAFOs do not have adequate land application area to ensure the agronomic uptake of land applied waste or are not designed, constructed, operated or maintained so that they do not discharge or propose to discharge. Furthermore, there are many animal feeding operations that meet the definition of a medium CAFO (i.e., discharge via a man-made conveyance) but are unpermitted and have not limited their impact on waters by applying Best Professional Judgment to effluent reductions.

As previously stated, there are several small CAFOs listed in the TMDL document, however, none of them are regulated under an NPDES permit. Animal feeding operations and unpermitted CAFOs are considered under the LA because there is not enough detailed information to know whether these facilities are required to obtain NPDES permits. This TMDL document does not reflect a determination by the EPA that such facility does 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 or proposes to discharge has a duty to obtain a permit. 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 this TMDL document as approved.

All known sources have been considered.

Allocation - Loading Capacity

Submittal identifies appropriate WLA for point, and load allocations 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 phase II TMDL the change in LC will be documented in this section.

$$LC = WLA + LA + MOS$$

The loading capacity for Briggs Woods Lake is 8,515 pounds per year, or 93 pounds per day total phosphorus (TP). To meet target loads, a 15 percent reduction from the current load is required.

The wasteload allocation is zero because there are no permitted point source dischargers in the watershed.

The load allocation is 7,663 lbs/yr, with a daily maximum of 84 lbs/day TP. Table 3-5 of the TMDL document shows individual reductions and is an example of the load allocation scheme to meet TP target load.

An explicit 10 percent margin of safety was incorporated into this TMDL. The MOS is 852 pounds per year, or 9 pounds per day TP.

WLA Comment

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 WQS excursions, the source is contained in a general permit addressed by the TMDL, or extenuating circumstances exist which prevent assignment of individual WLAs. 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 phase II TMDL any differences in phase I and phase II WLAs will be documented in this section.*

There were no permitted or regulated point sources in the watershed, therefore, the wasteload allocation is zero.

LA Comment

Includes all nonpoint sources loads, natural background, and potential for future growth. If no nonpoint sources are identified the LA must be given as zero [40 CFR § 130.2(g)]. If this is a phase II TMDL any differences in phase I and phase II LAs will be documented in this section.

The load allocation is 7,663 pounds per year, with a daily maximum of 84 pounds per day total phosphorus. Table 3-5 of the TMDL document shows individual reductions and is an example of the load allocation scheme to meet the TP target load.

Margin of Safety

Submittal describes explicit and/or implicit MOS 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 phase II TMDL any differences in MOS will be documented in this section.

An explicit 10 percent margin of safety was incorporated into this TMDL. The MOS is 852 pounds per year total phosphorus, or 9 pounds per day TP.

Seasonal Variation and Critical Conditions

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 WQS. If this is a phase II TMDL any differences in conditions will be documented in this section.

The critical season for the occurrence of algal blooms as a result of high phosphorus levels is during the growing season, April to September. However, long-term phosphorus loads lead to the buildup of phosphorus in the reservoir and contributes to blooms regardless of seasonal effects. The combined watershed and in-lake modeling approach using EPA's Spreadsheet Tool for Estimating Pollutant Loads and BATHTUB helped with the analysis of the annual average conditions. Therefore, both existing and allowable TP loads to Briggs Woods Lake are expressed as annual averages. Phosphorus loads are also expressed as daily maximums to comply with the EPA guidance.

Public Participation

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

On September 13, 2011, from 6:00-8:00 p.m., at the Hamilton County Conservation Board offices near Webster City, Iowa, a public meeting was held to present the results of the TMDL study and discuss next steps for community-based watershed planning. Several patrons of the lake, especially anglers, farmers and producers were represented at the meeting. The Director of the Hamilton County Conservation Board and several board members were present. Dr. Michelle Soupir, of the Agricultural and Biosystems Engineering Department at Iowa State University, attended the meeting along with several engineering students. Also, local media was present at the meeting.

The IDNR staff that attended the meeting included the District Fisheries Biologist (Scott Grummer), Jeff Berckes and Charles Ikenberry with the Watershed Improvement Section.

No comments were received for this TMDL document.

Monitoring Plan for TMDL(s) Under 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 phased approach is used) [40 CFR § 130.7].

Future data collection and monitoring for Briggs Woods Lake include monitoring conducted as part of the IDNR Beach Monitoring Program and the IDNR Ambient Lake Monitoring Program. The Beach Monitoring Program consists of routine *E. coli* monitoring at state park beaches and locally managed beaches throughout Iowa. These beaches are sampled at least twice a week from Memorial Day to Labor Day.

To better assess the water quality of the lakes in Iowa, the Ambient Lake Monitoring Program was initiated in 2000. During this sampling program, one location near the deepest part of the lake is sampled measuring many chemical, physical and biological parameters. Sampling events take place at least three times every summer, typically between Memorial Day and Labor Day. Sampling parameters are listed in Table 5-1 of the TMDL document.

Reasonable Assurance

Reasonable assurance only applies when less stringent WLAs are assigned based on the assumption of 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, the IDNR included an implementation plan in this TMDL document to provide information regarding how point and nonpoint sources can or should be controlled to ensure implementation efforts achieve the loading reductions identified in these TMDLs. The EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in this document. Therefore, discussion of reduction efforts relating to point and nonpoint sources can be found in the Best Management Practices section of the TMDL document and are briefly described below.

Potential best management practices are grouped into three types: land management, structural and in-lake alternatives. Some BMPs can be identified for implementation. Implementation alternatives are shown in Tables 4-1 through 4-3 in the TMDL document. These alternatives are the foundation for an implementation strategy and are not all inclusive, and further investigation may reveal some alternatives are more or less feasible and applicable to site-specific conditions than others.

The IDNR has 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 IDNR should provide reasonable assurance that instream water quality standards 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 wasteload allocations to serve that purpose, they must themselves be stringent enough so that (in conjunction with the water body's other loadings) they meet WQS. This generally occurs when the TMDL's combined nonpoint source load allocations and point source WLAs do not exceed the WQS-based loading capacity and there is reasonable assurance that the TMDL's allocations can be achieved. Discussion of reduction efforts relating to nonpoint sources can be found in the Implementation section of the TMDL.

Excess nutrients, particularly phosphorus, causes eutrophic conditions associated with both impairments to Briggs Woods Lake. Excess plant and algae growth, driven by excess nutrients, can often lead to low DO levels when the aquatic plants die and are broken down by oxygen consuming organisms. Therefore, addressing the algae impairment in the lake by targeting phosphorus will also address the organic enrichment/low DO impairment. In order to de-list a lake impaired by algae from the 303(d) list, the median growing season chlorophyll-a trophic state index must not exceed 63 in two consecutive listing cycles, per IDNR de-listing methodology. This TSI value is equivalent to a median summer chlorophyll-a concentration of 27 micrograms per liter. With respect to the fish kill and organic enrichment/low DO impairment, there was not sufficient data to compare DO in Briggs Woods Lake to the numeric standard of not less than 5.0 milligrams per liter in the upper layer of stratification. Despite the absence of data showing a violation of numeric criteria, the aquatic life use was impaired because of the fish kill, which provided evidence that this designated use was not supported.

Funding assistance for controlling nonpoint sources of bacteria loads are available, including Section 319 grants, Watershed Improvement Review Board grants and the Water Protection Fund.

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

Ms. Lori McDaniel
Water Quality Bureau Chief
Iowa Department of Natural Resources
Wallace Building,
Wallace State Office Building E. 9th St.
Des Moines, Iowa 50319

RE: Approval of Total Maximum Daily Load pH document for Briggs Woods Lake

Dear Ms. McDaniel:

This letter responds to the submission from the Iowa Department of Natural Resources, received by the U.S. Environmental Protection Agency, Region 7 on January 21, 2021 and updated on February 11, 2021, for a Total Maximum Daily Load document which contained a TMDL for pH. Briggs Woods Lake was identified on the 2018 Iowa Section 303(d) List as impaired by not supporting its primary contact use, which is caused by pH. This submission fulfills the Clean Water Act statutory requirement to develop TMDLs for impairments listed on a state's §303(d) List. The specific impairment (water body segment and causes) are:

Water Body Name	WBIDs	Causes
Briggs Woods Lake	IA 04-UDM-1255 Legacy ID (04-UDM-01880-L_0)	pH

The EPA has completed its review of the TMDL document with supporting documentation and information. By this letter, the EPA approves the submitted TMDL amendment. This TMDL amendment does not supersede the original TMDL for Briggs Woods Lake, which was approved by the EPA on August 30, 2012. Enclosed with this letter is the Region 7 TMDL Decision Document which summarizes the rationale for the EPA's approval of this TMDL amendment. The EPA believes the separate elements of the TMDLs described in the TMDL amendment and original TMDL document adequately address the pollutants of concern, taking into consideration seasonal variation and a margin of safety.

The EPA appreciates the thoughtful effort that the Iowa DNR has put into this TMDL amendment. 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 Jennifer Kissel, of my staff, at (913) 551-7982.

Sincerely,

JEFFERY ROBICHAUD Digitally signed by JEFFERY ROBICHAUD
Date: 2021.02.19 11:43:58 -06'00'

Jeffery Robichaud
Director
Water Division

Enclosure

cc: Mr. Jeff Berckes Iowa DNR

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

Briggs Woods Lake
Iowa – Amendment to 2012 TMDL

pH

JEFFERY ROBICHAUD

Digitally signed by JEFFERY ROBICHAUD
Date: 2021.02.19 11:46:51 -06'00'

Jeffery Robichaud
Director
Water Division

Date

(This page intentionally left blank)

EPA Region 7 TMDL Review

Submittal Date || Initial: 1/21/21 **Approved: Yes**

TMDL ID	IA 04-UDM-1255 (Legacy ID 04-UDM-01880-L_0)
State	Iowa
Document Name	Briggs Woods Lake
Basin(s)	Des Moines River
HUC(s)	07100005
Water body(ies)	Briggs Woods Lake
Tributary(ies)	N/A
Number of Segments	1
Number of Segments for Protection 303(d)(3)	0
Causes	pH

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 original TMDL document, submitted by the Iowa Department of Natural Resources to Region 7 of the U.S. Environmental Protection Agency, was approved on August 30, 2012. The 2012 TMDL targeted the following pollutants: Algae, low dissolved oxygen, organic enrichment, and total phosphorus.

,

The Iowa DNR submitted this TMDL for pH on January 21, 2021 that builds on the information and analysis from the September 2012 TMDL. Following comments from the EPA, IDNR resubmitted the TMDL on February 11, 2021. This TMDL does not supersede the 2012 TMDL, but adds to it. This decision document only addresses the TMDL for pH. The EPA's decision document for the 2012 TMDL contains the rationale for the approval of the original TMDL. The EPA approves this TMDL for pH.

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, total phosphorus, is validated and identified through assessment and data. Iowa DNR's review and interpretation of the water quality provides the justification for linking phosphorus loads to pH. Additional analysis shows that the targeted concentrations of chlorophyll-a should result in pH levels that meet water quality standards. The Loading Capacity (LC) is calculated at monitoring stations, but the targeted TP concentrations apply at all points in the segments identified in the water body.

Iowa DNR listed pH as an impairment to Brigg's Woods Lake in the 2018 list based on nine exceedances of the pH criterion from 2010-2016.

The allowable in-lake TSI algae (chlorophyll-a) target was translated to the total phosphorus loading capacity by performing water quality simulations using the BATHTUB model. The Spreadsheet Tool for Estimating Pollutant Load predicted sediment and nutrient loads from various land use and animal sources and estimated potential sediment and nutrient reductions resulting from best management practices.

TMDL = LC = WLA (0 lbs-TP/year) + LA (7,663 lbs-TP/year) + MOS (852 lbs-TP/year) = 8,515 lbs-TP/year

TMDL = LC = WLA (0 lbs-TP/day) + LA (84 lbs-TP/day) + MOS (9 lbs-TP/day) = 93 lbs-TP/day

The ultimate endpoint of this TMDL will be to meet water quality standards for pH.

Designated Use(s), Applicable Water Quality Standard(s) and Numeric Target(s)

The submittal describes applicable water quality standards, 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.

Designated uses for Briggs Woods Lake are primary contact recreation (Al), aquatic life (B(LW)) and human health (fish consumption) (HH).

The state of Iowa Water Quality Standards, as published in the Iowa Administrative Code, Environmental Protection Rule 567, Chapter 61. IAC 567.61.3, "The pH shall not be less than 6.5 nor greater than 9.0."

In order to remove the water body/pollutant from the 303(d) list for the pH impairment, pH violations from water quality sampling must not be significantly greater than 10 percent for two consecutive listing cycles, per DNR listing methodology. The total phosphorus targets from the original TMDL targeted a TSI algae (chlorophyll-a) value of 63. This TMDL for pH analyzed the link between chlorophyll-a and the resulting pH. As the TSI algae (chlorophyll-a) values decreased, pH was more likely to meet WQS, see Figure 2 in the new TMDL document.

This relationship shows that total phosphorus target of the original TMDL document and this TMDL, addressing pH will meet WQS.

Pollutant(s) of Concern

A statement that the relationship is either directly related to a numeric water quality standard, or established using surrogates and translations to a narrative WQS is included. An explanation and analytical basis for expressing the TMDL(s) through surrogate measures, or by translating a narrative water quality standard to a numeric target is provided (e.g., parameters such as percent fines and turbidity for sediment impairments, or chlorophyll-a and phosphorus loadings for excess algae). For each identified pollutant, the submittal describes 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 water quality standard 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.

The TMDL document establishes the link between the numeric (pH) water quality standards for Briggs Woods Lake and the total phosphorus impairment. Briggs Woods Lake is impaired for pH. Excess phosphorus enters surface waters and results in eutrophication stimulating blooms of algae, thus increasing pH.

The linkage between total phosphorus and the listed impairment is appropriate and would attain and maintain water quality standards.

The EPA agrees that the TMDL targets the appropriate pollutant.

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 load allocation, as opposed to the wasteload allocation 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 TMDL document identified that the same sources as the original TMDL would also contribute to elevated pH. The original TMDL document only identified nonpoint sources.

As described in the 2012 TMDL, Briggs Woods Lake is a manufactured impoundment located one mile south of Webster City in Hamilton County in central Iowa. Briggs Woods Park, which encompasses 550 acres surrounding the 61-acre lake, is operated and maintained by the Hamilton County Conservation

Board. The lake provides 300,000 Iowa citizens opportunities to canoe, swim and fish. It is estimated that Briggs Woods Lake averages over 240,000 visitors annually.

This reservoir lies within the Boone River hydrological unit code 8 and Drainage Ditch 206 HUC 12. This reservoir was formed in 1966 with the construction of two earthen dams and outlet structures. A 900-foot-long, 43 foot high earthen dam and primary outlet structure is located at the south end of the lake. The primary outlet includes a concrete riser with small weir, as a drawdown pipe and valve that can be used to drain the lake. At the northwest corner of the lake, there is a 2,200-foot-long, 26 foot high earthen dam with a 40-foot-wide ogee spillway, in addition to a 600 foot wide emergency spillway. The majority of the flow to the lake discharges through the ogee spillway to the Boone River under high flow conditions (flows greater than 4-6 cubic feet per second). This configuration bypasses high flows around the lake in an attempt to minimize negative impacts of sediment and nutrient-laden runoff on lake water quality. A berm was constructed in 2006 across the north end of the lake that further limits sediment-laden high flows from negatively impacting the main body of the lake. North of the berm is expected to evolve into a shallow wetland area as it retains sediment and nutrients. Low flows pass through the berm via a concrete box culvert and stop log structure.

Land use composition of Briggs Woods Lake consists of 47 percent com, 35.4 percent soybeans, 10.3 percent grasslands/hay, 3.4 percent roads and 1.3 percent farmsteads. Other land uses include a small golf course that is. 0.4 percent, timbered areas accounting for <0.1 percent and commercial property that is 1.3 percent.

The Briggs Woods Lake watershed has four general soil series: Bode, Browton, Kossuth and Ottosen. Of these, Bode and Browton soils comprise the largest portion of the watershed, by 37 percent and 24 percent, respectively. Bode soils consist of well drained, moderately permeable soils on knobs, ridges and convex side slopes in upland areas. Browton soils are poorly drained, calcareous soils often found in flats, swales and drainage ways surrounding depressions. Both soils were formed in glacial or lacustrine sediments and were heavily vegetated with prairie grasses, in their native state. Over the years, many of the natural wetlands that were common in the watershed pre-settlement have been lost or drastically altered. With the draining of· depressional "pothole" wetlands, remnants of these wetland soils create adverse effects to crop yields. This results in the disconnection of these potholes from the primary drainage course of the watershed and the contribution of surface runoff. This also increases subsurface flows through the tile drain network. This modification may decrease sediment and attached phosphorus transport, but could increase transport of nitrate and other dissolved nutrients. Tile drainage and loss of wetlands has a direct effect on the water quality of Briggs Woods Lake.

There are eleven National Weather Service Continuity of Operations Plan stations within 25 miles of the watershed with daily precipitation data available through the Iowa Environmental Mesonet. The three nearest stations are Webster City which is 4 miles northeast of the watershed centroid, Jewell (10 miles) and Williams (12 miles). The Thiessen polygon method was used to develop an area-weighted precipitation data set for the watershed using the closest weather stations. However, the use of this method resulted in a polygon that included only the Webster City station. Therefore, rainfall data from the NWS COOP station at Webster City was used for modeling purposes.

The Spreadsheet Tool for Estimating Pollutant Load was used to estimate average annual inflow. A BATHTUB model, developed by the Army Corps of Engineers, was developed to describe water quality conditions and estimate the assimilative capacity in water bodies was used calculate the water balance of

Briggs Woods Lake. Calculations from BATHTUB includes inflows from STEPL, direct precipitation, evapotranspiration estimates and lake morphometry.

Nonpoint sources are the sole contributor to phosphorus loading into Briggs Woods Lake. Watershed runoff and groundwater, including agricultural tile drainage, from land in row crop production are the predominant sources. Phosphorus transport is increased by the application of commercial and organic fertilizers. Internal recycling of phosphorus contributes about 2 percent of the annual average load. Other relatively insignificant sources, each comprising 2 percent or less of the total load, include background sources such as wildlife and atmospheric deposition, privately owned on-site wastewater treatment systems (e.g., septic systems), ungrazed grasslands and hay, farmsteads, a small golf course and runoff from roads and right-of-way areas.

There are over 8,900 hogs raised in or near the watershed. Manure production from these hogs account for nutrient loading into the watershed. There are no significant beef, dairy or poultry operations. There are no significant livestock grazing operations in the watershed; there are also no open feedlots. The estimated deer density in Hamilton County, based on road kills, is approximately two deer per square mile. Pollutant contributions from waterfowl included nutrients and bacteria contained in feces deposited in and near the lake by Canada geese. On an annual average basis, there are 69 geese residing at the lake. The estimated geese population consider the changes in goose population throughout the year due to migratory patterns, nesting season and the number of resident geese.

The TMDL for pH references the original TMDL document, which contains a complete listing of all known pollutant sources.

Allocation - Loading Capacity

The submittal identifies appropriate loading capacities, wasteload allocations for point sources and load allocations 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 formula to calculate the TMDL is:

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

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

The loading capacity for Briggs Woods Lake is 8,515 pounds per year, or 93 pounds per day total phosphorus (TP). To meet target loads, a 15 percent reduction from the current load is required. The wasteload allocation is zero because there are no permitted point source dischargers in the watershed.

The load allocation is 7,663 lbs/yr, with a daily maximum of 84 lbs/day TP. Table 3-5 of the TMDL document shows individual reductions and is an example of the load allocation scheme to meet TP target load.

An explicit 10 percent margin of safety was incorporated into this TMDL. The MOS is 852 pounds per year, or 9 pounds per day TP.

The EPA agrees that the LC will attain and maintain water quality standards.

Wasteload Allocation Comment

The submittal lists individual wasteload allocations 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 water quality standard excursion, the source is contained in a general permit addressed by the TMDL, or extenuating circumstances exist which prevent assignment of 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 were no permitted or regulated point sources in the watershed, therefore, the wasteload allocation 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 load allocation 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 load allocation is 7,663 pounds per year, with a daily maximum of 84 pounds per day total phosphorus. Table 3-5 of the original TMDL document shows individual reductions and is an example of the load allocation scheme to meet the TP target load.

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.

An explicit 10 percent margin of safety was incorporated into this TMDL. The MOS is 852 pounds per year total phosphorus, or 9 pounds per day TP.

The EPA agrees that the state has provided explicit MOS to support the TMDL.

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 critical season for the occurrence of algal blooms because of high phosphorus levels is during the growing season, April to September. However, long-term phosphorus loads lead to the buildup of phosphorus in the reservoir and contributes to blooms regardless of seasonal effects. The combined watershed and in-lake modeling approach using the EPA's Spreadsheet Tool for Estimating Pollutant

Loads and BATHTUB helped with the analysis of the annual average conditions. Therefore, both existing and allowable TP loads to Briggs Woods Lake are expressed as annual averages. Phosphorus loads are also expressed as daily maximums to comply with the EPA's guidance.

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

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)].

For the original TMDL: On September 13, 2011, from 6:00-8:00 p.m., at the Hamilton County Conservation Board offices near Webster City, Iowa, a public meeting was held to present the results of the TMDL study and discuss next steps for community-based watershed planning. Several patrons of the lake, especially anglers, farmers and producers were represented at the meeting. The Director of the Hamilton County Conservation Board and several board members were present. Dr. Michelle Soupir, of the Agricultural and Biosystems Engineering Department at Iowa State University, attended the meeting along with several engineering students. Also, local media was present at the meeting.

The Iowa DNR staff that attended the meeting included the District Fisheries Biologist (Scott Grummer), Jeff Berckes and Charles Ikenberry with the Watershed Improvement Section.
No comments were received for this TMDL document.

For the current TMDL: Iowa DNR posted a public presentation to their YouTube channel on December 17, 2020. Iowa DNR also issued a press release on December 17, 2020 to start a 30-day public comment period.

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 water quality standards, 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 TMDLs and determine if future revisions are necessary or appropriate to meet applicable water quality standards.

The 2012 TMDL document outlined plans for monitoring. This included continued ambient monitoring under the Iowa DNR Ambient Lake Monitoring Program which was initiated in 2000. Implementation monitoring is identified to determine the effect of best management practices undertaken in the watershed. Any such monitoring could include automated samplers as well as grab samples during runoff events. This implementation monitoring would include a greater sampling frequency than currently undertaken pursuant to the ambient lake monitoring program. It will also require local stakeholders to implement BMPs and monitor success.

Reasonable Assurance

Reasonable assurance only applies when less stringent wasteload allocation are assigned based on the assumption that nonpoint source reductions in the load allocation 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 water quality standards 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 wasteload allocations to serve that purpose, they must themselves be stringent enough so that (in conjunction with the water body's other loadings) they meet WQS. This generally occurs when the TMDL(s)' combined nonpoint source load allocations and point source WLAs do not exceed the WQS-based loading capacity and there is reasonable assurance that the 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 this watershed, reasonable assurances are not a required component of this TMDL. However, the 2012 TMDL document does identify a general approach for planning and implementation which, if followed, will lead to the attainment of applicable water quality standards. Both management and structural BMPs are identified as well as potential total phosphorus reductions to be expected from their implementation.

Water Quality Improvement Plan
for

Briggs Woods Lake

Hamilton County, Iowa

Total Maximum Daily Load
for Organic Enrichment/Low DO and Algae

Prepared by:
Charles D. Ikenberry, P.E.

Iowa Department of Natural Resources
Watershed Improvement Section
2012

Table of Contents

List of Figures	4
List of Tables	5
General Report Summary	6
Technical Elements of the TMDL	8
1. Introduction	11
2. Description and History of Briggs Woods Lake	13
2.1. Briggs Woods Lake	15
Hydrology	15
Morphometry & Substrate	20
2.2 The Briggs Woods Lake Watershed	20
Land Use	20
Soils, climate, and topography	22
3. TMDL for Organic Enrichment/Low DO and Algae	25
3.1. Problem Identification	25
Applicable water quality standards	25
Problem statement	26
Data sources	26
Interpreting Briggs Woods Lake data	27
3.2. TMDL Target	36
General description of the pollutant	36
Selection of environmental conditions	36
Waterbody pollutant loading capacity (TMDL)	36
Decision criteria for water quality standards attainment	38
3.3. Pollution Source Assessment	38
Existing load	38
Departure from load capacity	38
Identification of pollutant sources	39
Allowance for increases in pollutant loads	40
3.4. Pollutant Allocation	40
Wasteload allocation	40
Load allocation	41
Margin of safety	41
Reasonable Assurance	41
3.5. TMDL Summary	42
4. Implementation Plan	43
4.1. Previous Watershed Planning and Implementation	43
4.2. General Approach & Timeline	45
General approach	45
Timeline	45
4.3. Best Management Practices	46
Land Management	46
Structural BMPs	47
In-Lake BMPs	53
5. Future Monitoring	56
5.1. Routine Monitoring for Water Quality Assessment	56
5.2. Idealized Monitoring for Detailed Assessment and Planning	57
6. Public Participation	61
6.1. Public Meetings	61

September 13, 2011 61
6.2. Written Comments 61
7. References 62
8. Appendices 64
Appendix A --- Glossary of Terms, Abbreviations, and Acronyms 64
Scientific Notation 73
Appendix B --- General and Designated Uses of Iowa's Waters 74
Appendix C --- Water Quality Data 77
Appendix D --- Watershed Model Development 84
D.1. STEPL Model Description 84
D.2. Meteorological Input 84
Precipitation Data 84
D.3. Watershed Characteristics 85
Topography 85
Land Use 87
Soils 88
Slopes 88
Curve Numbers 89
Sediment Delivery Ratio 89
Tile Drainage 89
D.4. Animals 90
Agricultural Animals and Manure Application 90
Livestock Grazing 90
Open Feedlots 90
Wildlife 90
D.5. Septic Systems 91
Septic Systems 91
Appendix E --- Water Quality Model Development 92
E.1. Lake Hydrology 92
E.2. BATHTUB Model Description 93
E.3. Model Parameterization 94
Model Selections 94
Global Variables 95
Segment Data 95
Tributary Data 99
E.4. References 100
Appendix F --- Model Performance and Calibration 101
F.1. STEPL Performance and Calibration 101
F.2. BATHTUB Model Performance 102
Calibration 102
F.3. References 103
Appendix G --- Expressing Average Loads as Daily Maximums 104
Appendix H --- 2010 305(b) Water Quality Assessment 106
Appendix I --- Public Comments 110

List of Figures

Figure 2-1. General watershed map. 14
Figure 2-2. Annual precipitation at Webster City, Iowa. 15
Figure 2-3. Map of nearby precipitation gages and Thiessen polygons. 16
Figure 2-4. Low flow/ drawdown intake at the southeast end of the lake. 17
Figure 2-5. Ogee spillway at northwest corner of Briggs Woods Lake. 18
Figure 2-6. Culvert/weir passing low flow through diversion berm. 18
Figure 2-7. Aerial photograph and bathymetry of Briggs Woods Lake. 19
Figure 2-8. Land use composition of Briggs Woods Lake watershed. 21
Figure 2-9. Briggs Woods Lake watershed land cover (2010). 22
Figure 2-10. Connected drainage area and depressional potholes. 24
Figure 3-1. Briggs Woods Lake mean TSI values (2007-2010 SHL data). 28
Figure 3-2. Briggs Woods Lake TSI values with productivity ranges shown. 30
Figure 3-3. TSI deviations based on mean concentrations and Secchi depth. 31
Figure 3-4. TSI deviations for individual sampling events. 32
Figure 3-5. Chlorophyll-a vs. total phosphorus (TP), 2007-2010 ambient data. 34
Figure 3-6. Chlorophyll-a vs. total nitrogen (TN), 2007-2010 ambient data. 34
Figure 3-7. Phytoplankton vs. total phosphorus (TP), 2007-2010 ambient data. 35
Figure 3-8. Phytoplankton vs. total nitrogen (TN), 2007-2010 ambient data. 35
Figure 3-9. Relative TP loads by source. 40
Figure 4-1. Nitrogen in Briggs Woods Lake before and after berm construction. 43
Figure 4-2. Chlorophyll-a before (top) and after (bottom) 2006. 44
Figure 4-3. Subwatersheds modeled using STEPL. 49
Figure 4-4. Subwatershed TP and TN loads predicted using STEPL. 50
Figure 4-5. Predicted subwatershed annual TP and TN unit loads (lbs/ac). 50
Figure 4-6. Pothole depressions in areas of row crop production. 51
Figure 4-7. Potential wetlands construction/restoration projects. 53
Figure 5-1. Recommended monitoring locations. 58
Figure C-1. Temperature and dissolved oxygen (DO) profiles. 83
Figure D-1. Historical delineation and LiDAR delineation for STEPL model. 86
Figure D-2. Relative land cover composition in STEPL watershed model. 88
Figure E-1. Eutrophication control pathways in BATHTUB (Walker, 1999). 94
Figure E-2. Segmentation of Briggs Woods Lake and inlet BATHTUB models. 97

List of Tables

Table 2-1. Briggs Woods Lake watershed and lake characteristics. 13
Table 2-2. Weather station information for Webster City, Iowa. 15
Table 2-3. Land use composition of Briggs Woods Lake watershed. 21
Table 2-4. Predominant soils in the Briggs Woods Lake watershed. 23
Table 3-1. TSI values in Briggs Woods Lake. 28
Table 3-2. Implications of TSI values on lake attributes. 29
Table 3-3. Existing and target chlorophyll-a and associated parameters. 36
Table 3-4. Average annual TP loads from each source (2007-2010). 39
Table 3-5. Example load allocation scheme to meet target TP load. 41
Table 4-1. Potential land management BMPs. 47
Table 4-2. Potential structural BMPs. 48
Table 4-3. Potential in-lake BMPs for water quality improvement. 55
Table 5-1. Ambient Lake Monitoring Program water quality parameters. 57
Table 5-2. Recommended monitoring plan. 59
Table B-1. Designated use classes for Iowa waterbodies. 75
Table C-1. ISU and SHL water quality sampling data ([1]ambient location). 77
Table C-2. Biomass sampling ([1]ambient location). 78
Table C-3. Water column profile data from 2005-2008 ([1]ambient location). 78
Table D-1. STEPL precipitation inputs. 85
Table D-2. STEPL land use inputs. 87
Table D-3. STEPL curve numbers (CNs). 89
Table E-1. Rating curve for flows into main body of lake. 93
Table E-2. Model selections for Briggs Woods Lake. 95
Table E-3. Global variables data for Briggs Woods Lake BATHTUB model. 95
Table E-4. Segment morphometry for the inlet model. 98
Table E-5. Segment morphometry for each segment of the lake model. 98
Table E-6. Observed water quality (2007-2010 growing season means). 99
Table E-7. Tributary data for inlet model (2007-2010 annual averages). 100
Table E-8. Tributary data for lake model (2007-2010 annual averages). 100
Table F-1. Sheet and rill erosion rates of Des Moines Lobe watersheds. 101
Table F-2. Comparison of TP exports in tile-drained watersheds. 102
Table F-3. In-lake water quality parameters and calibration factors. 103
Table G-1. Multipliers used to convert a LTA to an MDL. 105
Table G-2. Summary of LTA to MDL calculation for the TMDL. 105

General Report Summary

What is the purpose of this report?
This report serves multiple purposes. First, it is a resource for guiding locally-driven water quality improvements in Briggs Woods Lake. Second, it satisfies the Federal Clean Water Act requirement to develop a Total Maximum Daily Load (TMDL) report for impaired waterbodies. Briggs Woods Lake is an important water resource for many Iowans. As an impaired waterbody, it is eligible for financial assistance to improve water quality. This document is meant to help guide watershed improvement efforts to remove Briggs Woods Lake from the federal 303(d) list of impaired waters.

What's wrong with Briggs Woods Lake?
Briggs Woods Lake is listed as impaired on the 2010 303(d) list for not supporting its aquatic life designated use. The impairment is due to a 2005 fish kill that occurred as a result of low dissolved oxygen (DO) levels. The low DO levels were attributed to excessive growth of macrophytes (rooted aquatic plants). The primary contact recreation designated use is also impaired. Primary contact recreation is impaired due to aesthetically objectionable conditions caused by excessive algae growth. Both impairments indicate an imbalanced ecosystem in Briggs Woods Lake caused by overly abundant nutrient loads.

What is causing the problem?
Pollutants that affect water quality, such as sediment, nutrients, and bacteria, can originate from point or nonpoint sources, or a combination of both. Point sources of pollution are easily identified sources that enter a stream or lake at a distinct location, such as a wastewater treatment outfall. Nonpoint sources of pollution are discharged in a more indirect and diffuse manner, and often are more difficult to locate and quantify. Nonpoint source pollution is usually carried with rainfall or snowmelt over the land surface and into a nearby lake or stream. The area of land that drains to a lake or stream is called a watershed. Watershed runoff often carries nonpoint source pollution that degrades water quality.

There are several small animal feeding operations in the Briggs Woods Lake watershed. However, none of them are regulated under National Pollution Discharge Elimination System (NPDES) permits or other Clean Water Act programs. No regulated municipal or industrial point sources are located in the watershed. Therefore, all sediment and nutrients in the lake are attributed to nonpoint sources including wildlife, particles carried by dust and wind (i.e., atmospheric deposition), livestock, cropland, pets, and humans that live, work, and play in and around the lake.

What can be done to improve Briggs Woods Lake?
To improve the water quality and overall health of Briggs Woods Lake, the amount of nutrients entering the lake must be reduced. Phosphorus is of particular concern because it is the limiting nutrient for excess algae and aquatic plant growth. A combination of land and animal management practices must be implemented in the watershed to obtain required reductions. Reducing nutrient loss from row crops through strategic timing and

methods of manure and fertilizer application, increasing use of conservation tillage methods, and implementing structural BMPs such as terraces, grass waterways, and constructed wetlands in beneficial locations will significantly reduce nutrient loads to the lake. Targeted in-lake dredging and ongoing maintenance of the sediment basin and wetland immediately upstream of the lake will improve and protect water quality in the lake. Preventing waterfowl from gathering at the beach and ensuring septic systems throughout the watershed are functioning properly will also benefit water clarity and reduce the amount of nutrients (and bacteria) that enters the lake.

Who is responsible for a cleaner Briggs Woods Lake?

Everyone who lives, works, or plays in the Briggs Woods Lake watershed has a role in water quality improvement. Because there are no permitted or regulated point sources of pollution in the watershed, voluntary management of land and animals to reduce nonpoint source pollution will be required to see positive results. Much of the land draining to the lake is in agricultural production, and financial assistance is available from government agencies to individual landowners willing to adopt best management practices (BMPs) such as waterways, wetlands, and vegetated buffer strips. Additionally, homeowners can have their septic systems inspected to ensure they function properly. Improving water quality in Briggs Woods Lake will require a collaborative effort of citizens and agencies with a genuine interest in protecting the lake now and in the future.

Technical Elements of the TMDL

Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:	Briggs Woods Lake, Waterbody ID IA 04-UDM-01880-L_0, located in S17, T88N, R25W, one mile south of Webster City in Hamilton County
Surface water classification and designated uses:	A1 – Primary contact recreation B(LW) – Aquatic life (lakes/wetlands) HH – Human health (fish consumption)
Impaired beneficial uses:	A1 B(LW)
TMDL priority level:	High
Identification of the pollutants and applicable water quality standards (WQS):	Carlson's Trophic State Indices (TSI) for chlorophyll-a and total phosphorus using the median concentration of 23 samples collected from 2004 to 2008 place Briggs Woods Lake between the eutrophic and hypereutrophic range, with very high levels of suspended algae. This violates the narrative water quality criterion for "aesthetically objectionable conditions" per Iowa's water quality standards. Additionally, a fish kill occurred in 2005 and was attributed to low levels of dissolved oxygen related to excessive growth of submergent aquatic vegetation.
Quantification of the pollutant loads that may be present in the waterbody and still allow attainment and maintenance of WQS:	Excess algae and submergent aquatic plant growth are attributed to total phosphorus (TP). The allowable average annual TP load = 8,515 lbs/year (daily average = 23 lbs/day); the maximum daily TP load = 93 lbs/day.
Quantification of the amount or degree by which the current pollutant loads in the waterbody, including the pollutants from upstream sources that are being accounted for as background loading, deviate from the pollutant loads needed to attain and maintain WQS:	The existing annual load of 10,011 lbs/year must be reduced by 1,496 lbs/yr to meet the allowable TP load of 8,515 lbs/yr. This is a reduction of 15 percent.

Identification of pollution source categories:	There are no permitted or regulated point source discharges of phosphorus in the watershed. Nonpoint sources of phosphorus include fertilizer and manure from row crops, sheet and rill erosion, waterfowl, other wildlife, septic systems, atmospheric deposition, and others.
Wasteload allocations (WLAs) for pollutants from point sources:	There are no permitted or regulated point source discharges in the watershed. Therefore, there is no numeric WLA in this TMDL.
Load allocations (LAs) for pollutants from nonpoint sources:	The allowable annual average TP LA is 7,663 lbs/year, and the allowable maximum daily LA is 84 lbs/day.
A margin of safety (MOS):	An explicit MOS of 10 percent (852 lbs/yr, 9 lb/day) was utilized in the development of this TMDL.
Consideration of seasonal variation:	The TMDL is based on annual TP loading. Although daily maximum loads are provided to address legal uncertainties, the average annual loads are critical to in-lake water quality and lake/watershed management decisions.
Reasonable assurance that load and wasteload allocations will be met:	Only nonpoint sources of pollution are contributing to the impairment of Briggs Woods Lake. Therefore, documentation of reasonable assurance is not required. See Section 3.4 for more detailed discussion of reasonable assurance and attainment of nonpoint source reductions.
Allowance for reasonably foreseeable increases in pollutant loads:	Because there are no urbanizing areas in the watershed and significant land use change is unlikely, there is no allowance for reasonably foreseeable increases in pollutant loads.
Implementation plan:	An implementation plan is outlined in Section 4 of this Water Quality Improvement Plan. Phosphorus loading

	and associated impairments must be addressed through a variety of voluntary nutrient and soil management strategies and structural BMPs

1. Introduction

The Federal Clean Water Act requires all states to develop lists of impaired waterbodies not meeting water quality standards (WQS) and designated uses. This list of impaired waterbodies is referred to as the state's 303(d) list. In addition to developing the 303(d) list, a Total Maximum Daily Load (TMDL) report must be developed for each impaired waterbody included on the list. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can tolerate without exceeding WQS and impairing the waterbody's designated uses. The TMDL calculation is represented by the following general equation:

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

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

One purpose of this Water Quality Improvement Plan (WQIP) for Briggs Woods Lake, located in Hamilton County in central Iowa, is to serve as the TMDL for algae and organic enrichment/low dissolved oxygen (DO) impairments to water clarity. The second purpose of the plan is to provide local stakeholders and watershed managers with a tool to promote awareness of water quality issues, assist the development of a comprehensive watershed management plan and subsequent applications for funding, and guide implementation of water quality improvement projects. Algae and organic enrichment/low DO, which impair primary contact recreation and aquatic life support, are addressed collectively by development of total phosphorus (TP) limits in the TMDL.

The TMDL includes an assessment of the existing phosphorus load to the lake and a determination of how much phosphorus the lake can tolerate and still support its designated uses. The allowable amount of pollutant that the lake can receive is the loading capacity, also called the TMDL target load. The plan also includes a description of potential solutions to the water quality problems. This group of solutions is more precisely defined as a system of best management practices (BMPs) that will improve water quality in Briggs Woods Lake, with the ultimate goal of meeting water quality standards and supporting designated uses. These BMPs are outlined in the implementation plan in Section 4.

The Iowa Department of Natural Resources (IDNR) recommends a phased approach to watershed management. A phased approach is helpful when the origin, interaction, and quantification of pollutants contributing to water quality problems are complex and difficult to fully understand and predict. Iterative implementation of improvement practices and additional water quality assessment will help ensure gradual progress towards water quality standards, maximize cost efficiency, and prevent unnecessary or ineffective implementation of costly BMPs. A water quality monitoring plan designed to help assess water quality improvement and BMP effectiveness is provided in Section 5.

Much work has already been done to improve water quality in Briggs Woods lake and its watershed. This WQIP evaluates water quality improvement obtained by past efforts, and describes additional measures that may be taken for continued improvement. This WQIP will be of little value unless additional watershed improvement activities and BMPs are implemented. This will require the active engagement of local stakeholders and the collaboration of several state and local agencies. Experience has shown that locally-led watershed plans have the highest potential for success. The Watershed Improvement Section of IDNR has designed this WQIP for stakeholder use and is committed to providing ongoing technical support for the improvement of water quality in Briggs Woods Lake.

2. Description and History of Briggs Woods Lake

Briggs Woods Lake is man-made impoundment located one mile south of Webster City in Hamilton County central Iowa (Figure 2-1). The Hamilton County Conservation Board maintains and operates Briggs Woods Park, which encompasses 550 acres surrounding the 61-acre lake. Park amenities include picnic shelters, walking trails, campsites, cabins, and an 18-hole golf course. The lake provides opportunities for canoeing, swimming, and fishing for the 300,000 Iowans that live within a 50-mile radius of the lake. The Center for Agricultural and Rural Development (CARD) at Iowa State University estimates that between 2002 and 2005, Briggs Woods Lake averaged over 64,000 annual household visits (CARD, 2008). Local traffic counts indicate that as many as 240,000 individual visits are made each year. Lake visitors spend money at local businesses, thereby supporting the local economy of nearby communities.

Table 2-1 lists some of the general characteristics of Briggs Woods Lake and its watershed, as it exists today. Estimation of physical characteristics such as surface area, depth, and volume are based on a bathymetric survey conducted by IDNR (Bachman et al., 1994)

Table 2-1. Briggs Woods Lake watershed and lake characteristics.

IDNR Waterbody ID	IA 04-UDM-01880-L_0
STORET ID	22400004
12-Digit Hydrologic Unit Code (HUC)	071000050703
12-Digit HUC Name	Drainage Ditch 206
Location	Hamilton County, S17, T88N, R25W
Latitude	42° 26’ N
Longitude	93° 48' W
Designated Uses	A1 – Primary contact recreation B(LW) – Aquatic life (lakes and wetlands) HH – Human health (fish consumption)
Tributaries	Drainage Ditch 206, unnamed ditches/tiles
Receiving Waterbody	Boone River
Lake Surface Area	61 acres (per aerial image)
Maximum Depth	30.0 feet
Mean Depth	12.0 feet
Lake Volume	732 acre-feet
Length of Shoreline	2.37 miles (12,499 feet)
Watershed Area	6,955 acres (excludes lake and inlet area)
Watershed:Lake Ratio	114:1
Lake Residence Time	55 days (2007-2010 annual average)

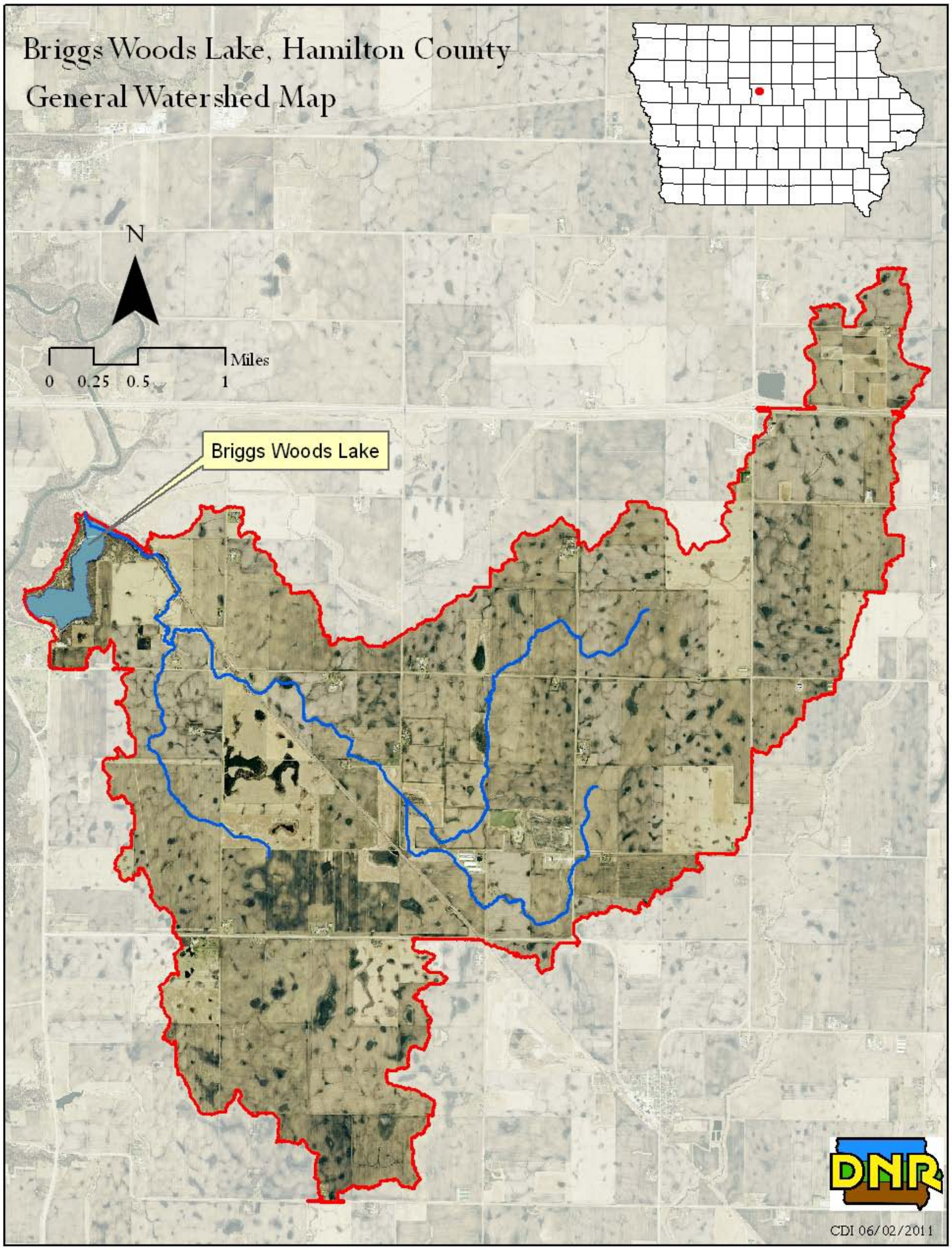


Figure 2-1. General watershed map.

2.1. Briggs Woods Lake

Hydrology

There are eleven National Weather Service (NWS) COOP stations within 25 miles of the Briggs Woods Lake watershed with daily precipitation data available through the Iowa Environmental Mesonet (IEM). The three nearest stations are Webster City (4 miles northeast of watershed centroid), Jewell (10 miles), and Williams (12 miles). The Thiessen polygon method was employed to develop an area-weighted precipitation data set for the watershed using the closest weather stations. However, application of the Thiessen polygon method resulted in a polygon that included only the Webster City station. Therefore, rainfall data from the NWS COOP station at Webster City was used for modeling purposes. Weather station information is provided in Table 2-2. Figure 2-2 shows the annual precipitation amounts at Webster City from 1990-2010.
A map of the precipitation gages is provided in Figure 2-3.

Table 2-2. Weather station information for Webster City, Iowa.

IEM Station ID	IA8806
Station Name	Webster City
Latitude	42 ^{o} 28' 16"
Longitude	-93^{o} 48' 01"
Average Annual Precipitation:	
1990-2010	36.9 inches
2007-2010	40.0 inches

IEM, 2011a

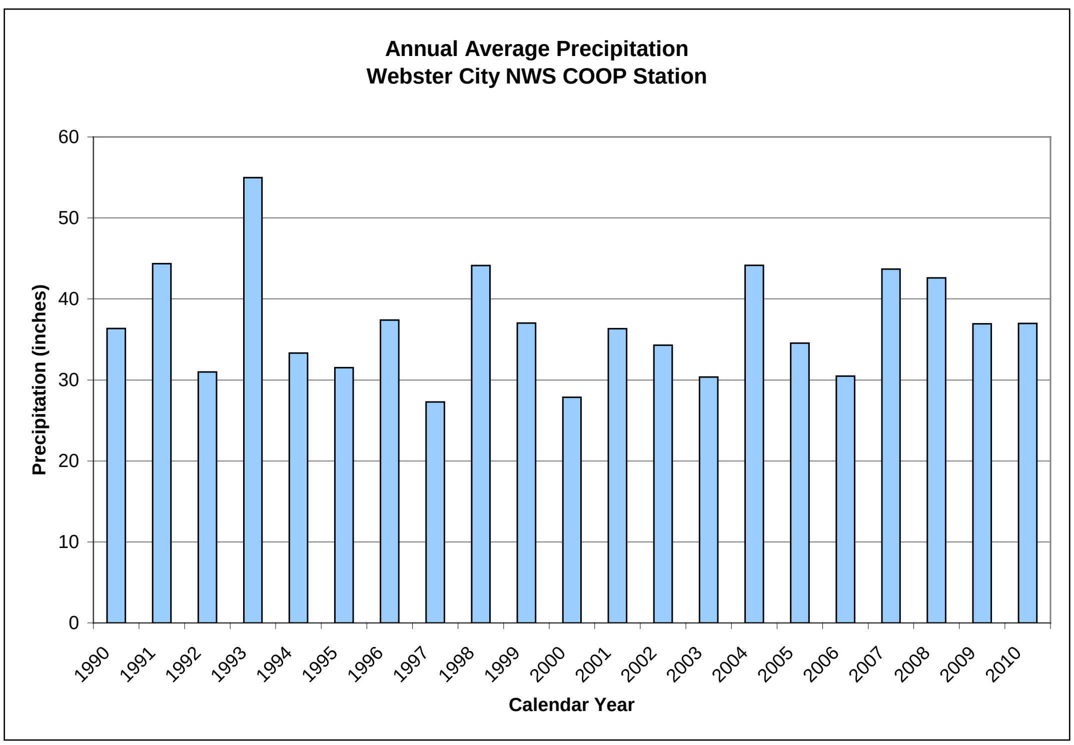


Figure 2-2. Annual precipitation at Webster City, Iowa.

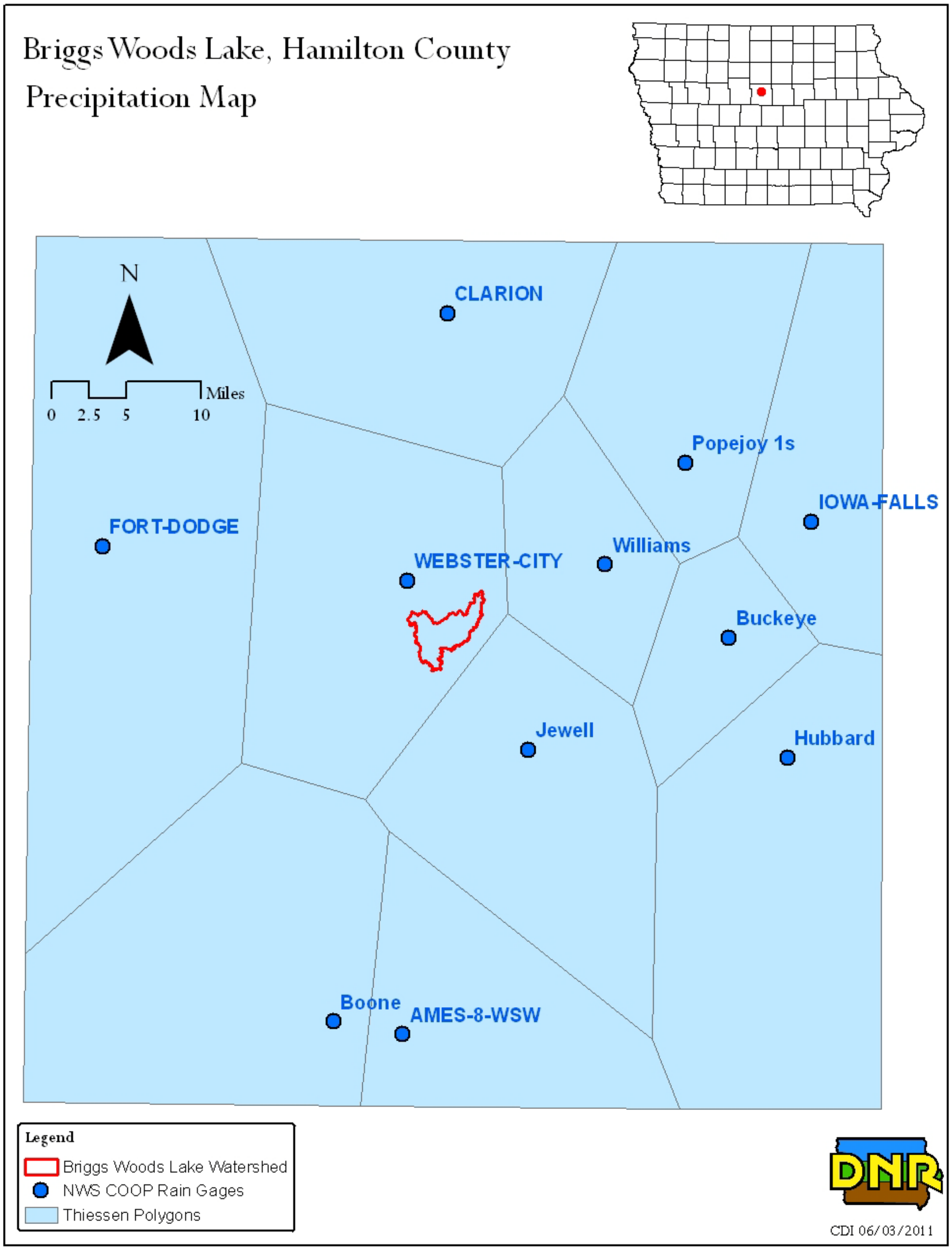


Figure 2-3. Map of nearby precipitation gages and Thiessen polygons.

Briggs Woods Lake is a man-made reservoir that lies within the Boone River HUC-8 and Drainage Ditch 206 HUC-12. The reservoir was formed in 1966 with the construction of two earthen dams and outlet structures. A 900-ft long, 43-ft high earthen dam and primary outlet structure, illustrated in Figure 2-4, is located at the south end of the lake.

The primary outlet includes a concrete riser with small weir, as well as a drawdown pipe and valve that can be used to drain the lake.

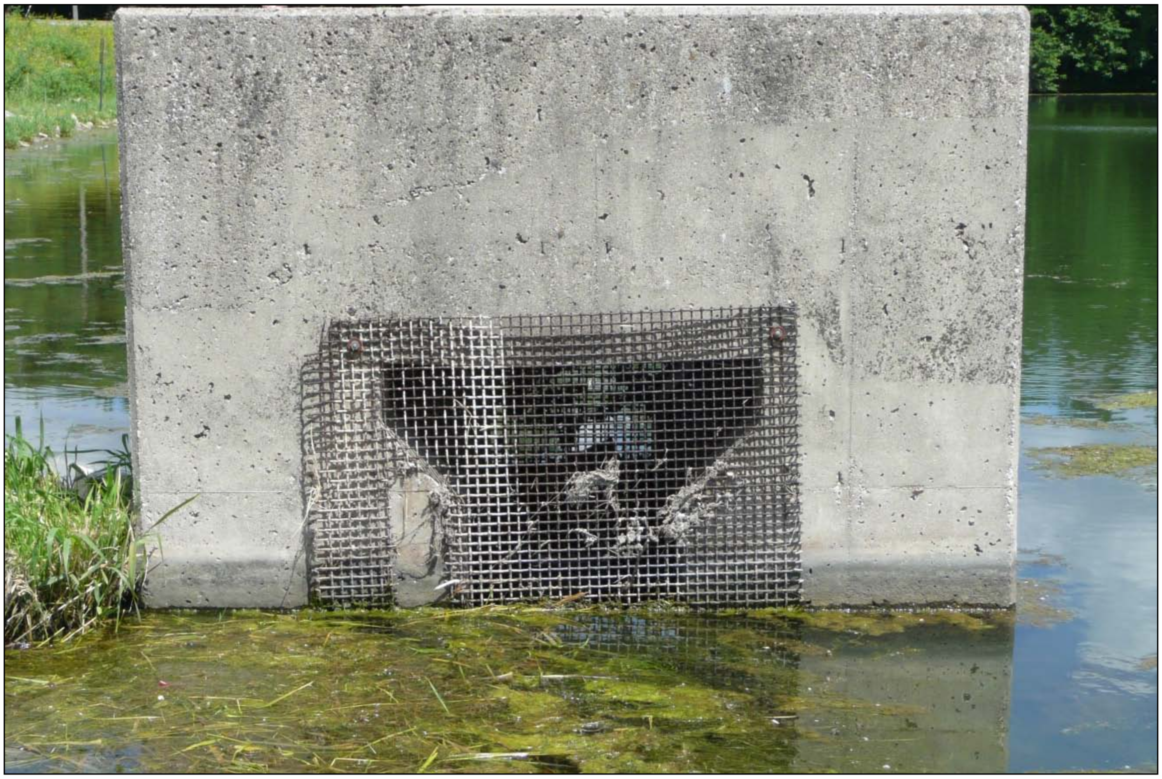


Figure 2-4. Low flow/ drawdown intake at the southeast end of the lake.

A 2,200-ft long, 26-ft high earthen dam with a 40-ft wide ogee spillway and 600-ft wide emergency spillway are at the northwest corner of the lake. A photo of the ogee spillway is shown in Figure 2-5. Under normal conditions, the lake discharges through the primary outlet at the south end of the lake to the Boone River. Under high flow conditions (flows greater than 4-6 cubic feet per second), the majority of the flow to the lake discharges through the ogee spillway to the Boone River. This configuration bypasses high flows around the lake in an attempt to minimize negative impacts of sediment and nutrient-laden runoff on lake water quality.

In 2006, a berm was constructed across the north end of the lake that further limits sediment-laden high flows from negatively impacting the main body of the lake. The area north of the berm is expected to evolve into a shallow wetland area as it retains sediment and nutrients. Low flows pass through the berm via a concrete box culvert and stop log structure, shown in Figure 2-6. Figure 2-7 illustrates the flow pattern and inflow and outflow locations on an aerial image of the lake.

Figure 2-5. Ogee spillway at northwest corner of Briggs Woods Lake.

Figure 2-6. Culvert/weir passing low flow through diversion berm.

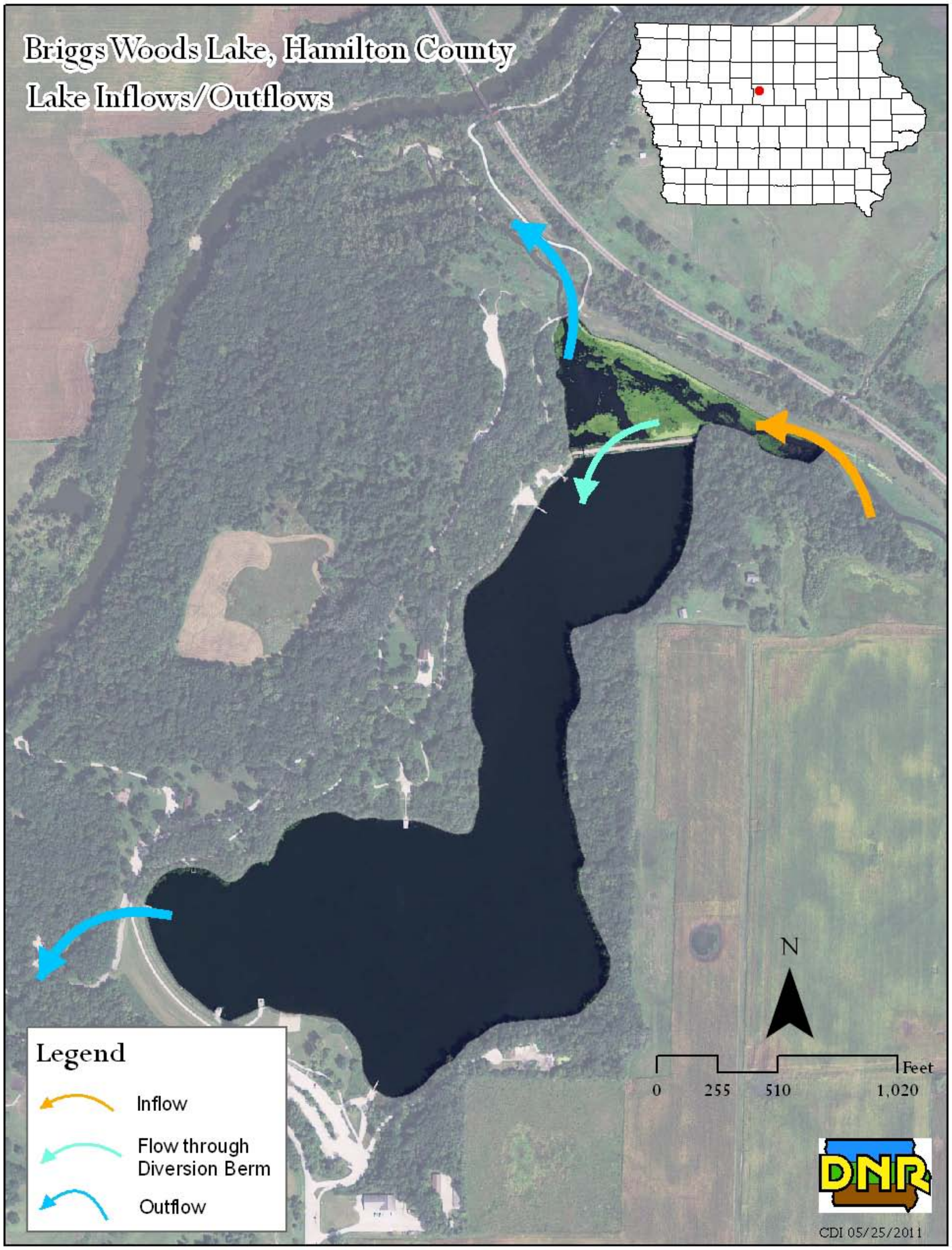


Figure 2-7. Aerial photograph and bathymetry of Briggs Woods Lake.

Rainfall runoff, agricultural tile drainage, direct precipitation, evapotranspiration, and groundwater are all part of the lake's hydrologic system. The hydraulic residence time of 55 days is based on annual precipitation statistics, Spreadsheet Tool for Estimating Pollutant Load (STEPL) estimates of average annual inflow, and a water balance calculated within the BATHTUB model. The BATHTUB water balance calculation includes inflows (from STEPL), direct precipitation, evapotranspiration estimates obtained from the Iowa State University Ag Climate Network on the Iowa Environmental Mesonet (IEM, 2011b), and lake morphometry. No physical measurement of inflow, outflow, or residence time is available.

Morphometry & Substrate
The historical surface area of Briggs Woods Lake was 59 acres, according to a 1994 lake assessment survey (IDNR, 1994). More recent aerial photography shows a surface area of 61.3 acres. The shoreline development index of the lake is 2.19 (Bachman et al., 1994). Values greater than 1.0 suggest the shoreline is highly dissected and indicative of a high degree of watershed influence (Dodds, 2000).

2.2 The Briggs Woods Lake Watershed

The drainage area to Briggs Woods Lake is a 6,955-acre watershed, not including the surface area of lake. The watershed to lake ratio of 114 to 1 is extremely high and indicates that watershed characteristics have a dominant impact on water quality in Briggs Woods Lake. The potential for successful lake restoration efforts is generally considered good in cases where the watershed to lake ratio is less than 20:1. Lakes with larger ratios usually require more costly measures to obtain significant water quality improvement. While there are many opportunities to improve the watershed and water quality of Briggs Woods Lake, implementation activities should be carefully planned so that limited resources and funds are used appropriately to obtain reasonable goals.

Land Use
Land use information was developed using a combination of sources. The Center for Agricultural and Rural Development (CARD) at Iowa State University (ISU) utilized common land unit (CLU) boundaries, as defined by the United States Department of Agriculture – Farm Services Agency (USDA-FSA), to develop high resolution land cover data for the entire Boone River watershed in 2005. This high resolution data was updated to reflect more recent land use conditions by IDNR during TMDL development. Updates were based on more recent USDA-FSA data, aerial imagery, and a windshield survey conducted by IDNR in February, 2011. Some CLUs were divided into multiple land units by IDNR because more than one land cover was observed within a single CLU.

Land cover information reveals that row crop agriculture is the most dominant feature of the Briggs Woods Lake watershed. Most of the land, over 82 percent, is in some variation of a corn-soybean rotation. Other land uses include ungrazed grassland, alfalfa, farmsteads, a small golf course, timbered areas, and a quarry operation. Table 2-3 reports the generalized land uses by acre and percent of watershed per the 2010 windshield assessment. The pie chart in Figure 2-8 illustrates the land use composition of the watershed, and Figure 2-9 shows the land use distribution on a map.

Table 2-3. Land use composition of Briggs Woods Lake watershed.

2010 Land Use	Area (Acres)	% of Watershed
Corn	3,297.8	47.0
Soybeans	2,487.3	35.4
Grasslands/Hay	723.0	10.3
Roads/ROW	237.4	3.4
Farmsteads	87.8	1.3
Golf Course	29.0	0.4
Timber	3.5	< 0.1
Commercial	89.8	1.3
Lake	61.3	0.9
Totals =	**7,016.9**	**100.0**

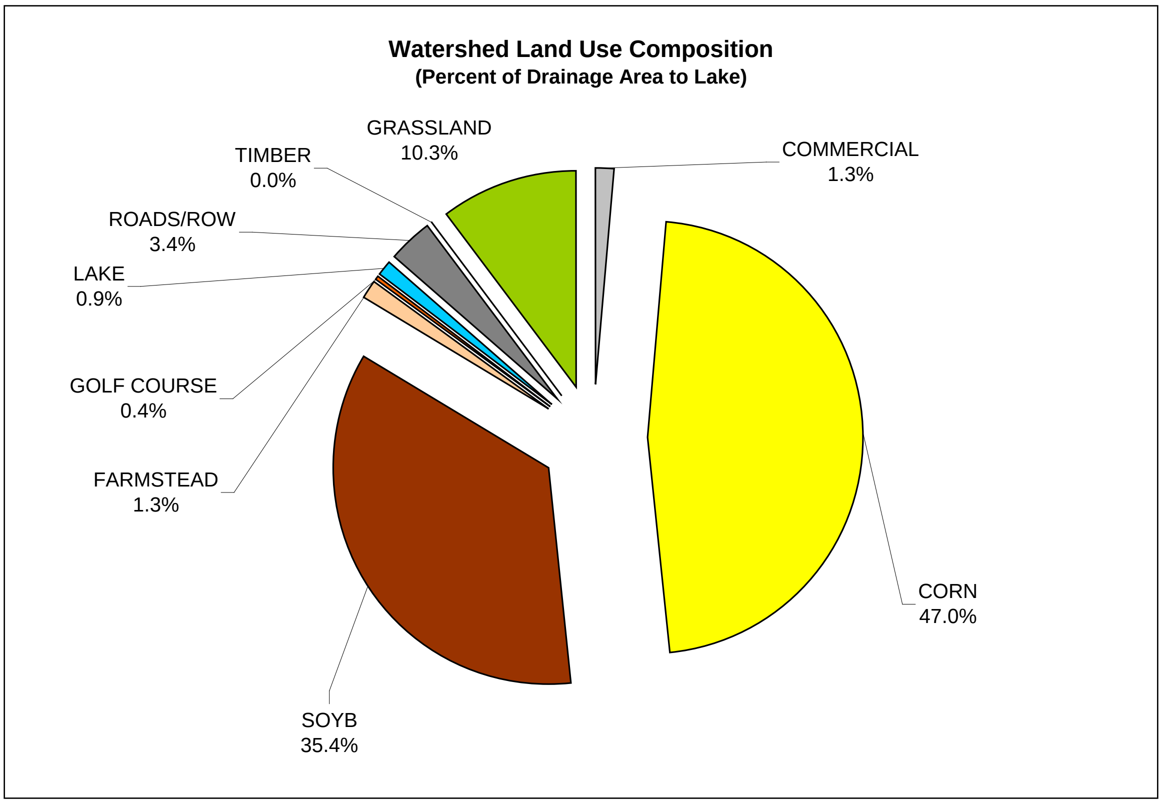


Figure 2-8. Land use composition of Briggs Woods Lake watershed.

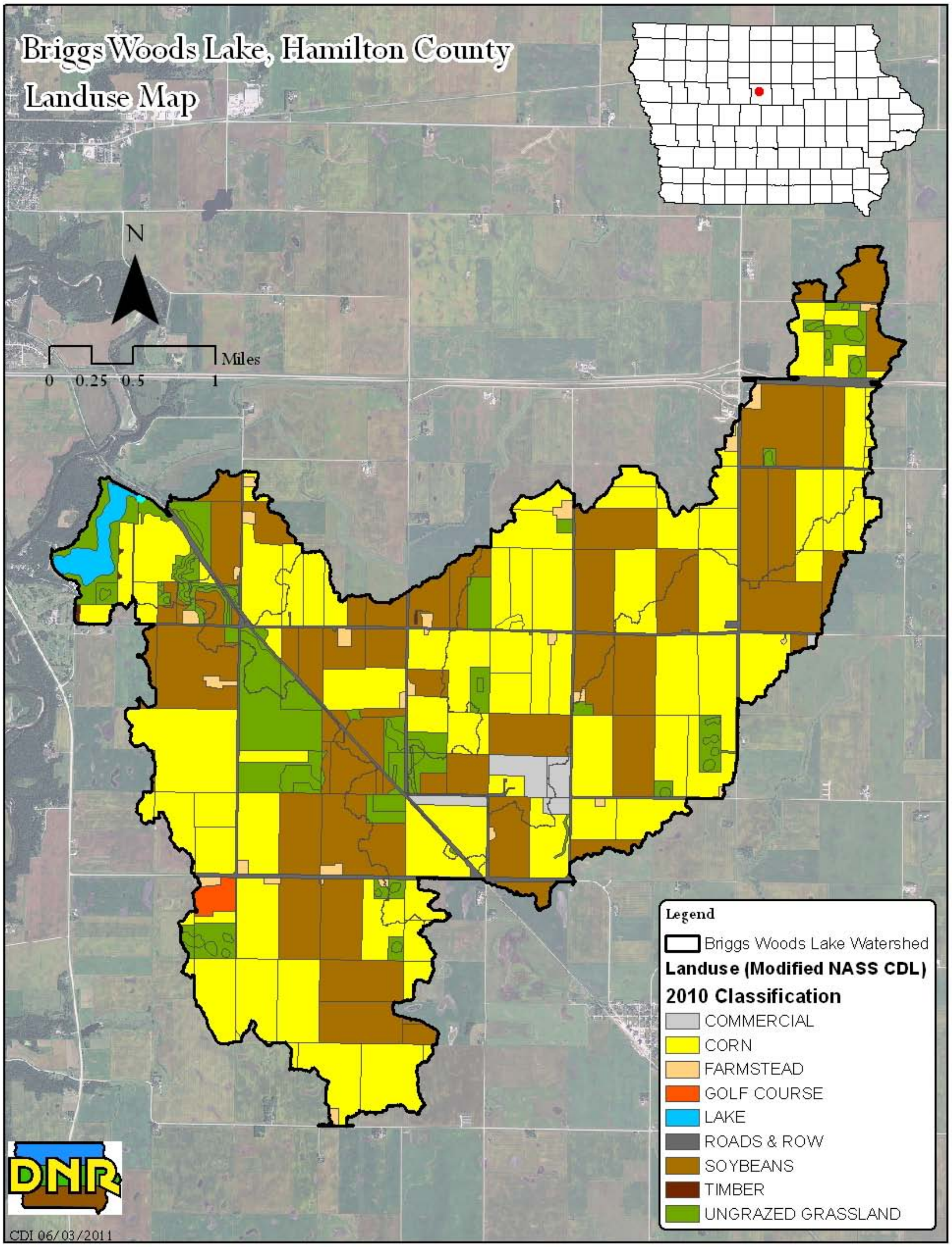


Figure 2-9. Briggs Woods Lake watershed land cover (2010).

Soils, climate, and topography

Four general soil series dominate the Briggs Woods lake watershed: Bode, Brownton, Kossuth, and Ottosen. Of these, Bode and Brownton soils comprise the largest portion of the watershed (37.7 percent and 24.6 percent, respectively). Bode soils consist of well drained, moderately permeable soils on knobs, ridges, and convex side slopes in upland areas. Bode soils formed in glacial or lacustrine sediments and in the underlying glacial till (USDA-NRCS, 1986). The native vegetation was prairie grasses. Browton soils are poorly drained, calcareous soils often found in flats, swales, and drainage ways surrounding depressions. Like Bode soils, Brownton soils were formed in glacial or lacustrine sediments and were heavily vegetated with prairie grasses in their native state (USDA-NRCS, 1986). Table 2-4 describes the most prevalent soil types (comprising the largest area) in the watershed.

Table 2-4. Predominant soils in the Briggs Woods Lake watershed.

Soil Name	Watershed Areas (%)	Description of Surface Soil Layer	Typical Slopes (%)
Bode	37.7	clay loam, well drained	2-5
Brownton	24.6	silty clay loam, poorly drained	0-2
Kossuth	15.1	silty clay loam, poorly drained	0-2
Ottosen	12.6	clay loam, somewhat poorly drained	1-3
Harps	3.1	clay loam, poorly drained	0-2
Okoboji	2.6	silty clay loam, poorly drained	0-1
All Others	4.3	varies	varies

Source: USDA-NRCS, 1986

Many of the natural wetlands that were common in the watershed pre-settlement have been lost or dramatically altered. Historical wetlands were mostly depressional wetlands in upland areas, with a few riparian wetlands adjacent to drainage corridors. The depressional "pothole" wetlands have been largely drained, which helped transform the landscape into one of the most productive agricultural areas in the nation. In wet years, however, remnants of these wetland soils retain water throughout much of the growing season, which negatively affects crop yields. Many of these potholes are "disconnected" from the primary drainage course of the watershed, as shown in Figure 2-10. This results in a smaller effective drainage area that contributes surface runoff, but increases subsurface flows through the tile drain network. This modification of the watershed may decrease sediment and attached phosphorus transport, but tends to increase transport of nitrate and other dissolved nutrients. Tile drainage and loss of wetlands in the watershed have a direct affect on water quality in Briggs Woods Lake. Balancing the desires for cropland drainage with water quality protection has been the subject of much study and debate, and continues to be a challenge for natural resource managers and producers alike.

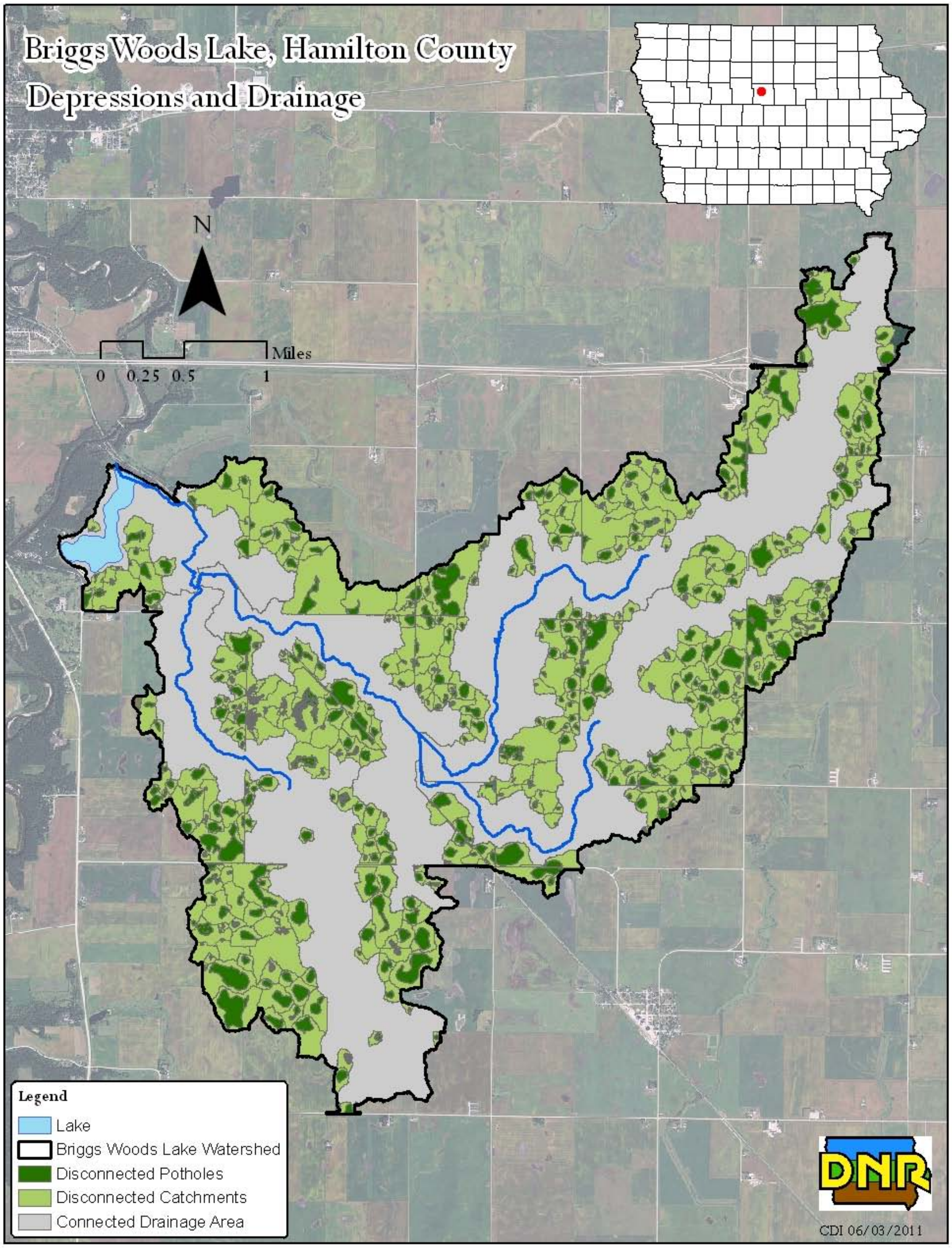


Figure 2-10. Connected drainage area and depressional potholes.

3. TMDL for Organic Enrichment/Low DO and Algae

A Total Maximum Daily Load (TMDL) is required for Briggs Woods Lake by the Federal Clean Water Act. This section of the Water Quality Improvement Plan (WQIP) quantifies the maximum amount of total phosphorus (TP) the lake can assimilate and still support primary contact recreation in Briggs Woods Lake. It is assumed that the TMDL for algae also addresses the organic enrichment/low DO impairment, which are both attributed to excess nutrient, particularly phosphorus, loads.

3.1. Problem Identification

Briggs Woods Lake is a Significant Publicly Owned Lake, and is protected for the following designated uses:

- Primary contact recreation – Class A1
- Aquatic life – Class B(LW)
- Fish Consumption – Class HH

The 2010 Section 305(b) Water Quality Assessment Report states that primary contact recreation in Briggs Woods Lake is assessed (evaluated) as “partially supported” due to elevated levels of indicator bacteria. This evaluated assessment does not result in an impairment because only two years of monitoring data is available, which is not sufficient to accurately characterize water quality. However, primary contact recreation is also assessed (monitored) as “partially supported” due to high levels of algae (chlorophyll-a) that violate Iowa’s narrative water quality standard protecting against “aesthetically objectionable conditions.” This does constitute an impairment, thus requiring a TMDL to be developed for algae.

Additionally, aquatic life uses are assessed (monitored) as “partially supported” due to a fish kill that occurred in 2005. The fish kill was attributed to low levels of dissolved oxygen (DO) related to excessive growth of submergent aquatic vegetation in the lake. According to Iowa Department of Natural Resources (IDNR) assessment methodology, this constitutes an organic enrichment/low DO impairment, and thus requires development of a TMDL.

The 2010 assessment is included in its entirety in Appendix H. This section details the development of the TMDL for algae and organic enrichment/low DO. The 305(b) report can be accessed at http://programs.iowadnr.gov/adbnet/assessment.aspx?aid=11452.

Applicable water quality standards
The State of Iowa Water Quality Standards (WQS) are published in the Iowa Administrative Code (IAC), Environmental Protection Rule 567, Chapter 61. Although the State of Iowa does not have numeric criteria for sediment, nutrients, or algae (chlorophyll-a), narrative water quality criteria do apply. Chapter 61.3(2) of the WQS contains the general water quality criteria, which are applicable to all surface waters. These narrative criteria require that waters be free from “aesthetically objectionable

conditions." The WQS can be accessed on the web at
http://www.iowadnr.gov/InsideDNR/RegulatoryWater/WaterQualityStandards/Rules.aspx

For 303(d) listing purposes, aesthetically objectionable conditions are present in a waterbody when the median summer chlorophyll-a or Secchi depth Trophic State Index (TSI) exceeds 65 (IDNR, 2008). In order to de-list a lake impaired by algae from the 303(d) list, the median growing season chlorophyll-a TSI must not exceed 63 in two consecutive listing cycles, per IDNR de-listing methodology. This TSI value is equivalent to a median summer chlorophyll-a concentration of 27 ug/L.

With respect to the fish kill and organic enrichment/low DO impairment, there was not sufficient data to compare DO in Briggs Woods Lake to the numeric standard of not less than 5.0 mg/L in the upper layer of stratification. Despite the absence of data showing a violation of numeric criteria, the aquatic life use was impaired because of the fish kill, which provided evidence that this designated use was not supported.

Excess nutrients, particularly phosphorus, causes eutrophic conditions associated with both impairments to Briggs Woods Lake. Excess plant and algae growth, driven by excess nutrients, can often lead to low DO levels when the aquatic plants die and are broken down by oxygen consuming organisms. Therefore, addressing the algae impairment in Briggs Woods Lake by targeting phosphorus will also address the organic enrichment/low DO impairment.

Problem statement

The 2010 305(b) report assesses water quality in Briggs Woods Lake as follows (bold underline added for emphasis):

> *"…Results from the ISU and UHL [SHL] lake surveys suggest that the Class A1 uses at Briggs Woods Lake are assessed (monitored) as "partially supported." Using the median values from these surveys from 2004 through 2008 (approximately 23 samples), Carlson's (1977) trophic state indices for Secchi depth, chlorophyll a, and total phosphorus were 50, 66, and 64 respectively for Briggs Woods Lake. According to Carlson (1977) the Secchi depth index value places Briggs Woods Lake at the lower end of the eutrophic category. The index values for chlorophyll a and total phosphorus place Briggs Woods Lake in between the eutrophic and hypereutrophic categories. **<u>These values suggest high levels of chlorophyll a and suspended algae in the water</u>**, very good water transparency, and moderately high levels of phosphorus in the water column…"*

Data sources

Sources of data used in the development of this TMDL include those used in the 2010 305(b) report, several sources of additional water quality data, and non-water quality related data used for model development. These sources are summarized in the following list.

- Results of statewide survey of Iowa lakes sponsored by IDNR and conducted by Iowa State University (ISU) from 2001-2005 and 2009-2010

- Water quality data collected by the State Hygienic Laboratory (SHL) at the University of Iowa from 2005-2008 as part of the Ambient Lake Monitoring Program
- Water quality data collected in 2001-2002 as part of previous water quality improvement efforts in the Briggs Woods Lake Watershed (data analyzed by National Laboratory for Agriculture and the Environment, then known as the National Soil Tilth Laboratory)
- National Weather Service (NWS) precipitation data (IEM, 2011a) and evaporation data (IEM, 2011b) accessed through the Iowa Environmental Mesonet
- 3-m LiDAR elevation data maintained by IDNR
- SSURGO soils data maintained by United States Department of Agriculture – Natural Resource Conservation Service (USDA-NRCS)
- High resolution land cover data for the Boone River watershed, developed by the Center for Agricultural and Rural Development (CARD) at Iowa State University
- Land cover and common land unit (CLU) areas maintained by the USDA Farm Services Agency (FSA)
- Land cover and land use data collected via windshield survey in 2011

Water quality data collected by SHL in 2007 and 2008 was grouped with data collected by ISU in 2009 and 2010 for statistical analysis of existing (baseline) conditions, water quality modeling, and development of in-lake water quality targets. In the summer of 2006, a diversion berm, box culvert, and weir were constructed across the north end of the lake to limit high flows and reduce the amount of sediment that enters the main body of the lake. These modifications significantly altered lake hydrology and water quality processes from previous conditions. Data collected in the lake prior to 2007 no longer reflect conditions in Briggs Woods Lake. For this reason, in-lake data obtained prior to 2007 was utilized only to assess general trends and make qualitative evaluations. In-lake water quality data collected from 2007-2010 are provided in Appendix C of this report.

Interpreting Briggs Woods Lake data
The 2010 305(b) assessment was based on both ISU and SHL ambient monitoring data from 2004-2008. Assessment of in-lake water quality in this TMDL utilized SHL data from 2007-2008 and ISU data from 2009-2010. Data prior to 2007 was used only qualitatively, since the hydrology of the lake was significantly altered by construction of a diversion berm across the north end of the lake in the summer of 2006.

Carlson's Trophic State Index (TSI) was used to evaluate the relationships between TP, algae (chlorophyll-a), and transparency (Secchi depth) in Briggs Woods Lake. If the TSI values for the three parameters are the same, the relationships between the three are strong. If the TP TSI values are higher than chlorophyll TSI, it suggests there are limitations to algal growth besides phosphorus. Figure 3-1 illustrates each of the individual TSI values throughout the sampling period, and Table 3-1 reports mean and median TSI values calculated using the ambient lake monitoring data. The general trend is that chlorophyll-a TSI values are significantly higher than those for Secchi depth, and TSI values for TP are slightly higher than those for chlorophyll-a.

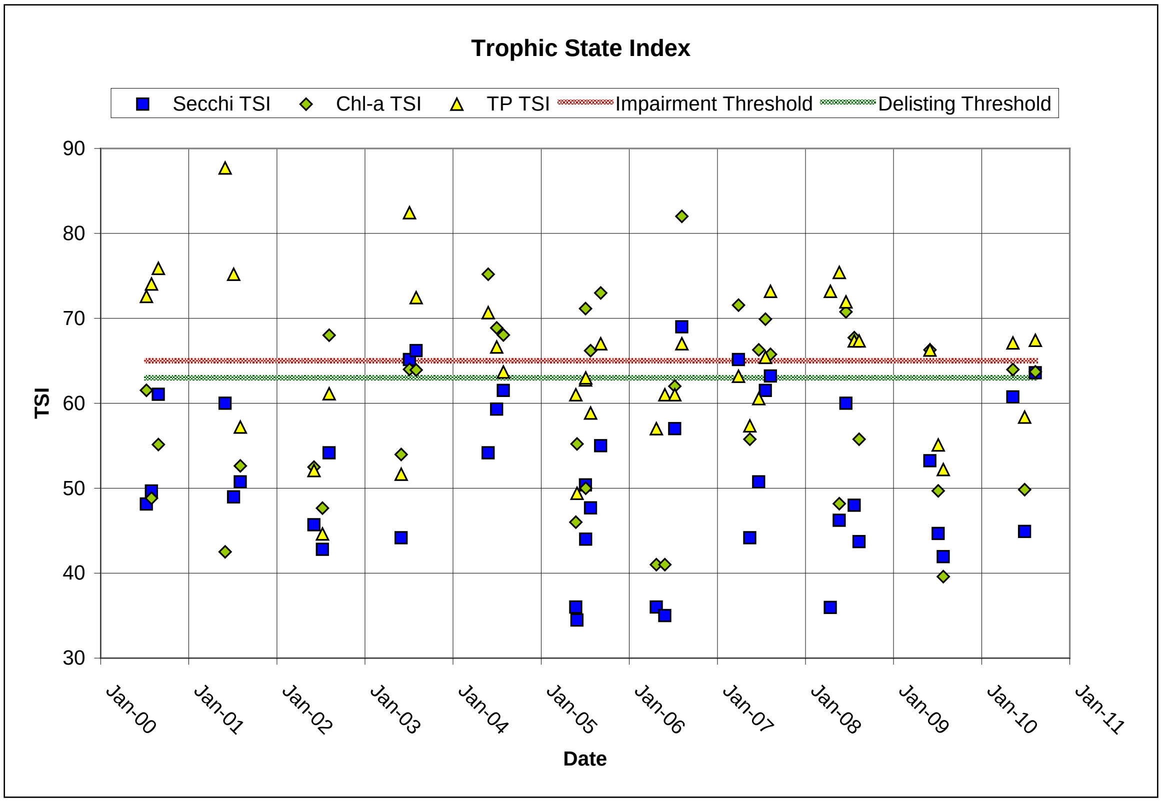


Figure 3-1. Briggs Woods Lake mean TSI values (2007-2010 SHL data).

Using the mean observed values across all these data, the overall TSI values for TP, chlorophyll-a, and Secchi depth at the ambient monitoring location are 67, 63, and 49, respectively. This suggests that factors besides TP may be limiting (i.e., controlling) algal growth at certain times and under certain conditions. However, there are many occurrences of chlorophyll-a TSI values above 70, and a number of instances in which the TSI is higher for chlorophyll-a than TP. This indicates that severe algal blooms do occur, and suggests that TP is often the limiting factor. TSI scores for both TP and chlorophyll-a are significantly higher than for Secchi depth, indicating that non-algal turbidity is not a concern.

Table 3-1. TSI values in Briggs Woods Lake.

	TSI (SD)	TSI (Chl)	TSI (TN)	TSI (TP)
[1]Mean TSI	49	63	72	67
[2]Median TSI	49	64	62	67
[3]Mean TSI	49	65	77	69
[4]Median TSI	49	66	64	67

[1]2007-2010 growing season mean values (used to establish baseline conditions)
[2]2007-2010 growing season median values
[3]2007-2008 growing season mean values
[4]2007-2008 growing season median (used in 2010 305(b) assessment)

The overall TN:TP ratio in Briggs Woods Lake, using growing season mean concentrations from 2007-2010, is 31.0. According to a study on blue-green algae dominance in lakes, ratios greater than 17 suggest a lake is phosphorus, rather than nitrogen, limited (MPCA, 2005). Carlson states that phosphorus may be a limiting factor at TN:TP ratios greater than 10 (Carlson and Simpson, 1996). Additionally, the TN TSI is 72, higher than the TSI for TP. Table 3-2 describes the implications of TSI values on attributes of lakes. Figure 3-2 shows these classifications on the plot of Briggs Woods Lake TSI values.

Table 3-2. Implications of TSI values on lake attributes.

TSI Value	Attributes	Primary Contact Recreation	Aquatic Life (Fisheries)
50-60	eutrophy: anoxic hypolimnia; macrophyte problems possible	[none]	Warm water fisheries only; [1]percid fishery; bass may be dominant
60-70	blue green algae dominate; algal scums and macrophyte problems occur	weeds, algal scums, and low transparency discourage swimming and boating	[2]Centrarcid fishery
70-80	hyper-eutrophy (light limited). Dense algae and macrophytes	weeds, algal scums, and low transparency discourage swimming and boating	Cyprinid fishery (e.g., common carp and other rough fish)
>80	algal scums; few macrophytes	algal scums, and low transparency discourage swimming and boating	rough fish dominate; summer fish kills possible

[1]Fish commonly found in percid fisheries include walleye and some species of perch
[2]Fish commonly found in centrarcid fisheries include crappie, bluegill, and bass
Note: Modified from Carlson and Simpson (1996).

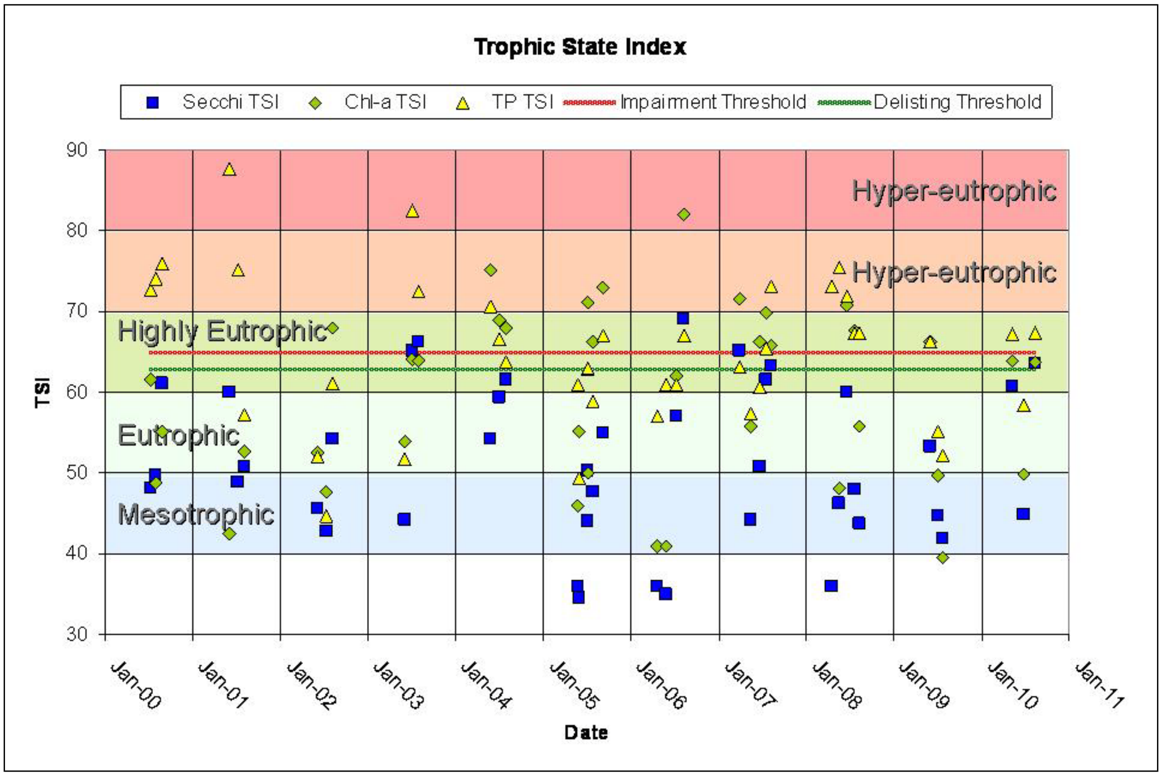


Figure 3-2. Briggs Woods Lake TSI values with productivity ranges shown.

Figures 3-3 and 3-4 illustrate a method for interpreting the meaning of the deviations between Carlson's TSI values for TP, Secchi depth, chlorophyll-a, and TN. Each quadrant of the chart indicates the potential factors that may limit algal growth in a lake. A detailed description of this approach is available in *A Coordinator's Guide to Volunteer Lake Monitoring Methods* (Carlson and Simpson, 1996). If the deviation between the chlorophyll-a TSI and TP TSI is less than zero (Chl TSI < TP TSI), the data point will fall below the X-axis. This suggests phosphorus may not be the limiting factor in algal growth. The X-axis, or zero line, is related to TN:TP ratios of greater than 33:1 (Carlson, 1992). Because phosphorus is thought to be a limiting nutrient at ratios greater than 10:1, deviations slightly below the X-axis do not necessarily indicate nitrogen limitation.

Points to the left of the Y-axis (Chl TSI < SD TSI) represent conditions in which transparency is reduced by non-algal turbidity, whereas points to the right reflect situations in which transparency is greater than chlorophyll-a levels would suggest, meaning that large particles, rather than fine clay particles, influence water clarity. Deviations to the right may also be caused by high zooplankton populations that feed on algae, keeping the algal populations lower than expected given other conditions. This phenomenon does appear to occur in Briggs Woods Lake, based on the deviation between the chlorophyll-a and Secchi depth TSI values. This may explain why chlorophyll-a TSI is lower than TP TSI – zooplankton graze on algae, keeping levels lower than TP levels would suggest.

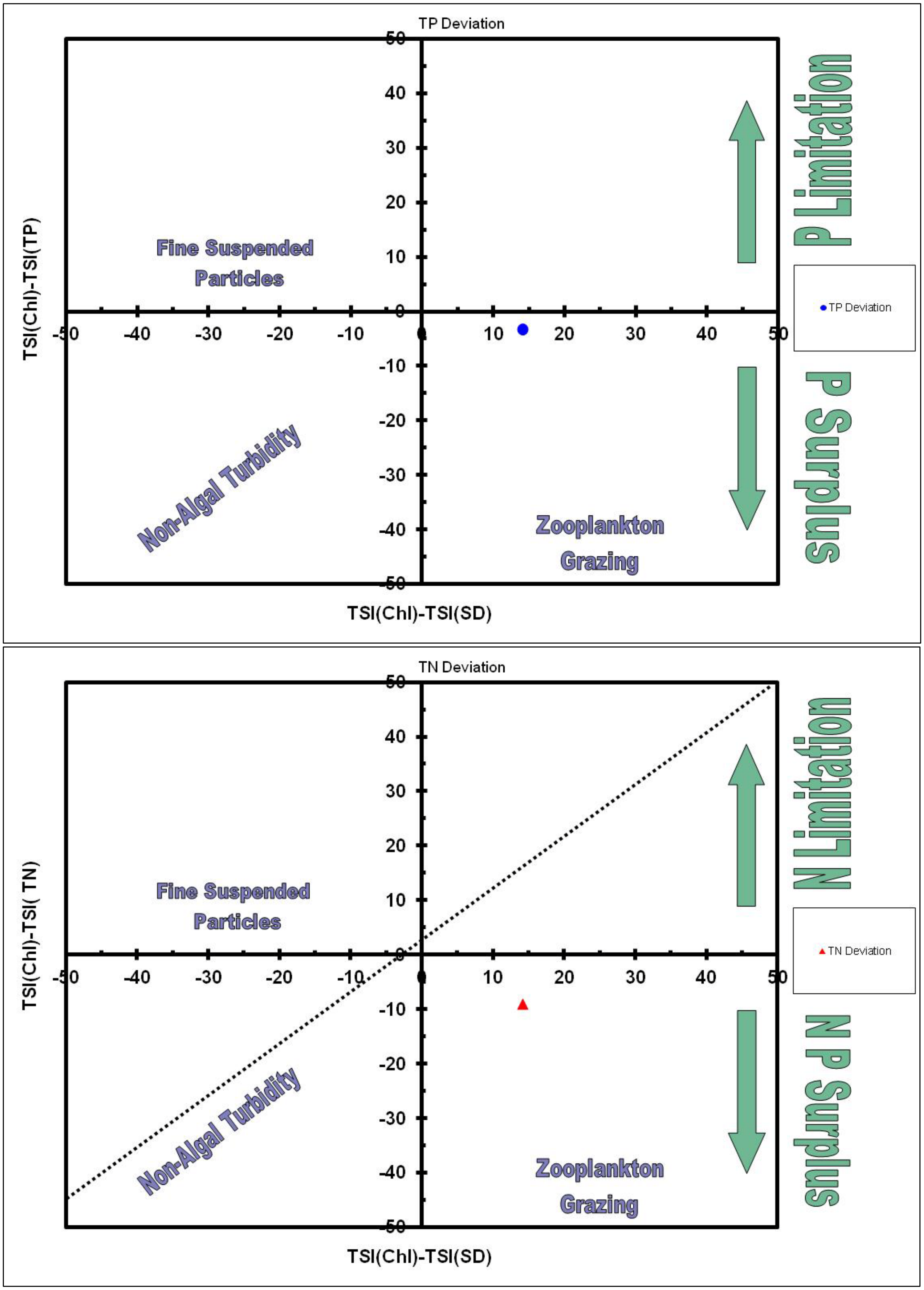
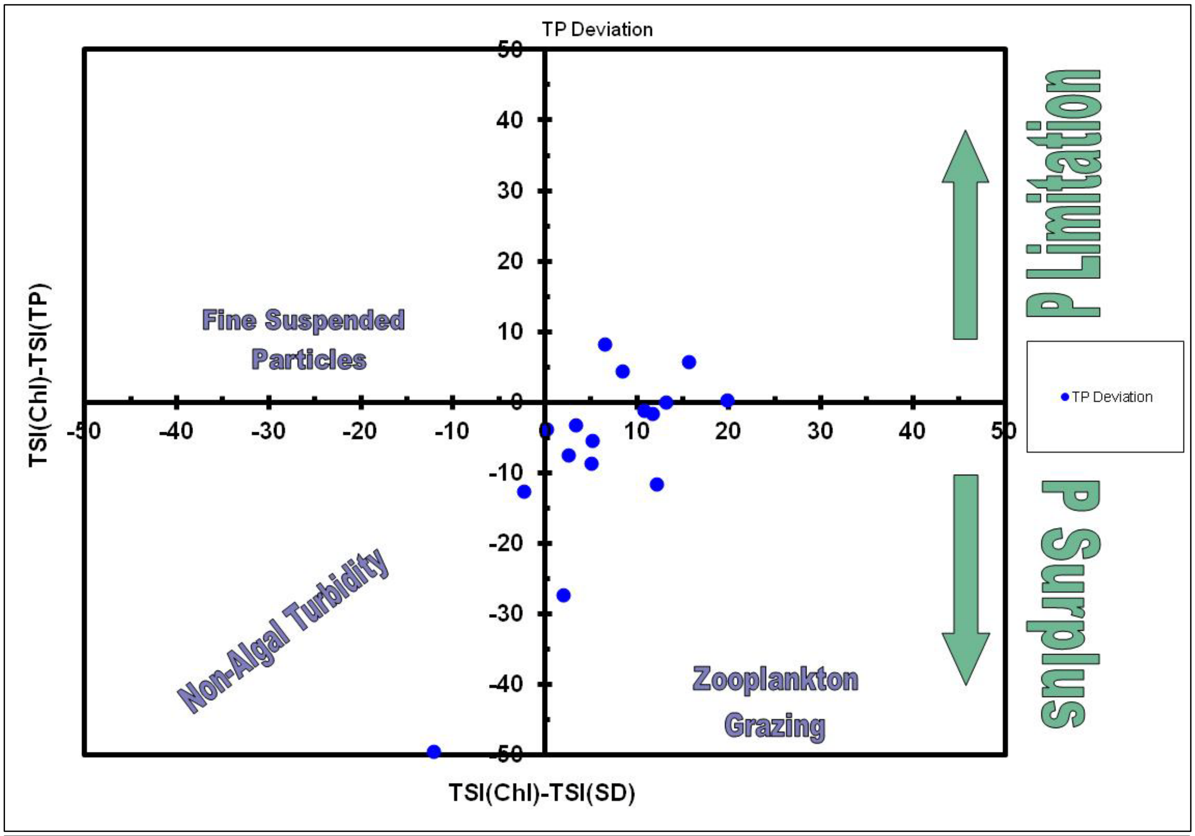


Figure 3-3. TSI deviations based on mean concentrations and Secchi depth.



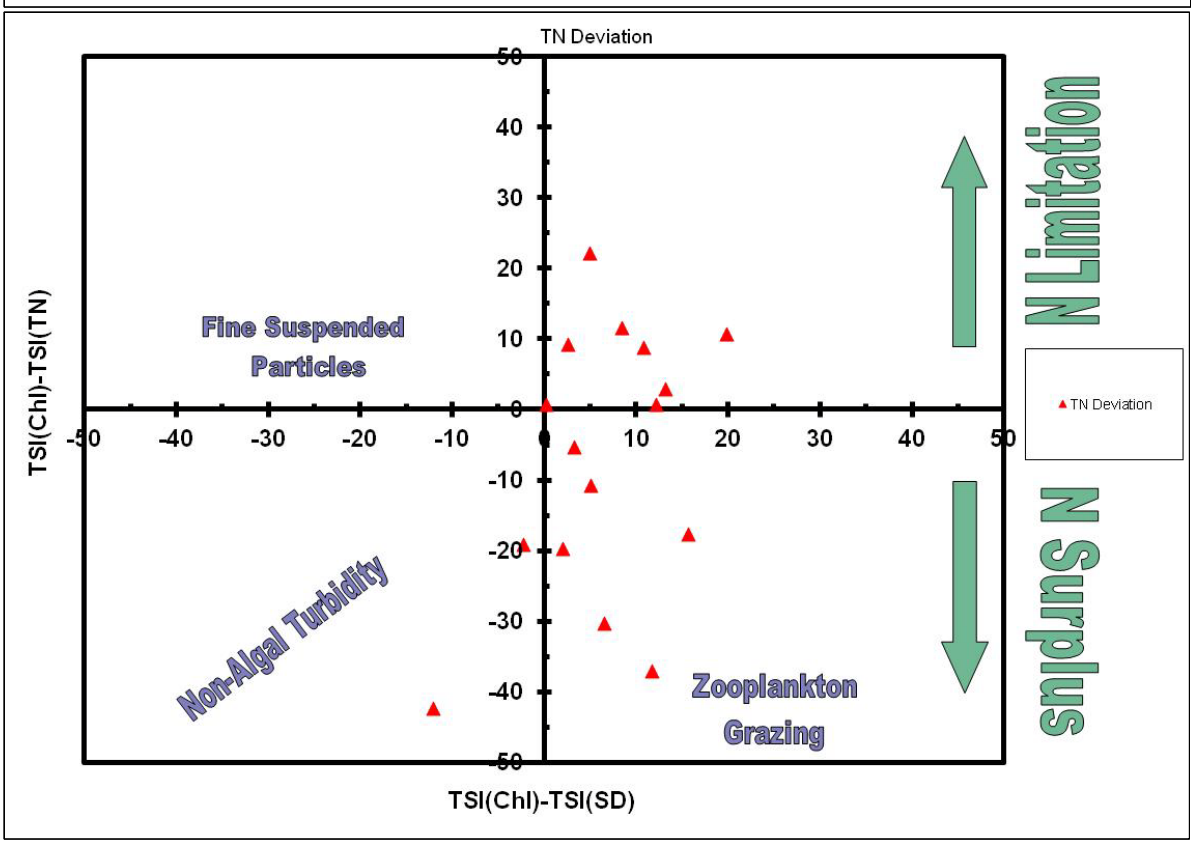


Figure 3-4. TSI deviations for individual sampling events.

The mean observed concentrations and Secchi depths in Briggs Woods Lake, based on the 2007-2010 ambient data, result in TSI deviations in the lower-right quadrant of Figure 3-3. Because the deviations are not extreme (i.e., the points lie near both the X and Y-axes), the importance of phosphorus in algal growth and transparency must be considered. The TN:TP ratio of 31:1 confirms that under most conditions, phosphorus is more limiting than nitrogen in algal growth in Briggs Woods Lake.

Examination of the presence or lack of correlation between nutrients and indicators of water quality such as chlorophyll-a and Secchi depth provide further insight regarding probable causes of eutrophication. It is important to recognize that correlation is not equivalent to causation, but this does not render correlation useless. It can be a valuable tool that should be used with other analyses to evaluate the relationship between water quality and nutrients. Figures 3-5 through 3-8 illustrate correlation, as expressed by linear regression, of a number of water quality parameters. Analysis of these figures reveals several observations, discussed below.

Figure 3-5 reveals algae, as measured by chlorophyll-a concentration, has a weak, positive correlation with TP. Figure 3-6 reveals a weak negative correlation between chlorophyll-a and TN. Figure 3-7 and 3-8 also reveal a lack of significant correlation between phytoplankton, another measure of algae, and TP or TN. These data illustrate the challenges of targeting nutrients to improve overall water quality in lakes. Given the lack of clear correlation and limitation of algal growth by any singular nutrient, professional judgment is often used by natural resource managers.

Although phosphorus may not be the sole limiting factor for algal growth at all times and under all conditions, it appears to play a larger role in limitation than nitrogen. The TN:TP ratio of 31.0 and the fact that the TP deviation lies above the TN deviation in Figure 3-3 support this assertion. However, lakes are complex and dynamic systems, and these relationships vary spatially and temporally. It is likely that nitrogen limitation does play a role in algal growth and speciation under certain conditions, and this should be acknowledged when developing lake restoration plans, even though phosphorus more directly and consistently influences eutrophication in Briggs Woods Lake. Many phosphorus reduction activities will also reduce nitrogen loads to the lake. If the phosphorus targets set forth in this TMDL are attained and excess algae persists, lake managers should consider implementation of additional nitrogen reduction measures.

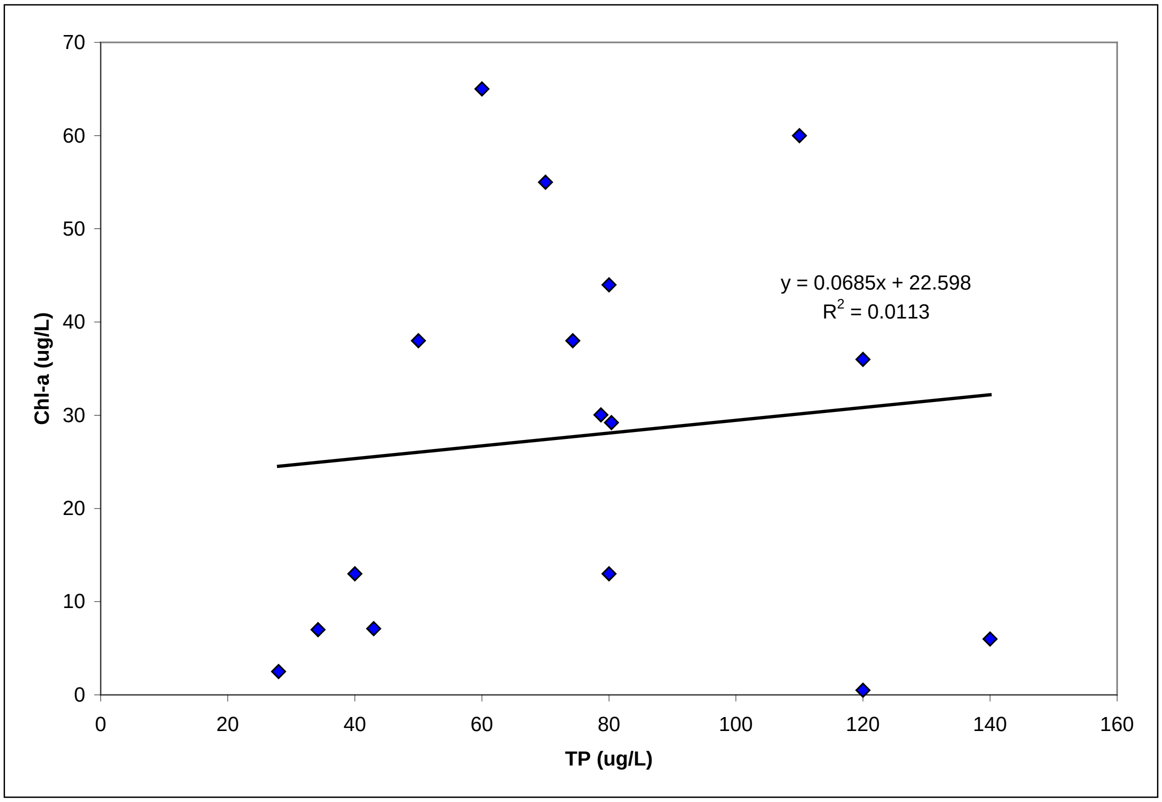


Figure 3-5. Chlorophyll-a vs. total phosphorus (TP), 2007-2010 ambient data.

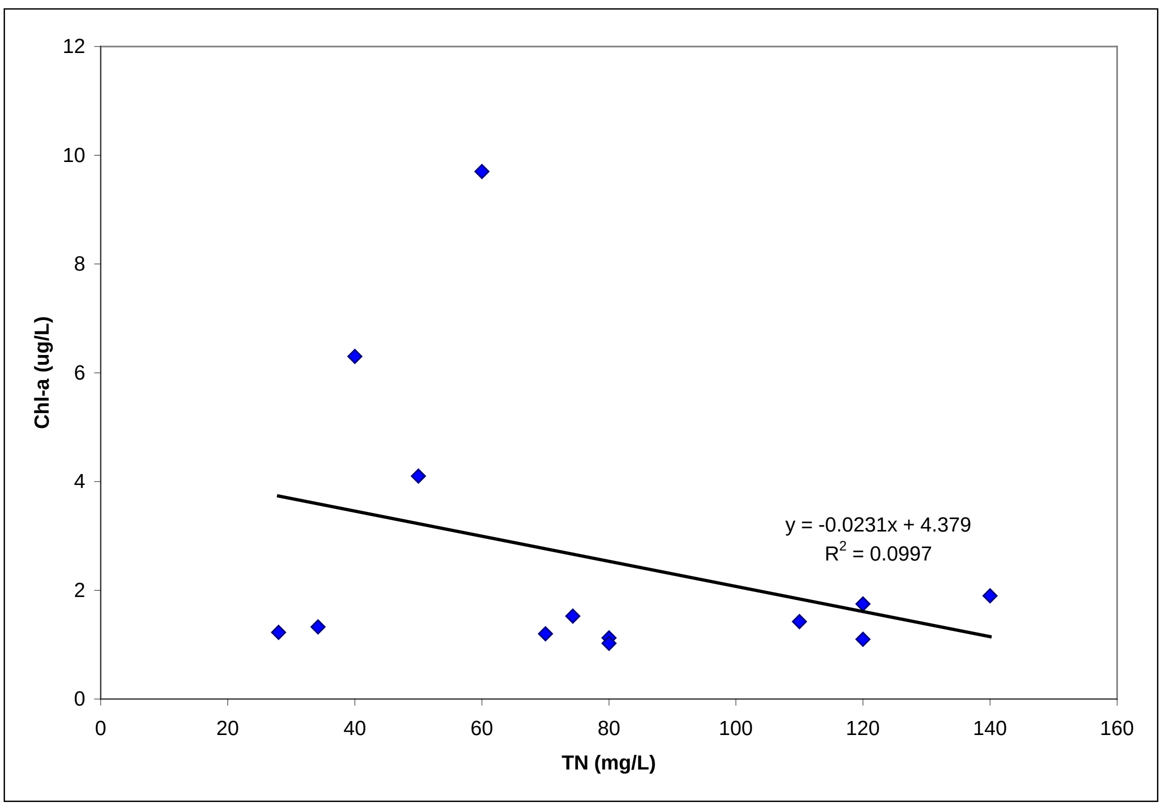


Figure 3-6. Chlorophyll-a vs. total nitrogen (TN), 2007-2010 ambient data.

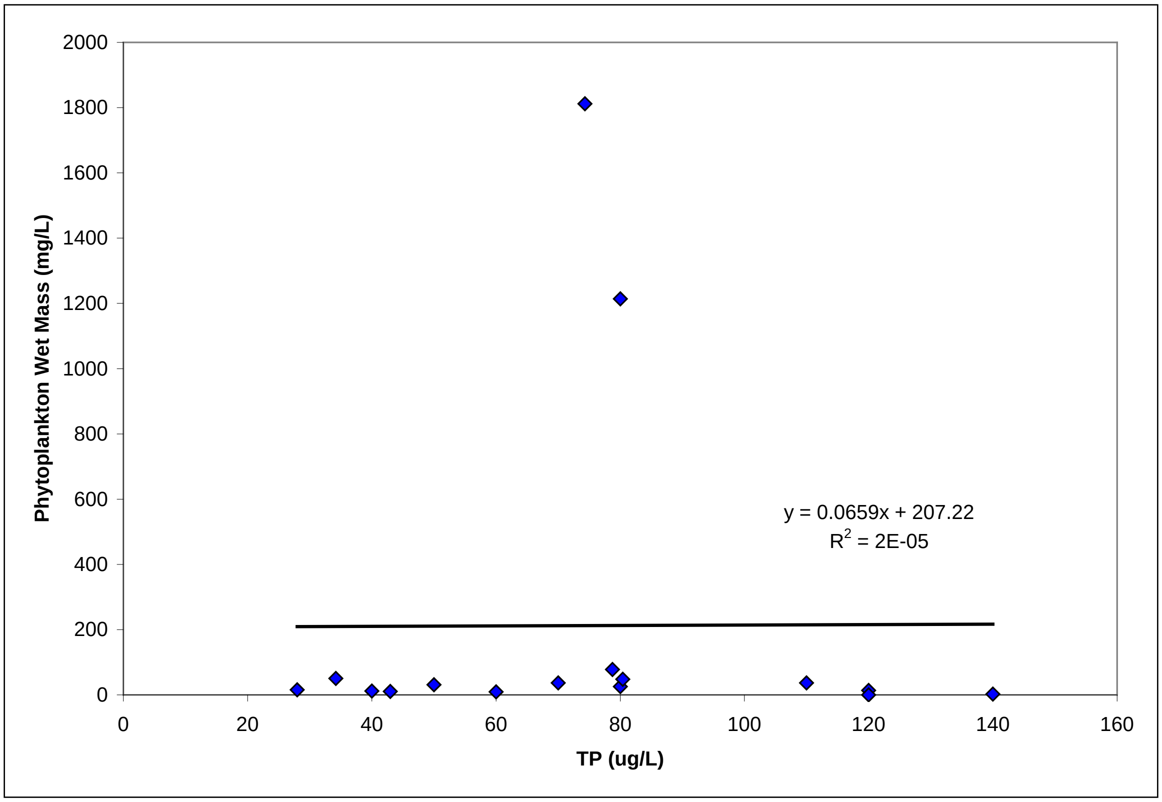


Figure 3-7. Phytoplankton vs. total phosphorus (TP), 2007-2010 ambient data.

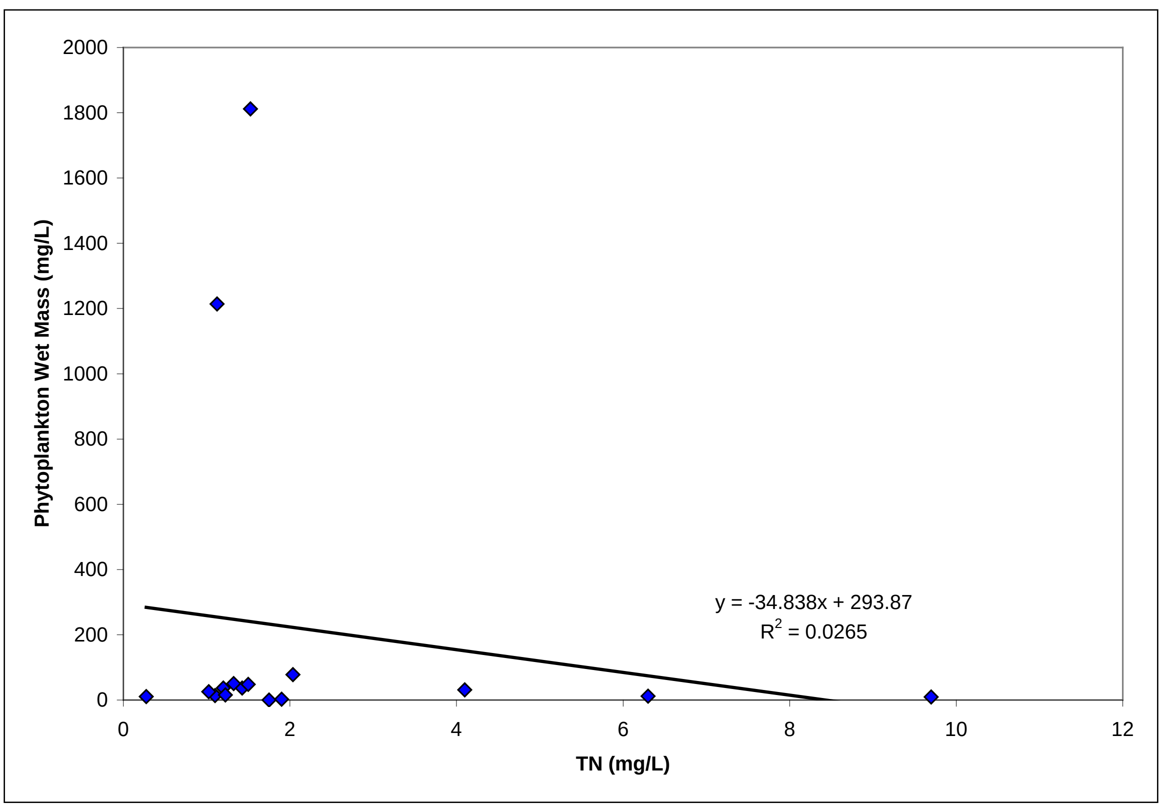


Figure 3-8. Phytoplankton vs. total nitrogen (TN), 2007-2010 ambient data.

3.2. TMDL Target

General description of the pollutant
The 2010 305(b) assessment and the data interpretation described in Section 3.1 reveal that algae is causing poor water quality in Briggs Woods Lake. Carlson's TSI methodology and the relatively high TN:TP ratio suggest that controlling phosphorus levels in Briggs Woods Lake will have more impact on transparency than nitrogen reductions. Additionally, nitrogen reduction in lieu of phosphorus controls may tilt the TN:TP ratio higher, which could lead to conditions that increase risk of potentially dangerous blue-green algae called cyanobacteria (Smith, 1983).

For these reasons, the TMDL for algae is based on in-lake targets for chlorophyll-a, which will be achieved by reducing phosphorus loads to the lake. As noted previously, phosphorus reductions should be accompanied by nitrogen reductions. If phosphorus targets are met and the algae impairment persists, more formal reductions of nitrogen should be considered. Table 3-3 reports the existing chlorophyll-a, TP, and Secchi depth, as well as the target chlorophyll-a concentration and associated TP concentration and Secchi depth. A growing season median chlorophyll-a TSI of 63 will result in delisting Briggs Woods Lake if attained in two consecutive 303(d) listing cycles. The modeling employed to develop this TMDL simulates mean values, which are nearly identical to historical median values. Therefore, this TMDL targets a growing season mean chlorophyll-a TSI of 63,

Table 3-3. Existing and target chlorophyll-a and associated parameters.

Parameter	2007-10 Mean TSI	Target TSI	2007-10 Mean	[1]Associated w/ Target	Improvement
Secchi depth	49	--	2.1 m	2.1	0% increase
Chlorophyll-a	63	63	28 ug/L	27 ug/L	4% decrease
Total Phosphorus	67	--	76 ug/L	72 ug/L	5% decrease

[1]The in-lake target is for chlorophyll-a, which determines the target TP load. The in-lake TP and Secchi depth associated with the target is also provided in this column.

Selection of environmental conditions
The critical period for the occurrence of algal blooms resulting from high phosphorus levels in the lake is the growing season (April through September). However, long-term phosphorus loads lead to buildup of phosphorus in the reservoir and contributes to blooms regardless of seasonal effects. Additionally, the combined watershed and in-lake modeling approach using EPA's Spreadsheet Tool for Estimating Pollutant Loads (STEPL) and BATHTUB lends itself to analysis of annual average conditions. Therefore, both existing and allowable TP loads to Briggs Woods Lake are expressed as annual averages. Phosphorus loads are also expressed as daily maximums to comply with EPA guidance.

Waterbody pollutant loading capacity (TMDL)
This TMDL for algae establishes an in-lake target for chlorophyll-a and an associated target TP load using analysis of existing water quality data and Carlson's trophic state index methodology. IDNR anticipates that the resulting TMDL will also address the

organic enrichment/low DO impairment resulting from a fish kill in 2005. The water quality target is attainable, but will require implementation of a comprehensive watershed management and lake restoration plan that builds on previous implementation efforts.

The allowable in-lake chlorophyll-a target was translated to the TP loading capacity by performing water quality simulations using the BATHTUB model. BATHTUB is a steady-state water quality model that performs empirical eutrophication simulations in lakes and reservoirs (Walker, 1999). The BATHTUB model was calibrated to water quality data collected by ISU and SHL from 2007 through 2010, and is driven by watershed hydrology and sediment and nutrient loads predicted by the STEPL model. STEPL utilizes simple equations to predict sediment and nutrient loads from various land use and animal sources, and includes a tool that estimates potential sediment and nutrient reductions resulting from implementation of Best Management Practices (BMPs). STEPL input included local soil, land cover, and climate data, as well as detailed information regarding agricultural practices and other land management activities. The annual TP loading capacity of 8,515 pounds per year (lbs/year) was obtained by adjusting the tributary and internal TP loads in the calibrated BATHTUB model until the target chlorophyll-a concentration was attained. A detailed discussion of the parameterization and calibration of the STEPL and BATHTUB models is provided in Appendices D through F.

In November of 2006, The U.S. Environmental Protection Agency (EPA) issued a memorandum entitled *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits.* In the context of the memorandum, EPA

> *"…recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increment. In addition, TMDL submissions may include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards…"*

As recommended by EPA, the loading capacity of Briggs Woods Lake for TP is expressed as a daily maximum load, in addition to the annual loading capacity of 8,515 lbs/year obtained above. The annual average load is more applicable to the assessment of in-lake water quality and water quality improvement actions, while the daily maximum load expression satisfies the legal uncertainty addressed in the EPA memorandum.

The maximum daily load was estimated from the annual average load using a statistical approach that is outlined in more detail in Appendix G. This approach uses a lognormal distribution to calculate the daily maximum from the long-term (e.g., seasonal) average load. The methodology for this approach is taken directly from a follow-up guidance document entitled *Options for Expressing Daily Loads in TMDLs* (EPA, 2007), and was issued shortly after the November 2006 memorandum cited previously. This methodology can also be found in EPA's 1991 *Technical Support Document for Water*

Quality Based Toxics Control. Using the approach, the allowable maximum daily load (loading capacity) for TP in Briggs Woods Lake is 93 lbs/day.

Decision criteria for water quality standards attainment
The narrative criteria in the water quality standards require that Briggs Woods Lake be free from “aesthetically objectionable conditions.” There are no numeric criteria associated with water clarity, therefore attainment of the standard is based on maintaining relatively good water clarity compared to other Iowa lakes. The primary metric for water quality standards attainment set forth in this TMDL is obtaining/maintaining a growing season m mean chlorophyll-a TSI of no greater than 63, which corresponds to a chlorophyll-a concentration of 27 ug/L.

3.3. Pollution Source Assessment

Existing load
Average annual simulations (2007-2010) of hydrology and pollutant loading were developed using the STEPL model (Version 4.1). STEPL was developed by Tetra Tech, for the US EPA Office of Water, and has been utilized extensively in the United States for TMDL development and watershed planning. Model description and parameterization are described in detail in Appendix D.

Using STEPL, the average annual TP load to Briggs Woods Lake from 2007-2010, including watershed, internal, and atmospheric loading was estimated to be 10,011 lbs per year, an average of 27 lbs/day. This averaging period was selected for two primary reasons: First, an earthen berm with a concrete weir/culvert was constructed across the north end of the lake in the summer of 2006. The construction was implemented as part of a larger watershed improvement project that included other lake and watershed improvements, such as development of vegetative buffers and wetland restoration. The goal of the berm construction project was to restrict high flow and associated transport of sediment and nutrients from entering the main body of the lake. This alteration of lake hydrology and bathymetry appears to have had a profound impact on nitrate levels in the lake; however, impacts on phosphorus and algal growth are inconclusive thus far. This major change in hydrology and morphology results in a lake that functions and behaves significantly different than prior to berm construction. The second reason the 2007-2010 period was utilized in the analysis is that the algae impairment first appears on the 2010 303(d) list, making the earlier data less relevant to the impairment addressed by this TMDL.

The existing daily maximum load is 110 lbs/day. For consistency, the existing maximum daily load was estimated from the annual average load (STEPL output) using the same statistical approach described for the loading capacity.

Departure from load capacity
The target TP load, also referred to as the loading capacity, for Briggs Woods Lake is 8,515 lbs/year. This is an average of 23 lbs/day and daily max of 93 lbs/day. To meet the target loads, a reduction of 15 percent of the TP load is required. This will require

BMPs in addition to those already implemented during watershed improvement efforts. The implementation plan included in Section 4 describes potential BMPs, potential TP reductions, and considerations for targeting selection and location of BMPs.

Identification of pollutant sources
The existing TP load to Briggs Woods Lake is entirely from nonpoint sources of pollution. There are no point sources operating under a National Pollution Discharge Elimination System (NPDES) permit or regulated by other Clean Water Act programs. Table 3-4 reports estimated annual average TP loads to the lake from all known sources, based on watershed conditions between 2007-2010. Figure 3-9 illustrates the relative contributions of phosphorus sources.

The predominant source of phosphorus in the watershed is runoff and groundwater (including agricultural tile drainage) from land in row crop production. Phosphorus transport is increased by the application of commercial and organic fertilizers. Row crops comprise over 82 percent of the land use in the watershed, so it is not surprising that cropland is the largest contributor of phosphorus to Briggs Woods Lake.

Internal recycling of phosphorus in the lake, sometimes referred to as internal loading, appears to contribute a relatively small amount of phosphorus, only 2 percent of the annual average load. However, internal recycling may be more critical than this contribution suggests. In dry years, the internal load may drive algal blooms in the absence of significant phosphorus loads from the watershed. Additionally, short-term internal loads under certain conditions may contribute enough biologically available phosphorus to cause algal blooms, even though the net annual internal load appears relatively small. Estimation of internal phosphorus loads in lakes is challenging, and there is often a high degree of uncertainty associated with internal load estimates.

Table 3-4. Average annual TP loads from each source (2007-2010).

Source	Descriptions and Assumptions	TP Load (lb/yr)	Percent (%)
Row Crops	Corn and soybeans	9,385	93.7
Grass/Hay	Alfalfa and ungrazed grassland	77	0.8
Developed	Includes farmsteads, roads/ROW, and quarry	219	2.2
Golf course	Modeled as pasture in STEPL	12	0.1
Timber	Wooded areas	0.4	0.0
Septic systems	Private on-site wastewater treatment systems	103	1.0
Internal Recycling	Phosphorus recycled from lake bottom	197	2.0
Atmospheric Deposition	Wet and dry deposition from the atmosphere	17	0.2
Total		10,011	100.0

Other relatively insignificant sources, each comprising two percent or less of the total load, include natural background sources such as wildlife and atmospheric deposition, privately owned on-site wastewater treatment systems (e.g., septic systems), ungrazed grasslands and hay, farmsteads, a small golf course, and runoff from roads and right-of-way areas. Although overall loads from these sources are relatively small due to the relatively small amount of land associated with each source, their collective impacts on water quality (e.g., in tributaries or near outfalls) should be considered when developing a watershed management plan and implementing water quality improvement projects.

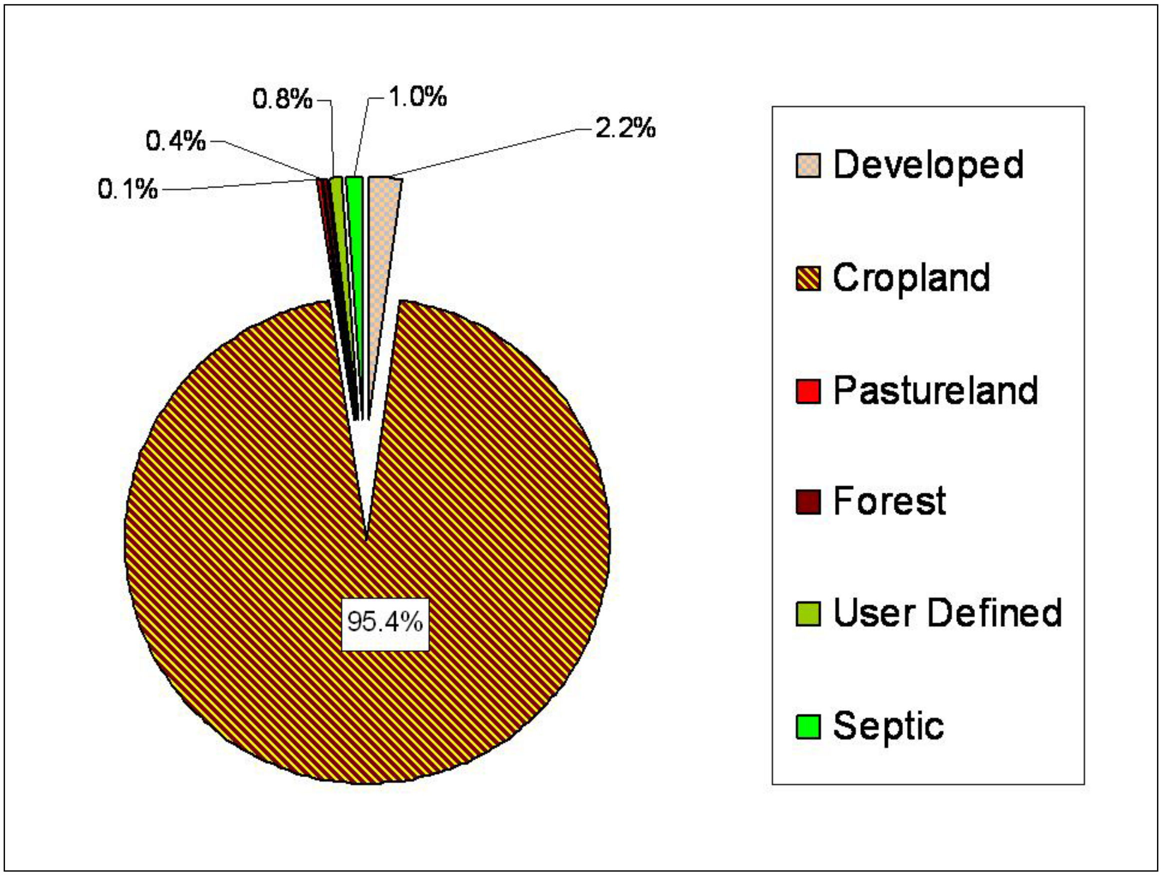


Figure 3-9. Relative TP loads by source.

Allowance for increases in pollutant loads
There is no allowance for increased TP loading included as part of this TMDL. A majority of the watershed is in agricultural row crop production, and is likely to remain in cropland in the future. Briggs Woods Park, which is adjacent to the lake, is unlikely to undergo significant land use changes. There are no incorporated unsewered communities in the watershed; therefore, it is unlikely that a future WLA would be needed for a new point source discharge. There may be an increase in residential development in the watershed in the future. Any transition from agriculture to residential land use would change the nature and the source of loading, but not the total LA as set forth in the TMDL.

3.4. Pollutant Allocation

Wasteload allocation
There are no permitted point source dischargers of phosphorus in the Briggs Woods Lake watershed. While private on-site septic systems are prevalent, none of them are designed

or permitted to discharge. A portion of existing septic systems are assumed to be failing or directly discharging to tile drains, but these are included as nonpoint sources. Several animal feeding operations are also present, none of which are permitted or regulated by the Clean Water Act. Therefore, there is no wasteload allocation (WLA) included in the TMDL.

Load allocation
Nonpoint sources to Briggs Woods Lake include loads from agricultural land uses, internal recycling in the lake, and natural/background sources in the watershed, including wildlife and atmospheric deposition. Septic systems, which are not regulated or permitted under the Clean Water Act, but occasionally fail or drain directly to tiles, also contribute phosphorus to the lake. It is seldom feasible or economical to achieve large load reductions from natural/background sources. However, changes in agricultural land management, implementation of structural best management practices (BMPs), repair or replacement of failing septic systems, and in-lake restoration techniques can reduce phosphorus loads and improve water quality in Briggs Woods Lake.

Table 3-5 shows a potential load allocation scheme for the Briggs Woods Lake watershed that would meet the overall TMDL phosphorus target. The LA is 7,663 lbs/year, with a maximum daily LA of 84 lbs/day. Individual reductions shown in Table 3-5 are not required, but are provided as an example of how the overall reduction may be accomplished.

Table 3-5. Example load allocation scheme to meet target TP load.

TP Source	Existing Load (lb/year)	LA (lb/year)	Load Reduction (%)
Row Crops	9,385	7,133	34
Grass/Hay	77	77	0
Developed	219	219	0
Golf course	12	12	0
Timber	0.4	0.4	0
Septic systems	103	7	93
Internal Recycling	197	197	0
Atmospheric Deposition	17	17	0
Total	**10,011**	**7,663**	**23.5**

Margin of safety
An explicit10 percent MOS was utilized in the development of this TMDL. The resulting MOS is 852 lbs/yr for the annual average TMDL equation. The daily maximum TMDL equation includes an MOS of 9 lbs/day.

Reasonable Assurance
Under current EPA guidance, when a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurance that nonpoint source control measures will achieve expected load reductions. Because there are no

permitted or regulated point sources contributing phosphorus to Briggs Woods Lake, reasonable assurance is not required in this TMDL.

3.5. TMDL Summary

The following general equation represents the total maximum daily load (TMDL) calculation and its components:

TMDL = LC = Σ WLA + Σ LA + MOS

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

Once the loading capacity, wasteload allocations, load allocations, and margin of safety have all been determined for the Briggs Woods Lake watershed, the general equation above can be expressed for the Briggs Woods Lake algae TMDL.

Expressed as the allowable annual average, which is helpful for water quality assessment and watershed management:

TMDL = LC = Σ WLA (0 lbs-TP/year) + Σ LA (7,663 lbs-TP/year) + MOS (852 lbs-TP/year) = **8,515 lbs-TP/year**

Expressed as the maximum daily load:

TMDL = LC = Σ WLA (0 lbs-TP/day) + Σ LA (84 lbs-TP/day) + MOS (9 lbs-TP/day) = **93 lbs-TP/day**

4. Implementation Plan

This implementation plan is not a requirement of the Federal Clean Water Act. However, the Iowa Department of Natural Resources (IDNR) recognizes that technical guidance and support are critical to achieving the goals outlined in this Water Quality Improvement Plan (WQIP). Therefore, this general implementation plan is included for use by local agencies, watershed managers, and citizens for decision-making support and planning purposes. The best management practices (BMPs) discussed represent a package of potential tools that will help achieve water quality goals if appropriately utilized. It is up to land managers, citizens, and local conservation professionals to determine which practices are most applicable to the Briggs Woods Lake watershed and how best to implement them.

4.1. Previous Watershed Planning and Implementation

IDNR recognizes that public agencies, residents, and landowners in the Briggs Woods Lake watershed have already made much progress towards improving and protecting water quality in the lake. The Hamilton County Soil and Water Conservation District (SWCD) worked with local stakeholders to develop and implement a watershed project, which was completed in 2007. Many of the goals of that project have been attained, and noticeable improvements in the watershed landscape can be observed. It appears as though construction of the diversion berm and culvert structure have significantly reduced nitrate levels in the main body of the lake (measured at the Ambient Lake Monitoring location), as shown in Figure 4-1.

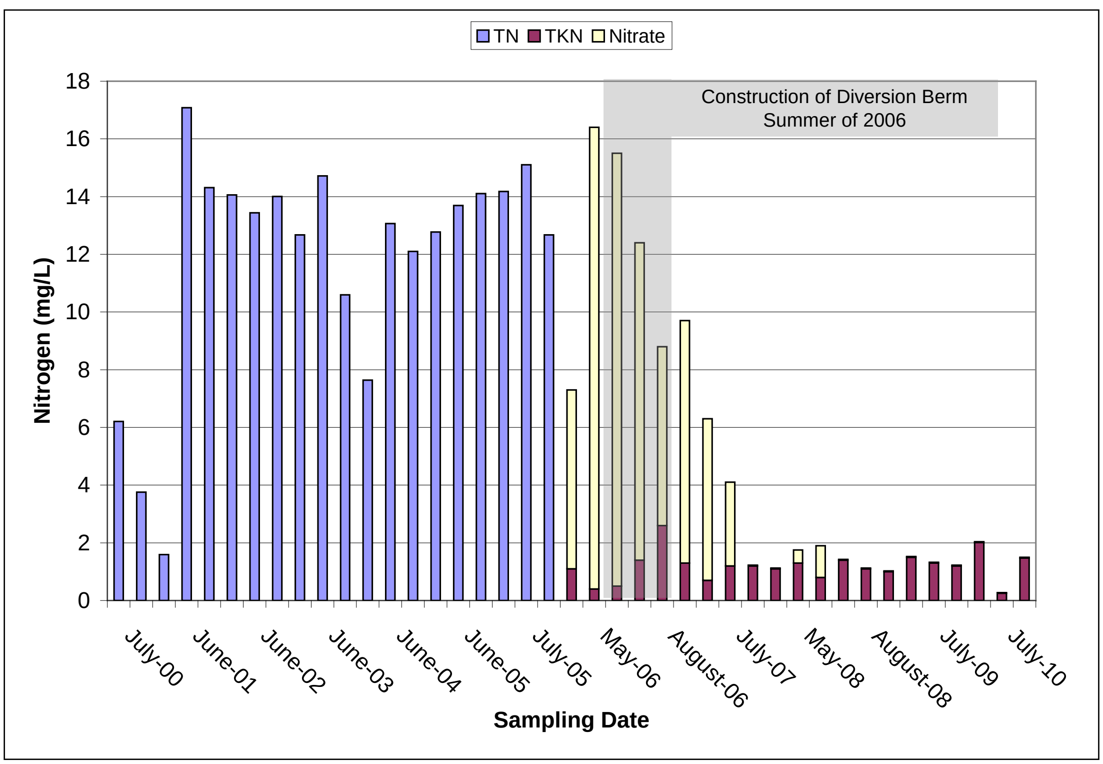


Figure 4-1. Nitrogen in Briggs Woods Lake before and after berm construction.

Figure 4-2 suggests reductions in phosphorus have also occurred. The trend in phosphorus concentration was increasing from 2000 to 2005, but has slightly decreased since implementation of BMPs and completion of the diversion berm in 2006. However, observed reductions in phosphorus are small and not statistically significant. The minimal improvements could be due to year-to-year variations in weather, differing sampling and analytical methods between ISU and SHL, and other factors not related to implementation of BMPs.

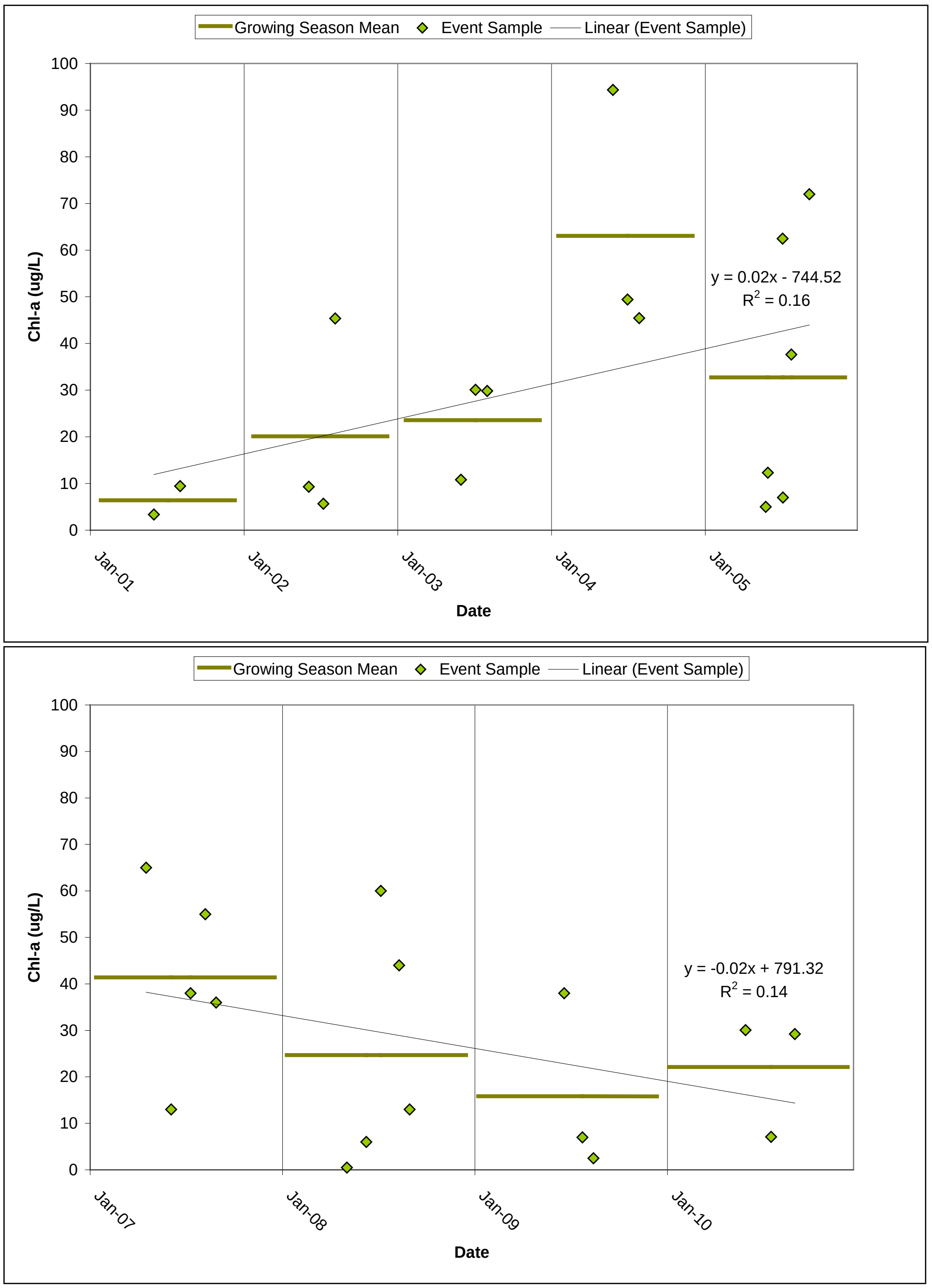


Figure 4-2. Chlorophyll-a before (top) and after (bottom) 2006.

While water quality of Briggs Woods Lake has improved, algal blooms, attributed to high phosphorus levels in the lake, still prevent full support of the lake's primary contact recreation use. If future monitoring shows algal blooms remain a problem, future watershed planning and implementation may be warranted.

The BMPs described in this general implementation plan are not redundant with improvement alternatives previously implemented by the local planning group. Nor do they ignore improvements that have already been achieved. Rather, they are meant to supplement and enhance previous water quality improvement measures. Potential BMPs included in this plan are based in part upon recommendations of SWCD personnel involved in the previous watershed project. These personnel offered many insights to practices and alternatives considered in previous efforts, but have not been implemented to date.

4.2. General Approach & Timeline

Collaboration and action by residents, landowners, lake patrons, and local agencies will be required to further improve water quality in Briggs Woods Lake and support its designated uses. Locally-driven efforts have proven to be the most successful in obtaining real and significant water quality improvements. Improved water quality in Briggs Woods Lake results in economic and recreational benefits for people that live, work, and play in the watershed. Therefore, each group has a stake in promoting awareness and educating others about water quality, working together to adopt a comprehensive watershed improvement plan, and applying additional BMPs and land management changes in the watershed.

General approach
Watershed management and BMP implementation to reduce algae in the lake should utilize a phased approach to improving water quality. Phase I consisted of the previous planning and implementation efforts led by the Hamilton SWCD. Phase II will include the planning and implementation of additional BMPs needed to build upon water quality improvements obtained in Phase I. Phase II should also include water quality monitoring to track progress towards goals and targets established in this TMDL. Future phases of planning and implementation may be necessary if additional phosphorus, or possibly nitrogen reductions, prove necessary to attain water quality standards (WQS).

Timeline
Implementation of a previous watershed management plan was completed in the summer of 2007. Development of the next phase of planning and implementation may take several years, or longer, depending on stakeholder interest, availability of funds, landowner participation, and time needed for design and construction of any structural BMPs. Realization and documentation of significant water quality benefits may take 10 years or longer, depending on weather patterns, amount of water quality data collected, and the successful location, design, construction, and maintenance of BMPs. A monitoring plan, based on the one outlined in Section 5 of this WQIP, should be implemented immediately to establish baseline conditions. Monitoring efforts should

continue throughout implementation of BMPs and beyond. Watershed planners should establish phased goals and milestones, verify achievement of goals with monitoring, and use monitoring data to guide future implementation efforts to continue progress towards WQS attainment.

4.3. Best Management Practices

No stand-alone BMP will be able to sufficiently reduce nutrient loads to Briggs Woods Lake. Rather, a comprehensive package of BMPs will be required to reduce algae levels, which create "aesthetically objectionable conditions" and impair primary contact recreation. The majority of the phosphorus and sediment that enter the lake is from agricultural land uses, specifically land in row crop production. Although small on an annual average basis, internal recycling can be a significant source of phosphorus and drive algal blooms, particularly in dry years. Because the drainage area under non-agricultural land use is very small, non-agricultural pollution sources contribute relatively small amounts of phosphorus to the lake. However, even small sources can have important localized and seasonal affects on water quality. It is also important that all sources are addressed to reduce nutrient loads in the most comprehensive manner possible. Additionally, experience has shown that watershed projects that involve widespread "ownership" of the problem and potential solutions have the best chance of success.

Potential BMPs are grouped into three types: land management, structural, and in-lake alternatives. Tables 4-1 through 4-3 identify potential BMPs in each of these groups. These lists are not all-inclusive, and further investigation may reveal some alternatives are more or less feasible and applicable to site-specific conditions than others. Development of a detailed watershed management plan will be helpful in selecting, locating, and implementing the most effective and comprehensive package of BMPs practicable, and will maximize opportunities for future technical and funding assistance.

Land Management

Many agricultural BMPs are designed to reduce erosion and nutrient loss from the landscape. Because a large portion of TP is attached to sediment, BMPs that reduce erosion and sediment transport will also reduce TP loads. Land management alternatives implemented in row crop areas should include conservation practices such as cross-slope farming, no-till and strip-till farming, diversified crop rotation methods, utilization of in-field and riparian buffers, and planting winter cover crops.

Incorporation of applied manure and fertilizer into the soil by knife injection equipment reduces phosphorus levels, as well as nitrogen and bacteria levels, in runoff from application areas. Strategic timing of manure and fertilizer application and avoiding over-application may have even greater benefits to water quality. Application of manure on frozen ground should be avoided, as should application prior to anticipated heavy rainfall.

Table 4-1. Potential land management BMPs.

BMP or Activity	[1] Potential TP Reduction
Conservation Tillage:	
Moderate vs. Intensive Tillage	50%
No-Till vs. Intensive Tillage	70%
No-Till vs. Moderate Tillage	45%
Cover Crops	50%
Diversified Cropping Systems	50%
In-Field Vegetative Buffers	50%
Pasture/Grassland Management:	
Livestock Exclusion from Streams	75%
Rotational Grazing vs. Constant Intensive Grazing	25%
Seasonal Grazing vs. Constant Intensive Grazing	50%
Phosphorus Nutrient Application Techniques	
[2]Deep Tillage Incorporation vs. Surface Broadcast	-15%
[2]Shallow Tillage Incorporation vs. Surface Broadcast	-10%
Knife/Injection Incorporation vs. Surface Broadcast	35%
Phosphorus Nutrient Application Timing and Rates:	
Spring vs. Fall Application	30%
Soil-Test P Rate vs. Over-Application Rates	40%
Application: 1-month prior to runoff event vs. 1-day	30%
Riparian Buffers	45%

[1]Adopted from USDA-ARS (2004). Actual reduction percentages may vary widely across sites and runoff events.
[2]Note: Tillage incorporation can increase TP in runoff.

Structural BMPs
Although they do not address the underlying generation of sediment or nutrients, structural BMPs such as sediment control basins, terraces, grass waterways, and wetlands creation/restoration can play a valuable role in reduction of sediment and nutrient transport to Briggs Woods Lake. Structural BMPs should be targeted in a similar manner to land management BMPs to increase their cost effectiveness and maximize pollutant reductions. Landowner willingness and the physical features of potential sites must also be considered when targeting structural practices. These practices may offer additional benefits not directly related with water quality improvement. These "secondary" benefits are often important to emphasize in order to increase landowner and public buy-in. Potential structural BMPs are listed in Table 4-2, which includes secondary benefits and potential TP reductions.

Repair and replacement of faulty septic systems may completely eliminate phosphorus from this source, if all failing systems were addressed. The example load allocation in Table 3-5 assumes a reduction of 90 percent because it is likely that there will always be some small portion of poorly functioning septic systems.

Table 4-2. Potential structural BMPs.

BMP or Activity	Secondary Benefits	[1] Potential TP Reduction
Terraces	Soil conservation, prevent in-field gullies, prevent wash-outs	50%
[2]Grass Waterways	Prevent in-field gullies, prevent washouts, some ecological services	Not reported
[2]Sediment Control Structures	Some ecological services, gully prevention	Not reported
[3]Wetlands	Ecological services, potential flood mitigation, aesthetic value	20%

[1]Adopted from USDA-ARS (2004). Actual reduction percentages may vary widely across sites and runoff events.
[2]No reductions reported by USDA-ARS for grass waterways or sediment structures
[3]Note: TP reductions in wetlands vary greatly depending on site-specific conditions. Increasing surface area, implementing multiple wetlands in series, and managing vegetation can increase potential TP reductions.

To obtain reductions in TP load necessary to meet water quality targets, land management strategies and structural BMPs should be implemented in a manner to obtain the largest and/or most cost-effective water quality benefit. Potential targeting efforts should consider areas with the highest potential to contribute phosphorus loads to the lake. Factors affecting phosphorus contribution potential include: steep slopes; proximity to water courses and surface intakes; and method, timing, and amount of manure and commercial fertilizer application.

Figure 4-3 illustrates five subbasins in the Briggs Woods Lake watershed. The Spreadsheet Tool for Estimating Pollutant Load (STEPL) model used in TMDL development is capable of estimating nutrient loads from each individual subbasin. Subwatershed TP and TN loads are illustrated in Figure 4-4, whereas average annual unit loads (lbs/ac) are shown in Figure 4-5. Although the primary pollutant of concern in the algae TMDL is phosphorus, nitrogen loads should also be reduced. Not surprisingly, subbasins with the highest TP contributions also contribute the most TN. Subwatersheds W3 and W4 are the highest contributors of nutrients to Briggs Woods Lake, and as such, warrant special attention in the implementation of BMPs.

Structural BMPs, in particular, should be located near the outlet of these subwatersheds in order to reduce TP transport to the lake in the most cost-efficient manner. TP loads per unit area are more uniform across subwatersheds than total loads, but slightly higher in W3, W4, and W5 than in W1 and W2. Higher per area loads suggest these areas should be given higher priority for both structural and land management alternatives.

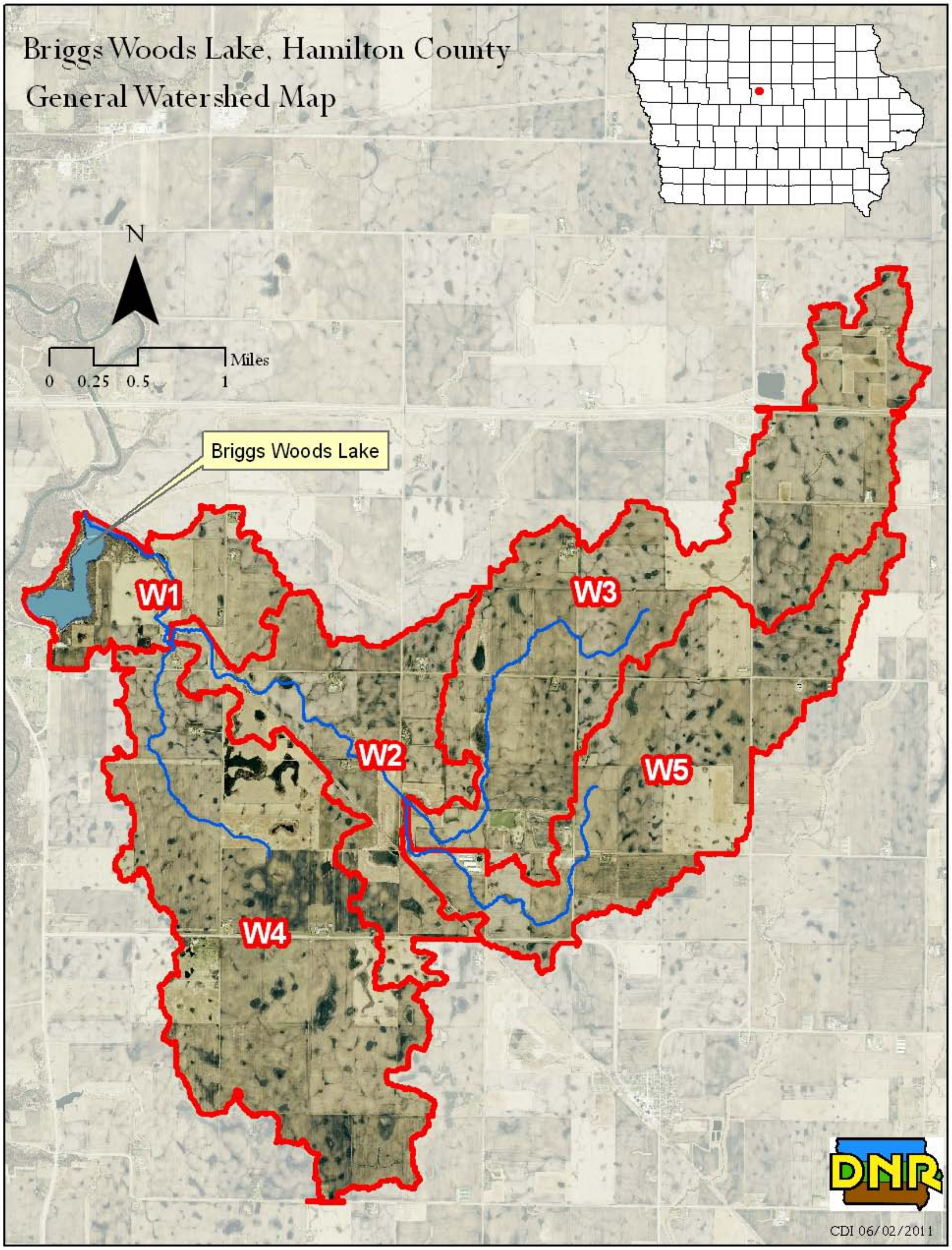


Figure 4-3. Subwatersheds modeled using STEPL.

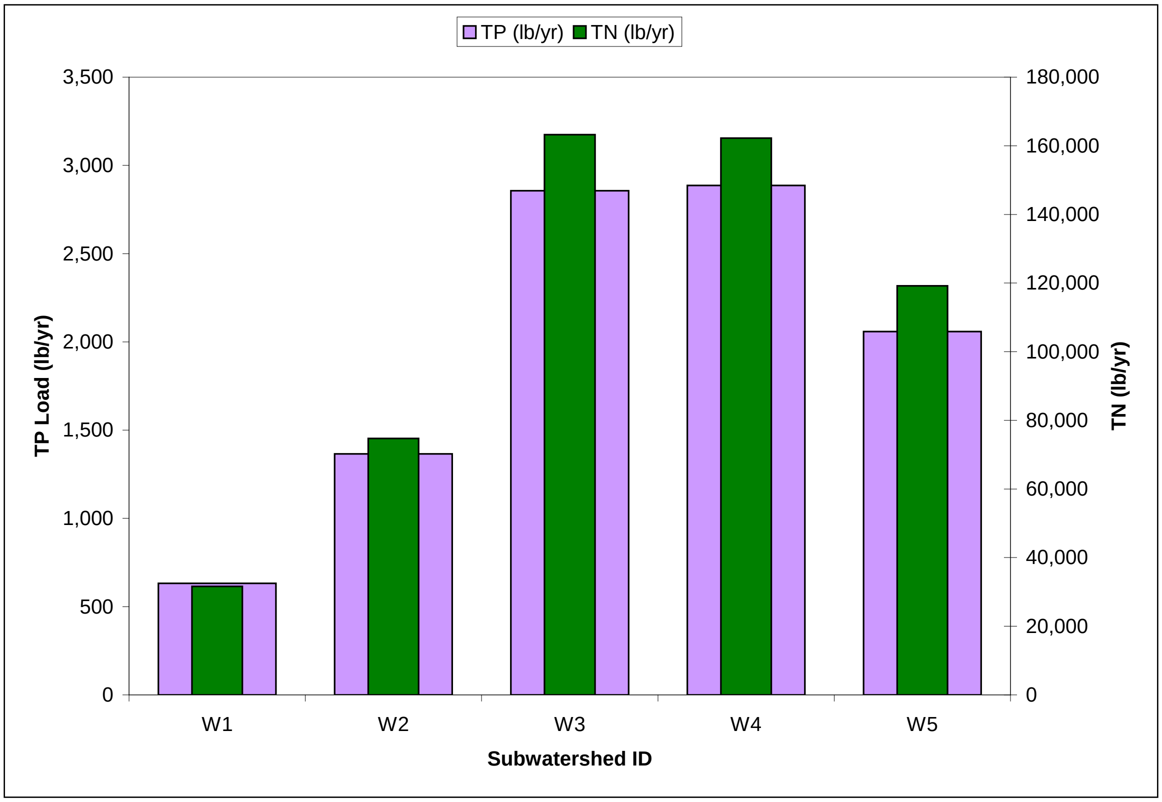


Figure 4-4. Subwatershed TP and TN loads predicted using STEPL.

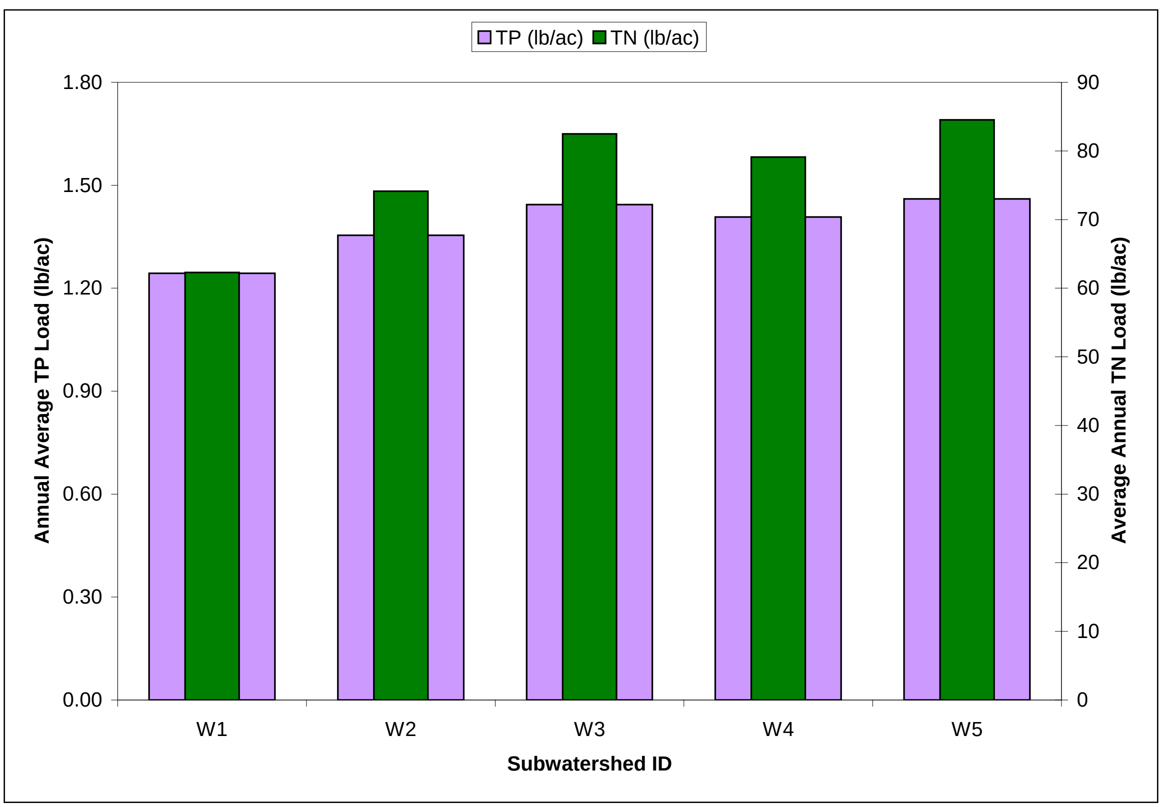


Figure 4-5. Predicted subwatershed annual TP and TN unit loads (lbs/ac).

There are many pothole/depressions in areas of row crop production in the Briggs Woods Lake watershed, as illustrated in Figure 4-6. These potholes lack a regular, well-defined surface flow path to the main surface water drainage course.

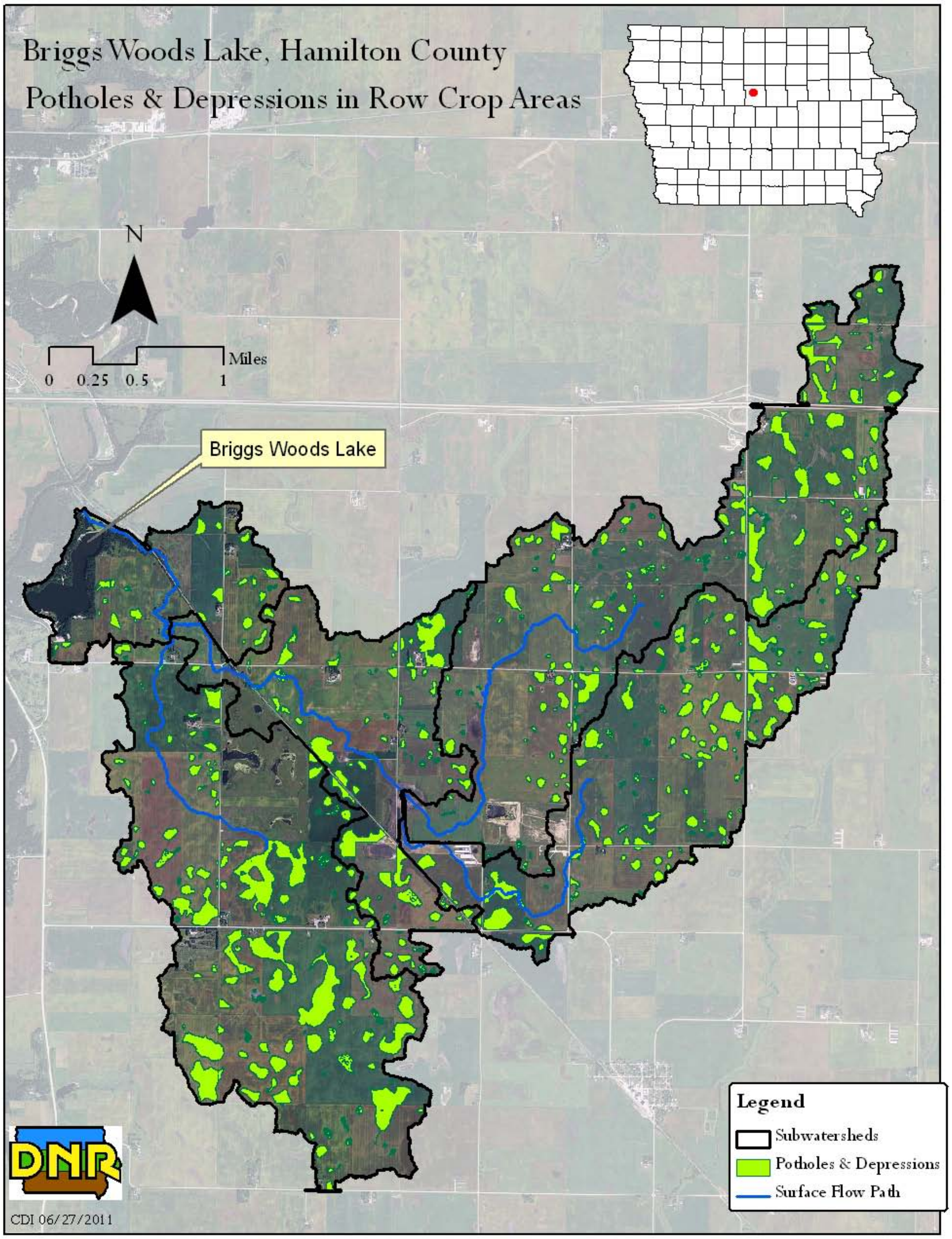


Figure 4-6. Pothole depressions in areas of row crop production.

Precipitation and runoff entering the vast majority of these potholes infiltrates into agricultural tile drains, or enters tile drains via surface water intakes. Tile drains are designed to move the water through the system quickly, thereby allowing the soil to dry so that agricultural productivity is not negatively affected by ponded water and saturated root zones. As a result, tile drains can transport high levels of dissolved nutrients such as orthophosphate and nitrate.

Consideration of the location of potholes in the landscape of the Briggs Woods Lake watershed may be an effective means of targeting BMPs. Potential management practices in and around potholes could include water level management (within the requirements of Iowa drainage laws), careful management of manure and fertilizer application surrounding pothole depressions, restoration of pothole wetlands, and construction of wetlands at the outlet of tile drains systems to reduce nutrient transport to the lake.

Several potential wetland restoration projects were discussed, but not implemented, as part of the previous watershed project. A windshield survey with the previous project coordinator was conducted to identify possible location of future projects. These potential wetland projects would provide tangible benefits to lake hydrology and water quality by intercepting and treating runoff and agricultural tile drainage. Potential project locations are shown in Figure 4-7. Note that these locations are based solely on topography and drainage patterns, and do not consider landowner participation or approval. Other potential locations may be available, depending on stakeholder buy-in.

Shading in Figure 4-7 indicates the amount of treatment each drainage area would receive if all potential wetland projects shown on the map are implemented. Dark blue areas would be treated by 3 wetlands, light blue areas by 2 wetlands, yellow areas by 1 wetland, and red areas would receive no additional treatment resulting from these potential wetland projects. Ideally, drainage would be captured by more than one wetland in series because “treatment train” approaches enhance water quality benefits.

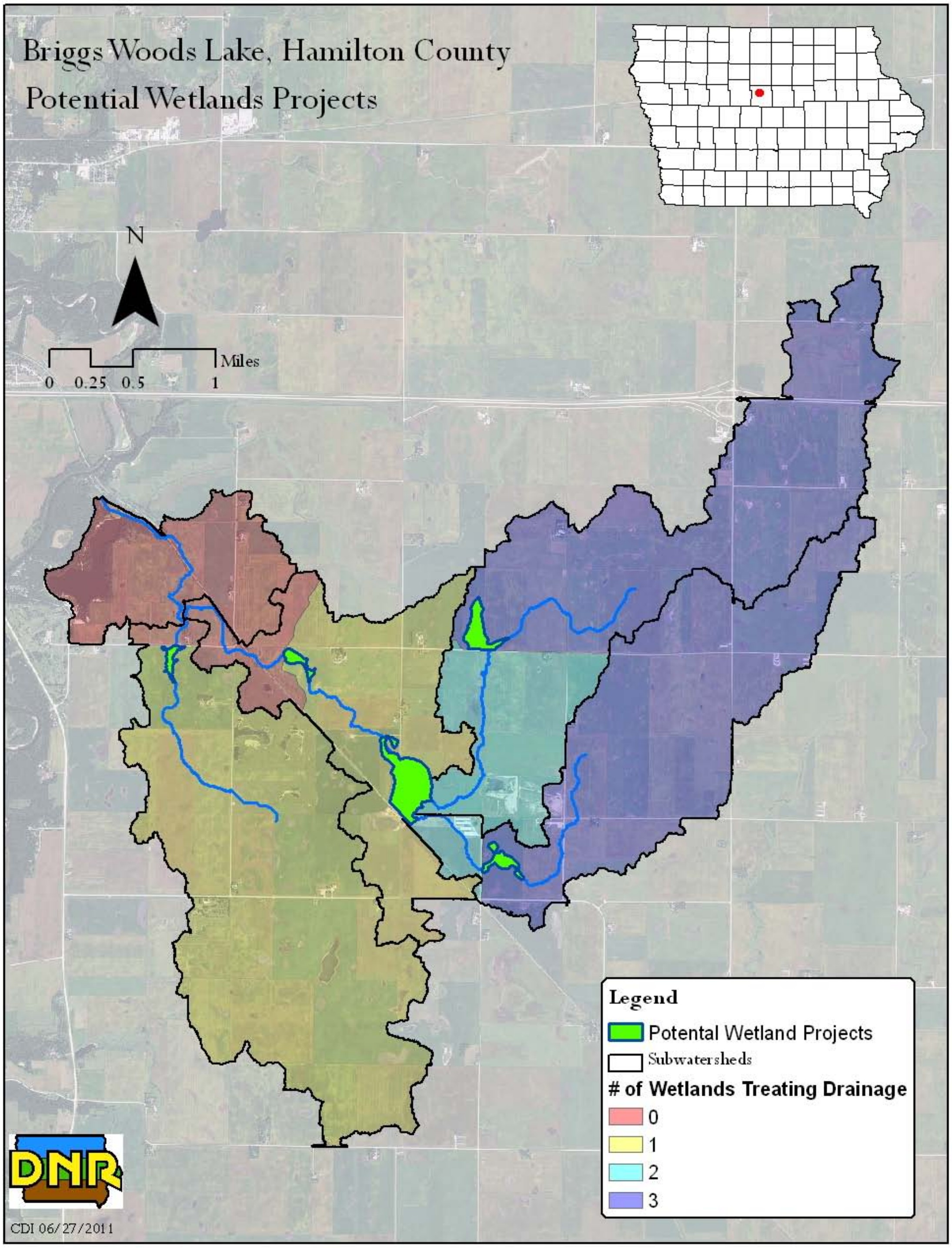


Figure 4-7. Potential wetlands construction/restoration projects.

In-Lake BMPs

Phosphorus recycled between the bottom sediment and water column of the lake may, at times, be an important contributor of bioavailable phosphorus to Briggs Woods Lake. The average annual contribution of TP to the system from internal loading is small relative to the load from the watershed. This is not surprising, given the extremely large watershed to lake ratio of 114:1. However, the influence of internal loading on in-lake water quality may be greater than the average annual contribution would suggest. While much smaller than watershed loads on an annualized basis, internal loads can be the primary driver of eutrophication in dry years with little surface runoff or tile flow to the lake. Additionally, internal loads may exacerbate algal blooms in late summer periods, which are typically dry with low external loads. Phosphorus exported from the watershed to the lake bottom sediments may become readily available through internal loading, which is most likely to happen during prolonged hot, dry periods in late summer. Uncertainty regarding the magnitude of internal loads is one of the biggest challenges to lake restoration. Because of this uncertainty, reductions from watershed sources of TP should be given implementation priority. If monitoring shows that the external watershed load is reduced/controlled, then additional in-lake measures may be warranted.

A brief description of potential in-lake restoration methods are included in Table 4-3, along with relative TP reductions. Actual reduction percentages of each alternative will vary and depend on a number of site-specific factors. It is virtually impossible to determine how much of the internal load is due to each of the contributing factors, and equally difficult to predict TP reductions associated with individual improvement strategies. In-lake measures should be a part of a comprehensive watershed management plan that includes watershed practices in order to enhance, prolong, and protect the effectiveness of in-lake investments.

Table 4-3. Potential in-lake BMPs for water quality improvement.

In-Lake BMPs	Comments	[1]Relative TP Reduction
Fisheries management	Low to moderate reductions in internal TP load may be possible. The existing carp population is thought to be fairly low. Full-scale restoration may not be possible without significant water level drawdown. Although this alternative may provide some benefit, the cost-benefit ratio may be unfavorable due to the depth of the lake and relatively low-density carp population.	Low
Targeted dredging, sediment forebays, and flow re-direction in the shallow inlet area	Targeted dredging in the shallow inlet area would create pockets of deep-water habitat for predatory fish that would help control carp populations. Strategic dredging would also increase the sediment capacity of the inlet, thereby reducing sediment loads to the larger, open water area of the lake. Sediment and nutrient capture in the inlet could be enhanced by constructing submerged berms and/or jetties to create additional sediment forebays and increasing the low-flow residence time of the inlet. Additional sediment forebays could be located and constructed in a manner that would facilitate future sediment removal.	Med-High
In-Lake Dredging	Dredging is seldom cost-effective on a large scale and as a stand-alone measure; disposal of dredged material is often a challenge; dredging should be focused on areas of known sediment deposition or to create deep-water habitat as part of fisheries management.	Med
Shoreline stabilization (public areas)	Helps establish and sustain vegetation, which competes with algae for nutrients. Impacts of individual projects may be small, but cumulative effects of widespread stabilization projects can be significant. The entire shoreline of Briggs Woods Lake is publicly owned, making this alternative possible in all areas of the lake.	Low-Med

[1]Reductions (High/Med/Low) are relative to each other and based on numerous research studies and previous IDNR projects.

5. Future Monitoring

Water quality monitoring is critical for assessing the current status of water resources as well as historical and future trends. Furthermore, monitoring is necessary to track the effectiveness of water quality improvements made in the watershed and document the status of the waterbody in terms of achieving total maximum daily loads (TMDLs) and water quality standards (WQS).

Future monitoring in the Briggs Woods Lake watershed can be agency-led, volunteer-based, or a combination of both. The Iowa Department of Natural Resources (IDNR) Watershed Monitoring and Assessment Section administers a water quality monitoring program, called IOWATER, that provides training to interested volunteers. More information can be found at the program web site: http://www.iowater.net/Default.htm

It is important that volunteer-based monitoring efforts include an approved water quality monitoring plan, called a Quality Assurance Project Plan (QAPP), in accordance with Iowa Administrative Code (IAC) 567-61.10(455B) through 567-61.13(455B). The IAC can be viewed here:
http://search.legis.state.ia.us/NXT/gateway.dll/ar/iac/5670___environmental%20protection%20commission%20__5b567__5d/0610___chapter%2061%20water%20quality%20standards/_c_5670_0610.xml?f=templates$fn=default.htm.

Failure to prepare an approved QAPP will prevent data collected from being used to assess a waterbody's status on the state's 303(d) list – the list that identifies impaired waterbodies.

5.1. Routine Monitoring for Water Quality Assessment

Future data collection in Briggs Woods Lake to assess water quality trends and compliance with water quality standards (WQS) is expected to include monitoring conducted as part of the IDNR Beach Monitoring Program and the IDNR Ambient Lake Monitoring Program. Unless there is local interest in collecting additional water quality data, these monitoring programs will comprise the vast majority of future sampling efforts.

The Beach Monitoring Program consists of routine *E. coli* monitoring at state park beaches and locally managed beaches throughout Iowa. The beaches are sampled at least two times per week from Memorial Day to Labor Day. The reported *E. coli* concentration for a particular sampling event is typically a composite sample average of nine sampling points collected at three approximate depths (ankle, knee, and chest) at three locations (e.g., left, middle, right) along the beach.

The Ambient Lake Monitoring Program was initiated in 2000 in order to better assess the water quality of Iowa lakes. Currently, 132 of Iowa's lakes are being sampled as part of this program, including Briggs Woods Lake. Typically, one location near the deepest part of the lake is sampled, and many chemical, physical, and biological parameters are measured. Sampling parameters are reported in Table 5-1. At least three sampling events are scheduled every summer, typically between Memorial Day and Labor Day.

Table 5-1. Ambient Lake Monitoring Program water quality parameters.

Chemical	Physical	Biological
• Total Phosphorus (TP) • Soluble Reactive Phosphorus (SRP) • Total Nitrogen (TN) • Total Kjeldahl Nitrogen (TKN) • Ammonia • Un-ionized Ammonia • Nitrate + Nitrite Nitrogen • Alkalinity • pH • Silica • Total Organic Carbon • Total Dissolved Solids • Dissolved Organic Carbon	• Secchi Depth • Temperature • Dissolved Oxygen (DO) • Turbidity • Total Suspended Solids (TSS) • Total Fixed Suspended Solids • Total Volatile Suspended Solids • Specific Conductivity • Lake Depth • Thermocline Depth	• Chlorophyll a • Phytoplankton (mass and composition) • Zooplankton (mass and composition)

5.2. Idealized Monitoring for Detailed Assessment and Planning

Data available from the IDNR Beach Monitoring Program and the IDNR Ambient Lake Monitoring Program will be used to assess general water quality trends and WQS attainment. More detailed monitoring data is required to reduce the level of uncertainty associated with water quality trend analysis, better understand the impacts of implemented watershed projects (i.e., BMPs), and guide future water quality modeling and BMP implementation efforts.

Existing resources will not allow more detailed monitoring data to be collected by IDNR. Only through the interest and action of local stakeholders will funding and resources needed to acquire this important information become available. Proposed monitoring locations are illustrated in Figure 5-1. Table 5-2 outlines the idealized monitoring plan by listing the components in order, starting with the highest priority recommendations. While it is unlikely that available funding will allow collection of all recommended data, this idealized plan can be used to help identify and prioritize monitoring data needs.

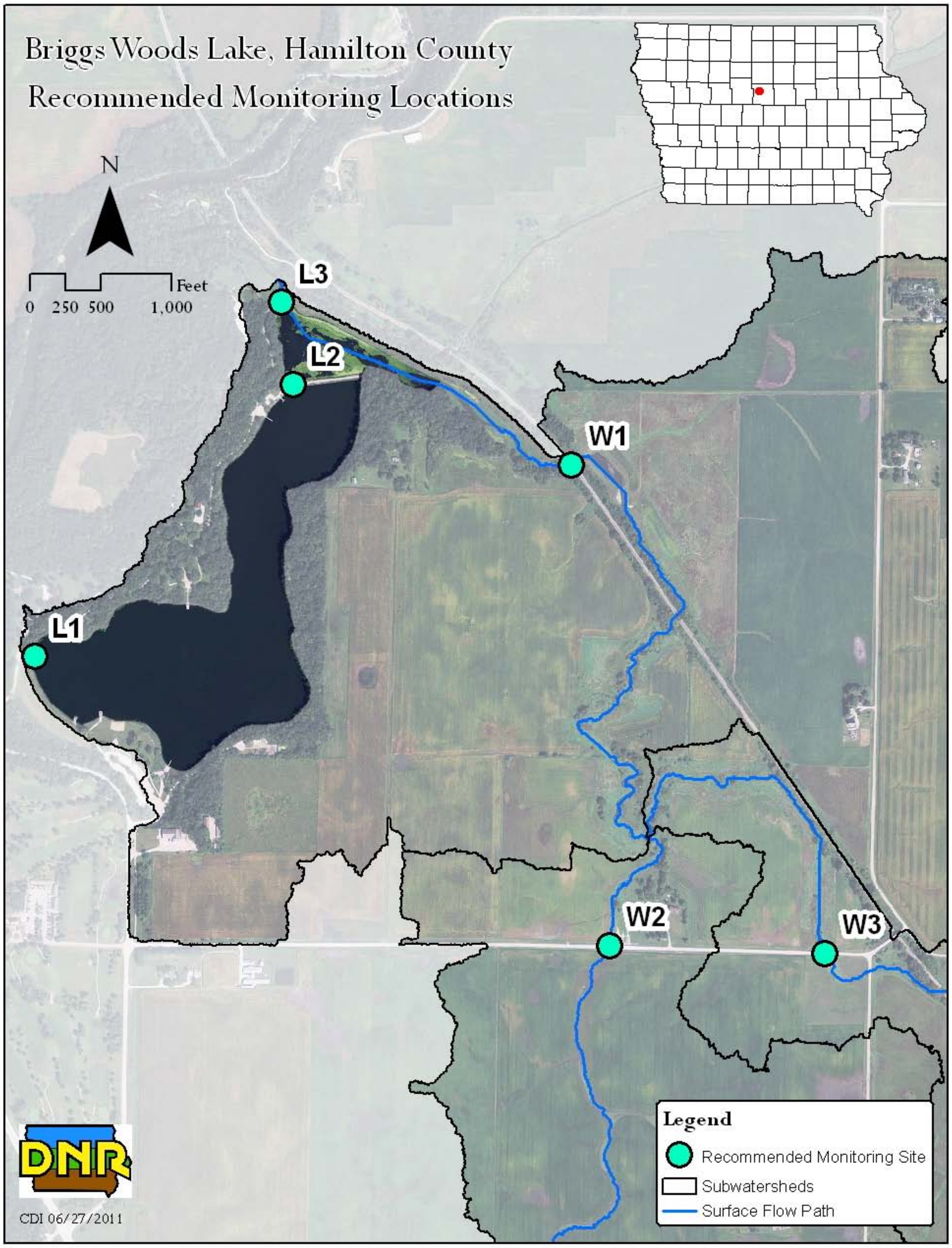


Figure 5-1. Recommended monitoring locations.

Table 5-2. Recommended monitoring plan.

Parameter(s)	Intervals	Duration	[1]Location(s)
Routine grab sampling for flow, sediment, P, and N	Every 1-2 weeks	April through October	L1, L3, W1
Continuous flow	15-60 minute	April through October	L1, L3, W1
Continuous pH, DO, and temperature	15-60 minute	April through October	L1 and L2
Runoff event flow, sediment, P, and N	Continuous flow, composite WQ	5 events between April and October	W1, W2, W3
Event or continuous tile drain flow, N, and P sampling	15-60 minute	10 to 14-day wet weather periods if continuous sampling is not feasible	W2 and W3

[1]Final location of tributary and tile drain site selection should be based BMP placement, landowner permission, and access/installation feasibility.

Routine weekly or bi-weekly grab sampling with concurrent in-lake and tributary data (locations L1, L3, and W1 in Figure 5-1) would help identify long-term trends in water quality and nutrient loading. Data collection should commence before additional BMPs are implemented in the watershed to establish baseline conditions. Selection of tributary sites should consider location of BMPs, location of historical data (for comparative purposes), landowner permission (if applicable), and logistical concerns such as site access and feasibility of equipment installation (if necessary). This data could form the foundation for assessment of general water quality trends; however, more detailed information will be necessary to evaluate loading processes, storm events, and reduce uncertainty. Therefore, routine grab sampling should be viewed only as a starting point for assessing trends in water quality.

Continuous flow data at the inlet (W1) and outlets (L1 and L3) of the lake would improve the predictive ability and accuracy of modeling tools, such as those used to develop the TMDL for Briggs Woods Lake. Reliable long-term flow data is also important because hydrology drives many important processes related to water quality, and a good hydrologic data set will be necessary to evaluate the success of BMPs such as reduced-tillage, sediment control structures, terraces and grass waterways, riparian buffers, and wetlands.

If funding is available, lake managers should consider deploying a data logger at L1 (and possibly L2) to measure pH, temperature, and dissolved oxygen (DO) on a continuous basis. This information will help answer questions about the causes and effects of algal blooms and will provide spatial resolution for evaluation of water quality in different areas of the lake. Routine grab sampling, described previously, should be coordinated with deployment of data loggers.

Because water quality appears to be predominately driven by lands in row crop production, data collection efforts should attempt to answer questions about the relative importance of surface runoff, baseflow (i.e., dry weather flow), and flow from tile drains. Collection of flow, sediment, and nutrient data in tributaries (W1) and at tile outlets (W2 and W3) during multiple periods of dry and wet weather will facilitate assessment of these distinct pollutant pathways. Final selection of tributary and tile drain sites must be based on the need to quantify specific potential pollutant sources, the location of proposed BMPs, land owner permission, and feasibility of equipment installation.

The proposed monitoring information would assist utilization of watershed and water quality models to simulate various scenarios and water quality response to BMP implementation. Monitoring parameters and locations should be continually evaluated. Adjustment of parameters and/or locations should be based on BMP placement, newly discovered or suspected pollution sources, and other dynamic factors. The IDNR Watershed Improvement Section can provide technical support to locally led efforts in collecting further water quality and flow monitoring data in the Briggs Woods Lake watershed.

6. Public Participation

Public involvement is important in the Total Maximum Daily Load (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 Briggs Woods Lake.

6.1. Public Meetings

September 13, 2011
A public meeting to present the results of the TMDL study and discuss next steps for community-based watershed planning was held from 6:00 to 8:00 pm on September 13, 2011, at Hamilton County Conservation Board offices near Webster City, Iowa. Farmers/producers were represented at the meeting, as were several patrons of the lake, especially anglers. The Director of the Hamilton County Conservation Board was present, as were several board members. Dr. Michelle Soupir, of the Agricultural and Biosystems Engineering Department at Iowa State University, attended along with several engineering students. A local media outlet was also present at the meeting.

IDNR staff in attendance included the District Fisheries Biologist (Scott Grummer), and Jeff Berckes and Charles Ikenberry with the Watershed Improvement Section.

6.2. Written Comments

IDNR received no public comments on the Briggs Woods Lake TMDL.

7. References

Bachman, R., T. Hoyman, L. Hatch, B. Hutchins. 1994. A Classification of Iowa's Lakes for Restoration. Iowa Cooperative Fisheries Unit and Department of Animal Ecology. Iowa State University, Ames, Iowa, pp 136-141.

Carlson, R.E. 1992. Expanding the trophic state concept to identify non-nutrient limited lakes and reservoirs. pp. 59-71 [In] Proceedings of a
National Conference on Enhancing the States' Lake Management Programs. Monitoring and Lake Impact Assessment. Chicago.

Carlson, R, and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

Center for Agricultural and Rural Development (CARD). 2008. Iowa State University. Iowa Lakes Valuation Project. Information specific to Briggs Woods Lake available at http://www.card.iastate.edu/lakes/lake_usage.aspx?id=14. Accessed in May, 2011

Dodds, W. 2000. Freshwater Ecology: Concepts and Environmental Applications. Draft textbook. Division of Biology, Kansas State University, Manhattan, Kansas.

Iowa Department of Natural Resources (IDNR). 2008. The Use of the Trophic State Index to Identify Water Quality Impairments in Iowa Lakes for the 2008 Section 305(b) Reporting and Section 303(d) Listing Cycles. Water Monitoring and Assessment Section, Geological and Water Survey Bureau.

Iowa Environmental Mesonet (IEM). 2011a. Iowa State University Department of Agronomy. National Weather Service Cooperative Observer Program (NWS COOP). Download available at http://mesonet.agron.iastate.edu/COOP/. Accessed in March 2011.

Iowa Environmental Mesonet (IEM). 2011b. Iowa State University Department of Agronomy. Iowa Ag Climate Network. Download available at http://mesonet.agron.iastate.edu/agclimate/index.phtml. Accessed in April 2011.

Minnesota Pollution Control Agency (MPCA). 2005. Lake Water Quality Assessment Report: Developing Nutrient Criteria. Third Edition.

Smith, V. 1983. Low nitrogen to phosphorus ratios favors dominance by blue-green algae in lake phytoplankton. Science 221: 669-671.

U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS). 2004. Assessments of Practices to Reduce Nitrogen and Phosphorus Nonpoint Source Pollution of Iowa's Surface Waters. Prepared for the Iowa Department of Natural Resources in Cooperation with the USDA-ARS National Soil Tilth Laboratory. Ames, Iowa.

U.S. Department of Agriculture, Natural Resource Conservation Service (USDA-NRCS). 1986. Soil Survey of Hamilton County, Iowa.

U.S. Environmental Protection Agency (EPA). 1991. Technical Support Document for Water Quality-based Toxics Control. EPA/505/2-90-001. EPA Office of Water, Washington, DC.

U.S. Environmental Protection Agency (EPA). 2006. Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits. Memorandum from Benjamin Grumbles, Assistant Administrator, EPA Office of Water, Washington, DC.

U.S. Environmental Protection Agency (EPA). 2007. Options for Expressing Daily Loads in TMDLs (Draft). EPA Office of Wetlands, Oceans & Watersheds, Washington, DC.

Walker, W., 1996 (Updated 1999). Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. US Army Corps of Engineers Waterways Experiment Station. Instruction Report W-96-2.

8. Appendices

Appendix A --- Glossary of Terms, Abbreviations, and Acronyms

303(d) list:	Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface waterbodies (creeks, rivers, wetlands, and lakes) that do not support their general and/or designated uses. Also called the state's "Impaired Waters List."
305(b) assessment:	Refers to section 305(b) of the Federal Clean Water Act, it is a comprehensive assessment of the state's public waterbodies' ability to support their general and designated uses. Those bodies of water which are found to be not supporting or only partially supporting their uses are placed on the 303(d) list.
319:	Refers to Section 319 of the Federal Clean Water Act, the Nonpoint Source Management Program. Under this amendment, States receive grant money from EPA to provide technical & financial assistance, education, & monitoring to implement local nonpoint source water quality projects.
AFO:	Animal Feeding Operation. A lot, yard, corral, building, or other area in which animals are confined and fed and maintained for 45 days or more in any 12-month period, and all structures used for the storage of manure from animals in the operation. Open feedlots and confinement feeding operations are considered to be separate animal feeding operations.
AU:	Animal Unit. A unit of measure used to compare manure production between animal types or varying sizes of the same animal. For example, one 1,000 pound steer constitutes one AU, while one mature hog weighing 200 pounds constitutes 0.2 AU.
Benthic:	Associated with or located at the bottom (in this context, "bottom" refers to the bottom of streams, lakes, or wetlands). Usually refers to algae or other aquatic organisms that reside at the bottom of a wetland, lake, or stream (see periphyton).
Benthic macroinvertebrates:	Animals larger than 0.5 mm that do not have backbones. These animals live on rocks, logs, sediment, debris and aquatic plants during some period in their life. They include crayfish, mussels, snails, aquatic worms, and the immature forms of aquatic insects such as stonefly and mayfly nymphs.

Base flow: Sustained flow of a stream in the absence of direct runoff. It can include natural and human-induced stream flows. Natural base flow is sustained largely by groundwater discharges.

Biological impairment: A stream segment is classified as biologically impaired if one or more of the following occurs, the FIBI and or BMIBI scores fall below biological reference conditions, a fish kill has occurred on the segment, or the segment has seen a > 50% reduction in mussel species.

Biological reference condition: Biological reference sites represent the least disturbed (i.e. most natural) streams in the ecoregion. The biological data from these sites are used to derive least impacted BMIBI and FIBI scores for each ecoregion. These scores are used to develop Biological Impairment Criteria (BIC) scores for each ecoregion. The BIC is used to determine the impairment status for other stream segments within an ecoregion.

BMIBI: Benthic Macroinvertebrate Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of bottom-dwelling invertebrates.

BMP: Best Management Practice. A general term for any structural or upland soil or water conservation practice. For example terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.

CAFO: Concentrated Animal Feeding Operation. A federal term defined as any animal feeding operation (AFO) with more than 1000 animal units confined on site, or an AFO of any size that discharges pollutants (e.g. manure, wastewater) into any ditch, stream, or other water conveyance system, whether man-made or natural.

CBOD5: 5-day Carbonaceous Biochemical Oxygen Demand. Measures the amount of oxygen used by microorganisms to oxidize hydrocarbons in a sample of water at a temperature of 20°C and over an elapsed period of five days in the dark.

CFU: A Colony Forming Unit is a cell or cluster of cells capable of multiplying to form a colony of cells. Used as a unit of bacteria concentration when a traditional membrane filter method of analysis is used. Though not necessarily equivalent to most probably number (MPN), the two terms are often used interchangeably.

Confinement feeding operation: An animal feeding operation (AFO) in which animals are confined to areas which are totally roofed.

Credible data law: Refers to 455B.193 of the Iowa Administrative Code, which ensures that water quality data used for all purposes of the Federal Clean Water Act are sufficiently up-to-date and accurate. To be considered “credible,” data must be collected and analyzed using methods and protocols outlined in an approved Quality Assurance Project Plan (QAPP).

Cyanobacteria (blue-green algae): Members of the phytoplankton community that are not true algae but are capable of photosynthesis. Some species produce toxic substances that can be harmful to humans and pets.

Designated use(s): Refer to the type of economic, social, or ecological activities that a specific waterbody is intended to support. See Appendix B for a description of all general and designated uses.

DNR (or IDNR): Iowa Department of Natural Resources.

Ecoregion: Areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources based on geology, vegetation, climate, soils, land use, wildlife, and hydrology.

EPA (or USEPA): United States Environmental Protection Agency.

Ephemeral gully erosion: Ephemeral gullies occur where runoff from adjacent slopes forms concentrated flow in drainage ways. Ephemerals are void of vegetation and occur in the same location every year. They are crossable with farm equipment and are often partially filled in by tillage.

FIBI: Fish Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of fish species.

FSA: Farm Service Agency (United States Department of Agriculture). Federal agency responsible for implementing farm policy, commodity, and conservation programs.

General use(s): Refer to narrative water quality criteria that all public waterbodies must meet to satisfy public needs and expectations. See Appendix B for a description of all general and designated uses.

Geometric Mean (GM):	A statistic that is a type of mean or average (different from arithmetic mean or average) that measures central tendency of data. It is often used to summarize highly skewed data or data with extreme values such as wastewater discharges and bacteria concentrations in surface waters. In Iowa's water quality standards and assessment procedures, the geometric mean criterion for *E. coli* is measured using at least five samples collected over a 30-day period.
GIS:	Geographic Information System(s). A collection of map-based data and tools for creating, managing, and analyzing spatial information.
Groundwater:	Subsurface water that occurs beneath the water table in soils and geologic formations that are fully saturated.
Gully erosion:	Soil movement (loss) that occurs in defined upland channels and ravines that are typically too wide and deep to fill in with traditional tillage methods.
HEL:	Highly Erodible Land. Defined by the USDA Natural Resources Conservation Service (NRCS), it is land, which has the potential for long-term annual soil losses to exceed the tolerable amount by eight times for a given agricultural field.
IDALS:	Iowa Department of Agriculture and Land Stewardship
Integrated report:	Refers to a comprehensive document that combines the 305(b) assessment with the 303(d) list, as well as narratives and discussion of overall water quality trends in the state's public waterbodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.
LA:	Load Allocation. The portion of the loading capacity attributed to (1) the existing or future nonpoint sources of pollution and (2) natural background sources. Wherever possible, nonpoint source loads and natural loads should be distinguished. (The total pollutant load is the sum of the wasteload and load allocations.)
LiDAR:	Light Detection and Ranging. Remote sensing technology that uses laser scanning to collect height or elevation data for the earth's surface.

Load: The total amount of pollutants entering a waterbody from one or multiple sources, measured as a rate, as in weight per unit time or per unit area.

Macrophyte: An aquatic plant that is large enough to be seen with the naked eye and grows either in or near water. It can be floating, completely submerged (underwater), or partially submerged.

MOS: Margin of Safety. A required component of the TMDL that accounts for the uncertainty in the response of the water quality of a waterbody to pollutant loads.

MPN: Most Probable Number. Used as a unit of bacteria concentration when a more rapid method of analysis (such as Colisure or Colilert) is utilized. Though not necessarily equivalent to colony forming units (CFU), the two terms are often used interchangeably.

MS4: Municipal Separate Storm Sewer System. A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned and operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act (CWA) that discharges to waters of the United States.

Nonpoint source pollution: Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related either to land or water use including failing septic tanks, improper animal-keeping practices, forestry practices, and urban and rural runoff.

NPDES: National Pollution Discharge Elimination System. The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under Section 307, 402, 318, and 405 of the Clean Water Act. Facilities subjected to NPDES permitting regulations include operations such as municipal wastewater treatment plants and industrial waste treatment facilities, as well as some MS4s.

NRCS: Natural Resources Conservation Service (United States Department of Agriculture). Federal agency that provides technical assistance for the conservation and enhancement of natural resources.

Open feedlot: An unroofed or partially roofed animal feeding operation (AFO) in which no crop, vegetation, or forage growth or residue cover is maintained during the period that animals are confined in the operation.

Periphyton: Algae that are attached to substrates (rocks, sediment, wood, and other living organisms). Are often located at the bottom of a wetland, lake, or stream.

Phytoplankton: Collective term for all photosynthetic organisms suspended in the water column. Includes many types of algae and cyanobacteria.

Point source pollution: Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources are generally regulated by a federal NPDES permit.

Pollutant: As defined in Clean Water Act section 502(6), a pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Pollution: The man-made or man-induced alteration of the chemical, physical, biological, and/or radiological integrity of water.

PPB: Parts per Billion. A measure of concentration that is the same as micrograms per liter (µg/L).

PPM: Parts per Million. A measure of concentration that is the same as milligrams per liter (mg/L).

RASCAL: Rapid Assessment of Stream Conditions Along Length. RASCAL is a global positioning system (GPS) based assessment procedure designed to provide continuous stream and riparian condition data at a watershed scale.

Riparian:	Refers to areas near the banks of natural courses of water. Features of riparian areas include specific physical, chemical, and biological characteristics that differ from upland (dry) sites. Usually refers to the area near a bank of a stream or river.
RUSLE:	Revised Universal Soil Loss Equation. An empirical model for estimating long term, average annual soil losses due to sheet and rill erosion.
Scientific notation:	See explanation on page 107.
Secchi disk:	A device used to measure transparency in waterbodies. The greater the Secchi depth (typically measured in meters), the more transparent the water.
Sediment delivery ratio:	A value, expressed as a percent, which is used to describe the fraction of gross soil erosion that is delivered to the waterbody of concern.
Seston:	All particulate matter (organic and inorganic) suspended in the water column.
SHL:	State Hygienic Laboratory (University of Iowa). Provides physical, biological, and chemical sampling for water quality purposes in support of beach monitoring, ambient monitoring, biological reference monitoring, and impaired water assessments.
Sheet & rill erosion:	Sheet and rill erosion is the detachment and removal of soil from the land surface by raindrop impact, and/or overland runoff. It occurs on slopes with overland flow and where runoff is not concentrated.
Single-Sample Maximum (SSM):	A water quality standard criterion used to quantify *E. coli* levels. The single-sample maximum is the maximum allowable concentration measured at a specific point in time in a waterbody.
SI:	Stressor Identification. A process by which the specific cause(s) of a biological impairment to a waterbody can be determined from cause-and-effect relationships.
Storm flow (or stormwater):	The discharge (flow) from surface runoff generated by a precipitation event. *Stormwater* generally refers to runoff that is routed through some artificial channel or structure, often in urban areas.

STP: Sewage Treatment Plant. General term for a facility that treats municipal sewage prior to discharge to a waterbody according to the conditions of an NPDES permit.

SWCD: Soil and Water Conservation District. Agency that provides local assistance for soil conservation and water quality project implementation, with support from the Iowa Department of Agriculture and Land Stewardship.

TDS: Total Dissolved Solids: The quantitative measure of matter (organic and inorganic material) dissolved, rather than suspended, in the water column. TDS is analyzed in a laboratory and quantifies the material passing through a filter and dried at 180 degrees Celsius.

TMDL: Total Maximum Daily Load. As required by the Federal Clean Water Act, a comprehensive analysis and quantification of the maximum amount of a particular pollutant that a waterbody can tolerate while still meeting its general and designated uses. A TMDL is mathematically defined as the sum of all individual wasteload allocations (WLAs), load allocations (LAs), and a margin of safety (MOS).

Trophic state: The level of ecosystem productivity, typically measured in terms of algal biomass.

TSI (or Carlson's TSI): Trophic State Index. A standardized scoring system developed by Carlson (1977) that places trophic state on an exponential scale of Secchi depth, chlorophyll, and total phosphorus. TSI ranges between 0 and 100, with 10 scale units representing a doubling of algal biomass.

TSS: Total Suspended Solids. The quantitative measure of matter (organic and inorganic material) suspended, rather than dissolved, in the water column. TSS is analyzed in a laboratory and quantifies the material retained by a filter and dried at 103 to 105 degrees Celsius.

Turbidity: A term used to indicate water transparency (or lack thereof). Turbidity is the degree to which light is scattered or absorbed by a fluid. In practical terms, highly turbid waters have a high degree of cloudiness or murkiness caused by suspended particles.

UAA: Use Attainability Analysis. A protocol used to determine which (if any) designated uses apply to a particular waterbody. (See Appendix B for a description of all general and designated uses.)

USDA: United States Department of Agriculture

USGS: United States Geologic Survey (United States Department of the Interior). Federal agency responsible for implementation and maintenance of discharge (flow) gauging stations on the nation's waterbodies.

Watershed: The land area that drains water (usually surface water) to a particular waterbody or outlet.

WLA: Wasteload Allocation. The portion of a receiving waterbody's loading capacity that is allocated to one of its existing or future point sources of pollution (e.g., permitted waste treatment facilities).

WQS: Water Quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the specific criteria by which water quality is gauged in Iowa.

WWTF: Wastewater Treatment Facility. General term for a facility that treats municipal, industrial, or agricultural wastewater for discharge to public waters according to the conditions of the facility's NPDES permit. Used interchangeably with wastewater treatment plant (WWTP).

Zooplankton: Collective term for all animal plankton suspended in the water column which serve as secondary producers in the aquatic food chain and the primary food source for larger aquatic organisms.

Scientific Notation

Scientific notation is the way that scientists easily handle very large numbers or very small numbers. For example, instead of writing 45,000,000,000 we write 4.5E+10. So, how does this work?

We can think of 4.5E+10 as the product of two numbers: 4.5 (the digit term) and E+10 (the exponential term).

Here are some examples of scientific notation.

10,000 = 1E+4	24,327 = 2.4327E+4
1,000 = 1E+3	7,354 = 7.354E+3
100 = 1E+2	482 = 4.82E+2
1/100 = 0.01 = 1E-2	0.053 = 5.3E-2
1/1,000 = 0.001 = 1E-3	0.0078 = 7.8E-3
1/10,000 = 0.0001 = 1E-4	0.00044 = 4.4E-4

As you can see, the exponent is the number of places the decimal point must be shifted to give the number in long form. A **positive** exponent shows that the decimal point is shifted that number of places to the right. A **negative** exponent shows that the decimal point is shifted that number of places to the left.

Appendix B --- General and Designated Uses of Iowa's Waters

Introduction

Iowa's water quality standards (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code) provide the narrative and numerical criteria by which waterbodies are judged when determining the health and quality of our aquatic ecosystems. These standards vary depending on the type of waterbody (lakes vs. rivers) and the assigned uses (general use vs. designated uses) of the waterbody that is being dealt with. This appendix is intended to provide information about how Iowa's waterbodies are classified and what the use designations mean, hopefully providing a better general understanding for the reader.

All public surface waters in the state are protected for certain beneficial uses, such as livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and other incidental uses (e.g. withdrawal for industry and agriculture). However, certain rivers and lakes warrant a greater degree of protection because they provide enhanced recreational, economical, or ecological opportunities. Thus, all public bodies of surface water in Iowa are divided into two main categories: *general* use segments and *designated* use segments. This is an important classification because it means that not all of the criteria in the state's water quality standards apply to all water ways; rather, the criteria which apply depend on the use designation & classification of the waterbody.

General Use Segments

A general use segment waterbody is one that does not maintain perennial (year-round) flow of water or pools of water in most years (i.e. ephemeral or intermittent waterways). In other words, stream channels or basins that consistently dry up year after year would be classified as general use segments. Exceptions are made for years of extreme drought or floods. For the full definition of a general use waterbody, consult section 61.3(1) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

General use waters are protected for the beneficial uses listed above, which are: livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses. The criteria used to ensure protection of these uses are described in section 61.3(2) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Designated Use Segments

Designated use segments are waterbodies that maintain flow throughout the year, or at least hold pools of water that are sufficient to support a viable aquatic community (i.e. perennial waterways). In addition to being protected for the same beneficial uses as the general use segments, these perennial waters are protected for more specific activities such as primary contact recreation, drinking water sources, or cold-water fisheries. There are thirteen different designated use classes (Table B-1) that may apply, and a waterbody may have more than one designated use. For definitions of the use classes and more detailed descriptions, consult section 61.3(1) in the state's published water quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Table B-1. Designated use classes for Iowa waterbodies.

Class prefix	Class	Designated use	Brief comments
A	A1	Primary contact recreation	Supports swimming, water skiing, etc.
	A2	Secondary contact recreation	Limited/incidental contact occurs, such as boating
	A3	Children's contact recreation	Urban/residential waters that are attractive to children
B	B(CW1)	Cold water aquatic life – Type 2	Able to support coldwater fish (e.g. trout) populations
	B(CW2)	Cold water aquatic life – Type 2	Typically unable to support consistent trout populations
	B(WW-1)	Warm water aquatic life – Type 1	Suitable for game and nongame fish populations
	B(WW-2)	Warm water aquatic life – Type 2	Smaller streams where game fish populations are limited by physical conditions & flow
	B(WW-3)	Warm water aquatic life – Type 3	Streams that only hold small perennial pools which extremely limit aquatic life
	B(LW)	Warm water aquatic life – Lakes and Wetlands	Artificial and natural impoundments with "lake-like" conditions
C	C	Drinking water supply	Used for raw potable water
Other	HQ	High quality water	Waters with exceptional water quality
	HQR	High quality resource	Waters with unique or outstanding features
	HH	Human health	Fish are routinely harvested for human consumption

Designated use classes are determined based on a Use Attainability Analysis, or UAA. This is a procedure in which the waterbody is thoroughly scrutinized, using existing knowledge, historical documents, and visual evidence of existing uses, in order to determine what its designated use(s) should be. This can be a challenging endeavor, and as such, conservative judgment is applied to ensure that any potential uses of a waterbody are allowed for. Changes to a waterbody's designated uses may only occur based on a new UAA, which depending on resources and personnel, can be quite time consuming.

It is relevant to note that on March 22, 2006, a revised edition of Iowa's water quality standards became effective which significantly changed the use designations of the state's surface waters. Essentially, the changes that were made consisted of implementing a "top down" approach to use designations, meaning that all waterbodies should receive the highest degree of protection applicable until a UAA could be performed to ensure that a particular waterbody did not warrant elevated protection. For more information about Iowa's water quality standards and UAAs, contact the Iowa DNR's Water Quality Bureau.

Appendix C --- Water Quality Data

The following include a portion of the sampling data from the Iowa State University (ISU) Iowa Lakes Information System and the Iowa Department of Natural Resources and University Hygienic Laboratory (IDNR/SHL) Ambient Lake Monitoring Program.

Table C-1. ISU and SHL water quality sampling data ([1]ambient location).

Date	Secchi (m)	Chl-a (ug/L)	TP (ug/L)	Ortho-P (ug/L)	TN (mg/L)	TKN (mg/L)	NH_3/NH_4 (ug/L)	NO_2/NO_3 (mg/L)
[2]6/4/2001	1.0	3.4	328.3	[4]--	17.1	[4]--	[4]--	19.16
[2]7/9/2001	2.2	[4]--	137.9	[4]--	14.3	[4]--	[4]--	15.26
[2]8/6/2001	1.9	9.4	39.6	[4]--	14.1	[4]--	[4]--	13.93
[2]6/10/2002	2.7	9.3	27.8	1.0	13.4	[4]--	[4]--	16.18
[2]7/15/2002	3.3	5.7	16.5	0.5	14.0	[4]--	[4]--	15.03
[2]8/12/2002	1.5	45.4	52.0	0.5	12.7	[4]--	[4]--	11.16
[2]6/9/2003	3.0	10.8	26.9	1.3	14.7	[4]--	[4]--	13.19
[2]7/14/2003	0.7	30.1	227.9	2.8	10.6	[4]--	[4]--	9.08
[2]8/11/2003	0.6	29.8	114.0	0.5	7.6	[4]--	[4]--	5.68
[2]6/7/2004	1.5	94.3	100.7	1.0	13.1	[4]--	108.1	11.29
[2]7/12/2004	1.0	49.4	76.1	[4]--	12.1	[4]--	27.8	12.13
[2]8/9/2004	0.9	45.4	62.1	0.5	12.8	[4]--	26.1	11.20
[3]6/8/2005	5.3	5.0	50.0	10.0	13.7	0.7	70.0	13.00
[2]6/13/2005	5.9	12.3	23.1	[4]--	14.1	[4]--	153.0	14.06
[2]7/18/2005	2.0	62.5	58.2	[4]--	14.2	[4]--	271.1	13.81
[3]7/19/2005	3.1	7.0	60.0	10.0	15.1	1.1	140.0	14.00
[2]8/8/2005	2.3	37.6	44.4	[4]--	12.7	[4]--	122.2	11.29
[3]9/20/2005	1.4	72.0	80.0	10.0	7.3	1.1	25.0	6.20
[3]5/10/2006	5.2	3.0	40.0	10.0	16.4	0.4	25.0	16.00
[3]6/15/2006	5.8	3.0	50.0	10.0	15.5	0.5	25.0	15.00
[3]7/26/2006	1.2	24.0	50.0	10.0	12.4	1.4	25.0	11.00
[3]8/25/2006	0.6	190.0	80.0	30.0	8.8	2.6	25.0	6.20
[3]4/18/2007	0.7	65.0	60.0	10.0	9.7	1.3	25.0	8.40
[3]6/5/2007	3.0	13.0	40.0	10.0	6.3	0.7	25.0	5.60
[3]7/12/2007	1.9	38.0	50.0	10.0	4.1	1.2	50.0	2.90
[3]8/9/2007	0.9	55.0	70.0	10.0	1.2	1.2	25.0	0.03
[3]8/30/2007	0.8	36.0	120.0	10.0	1.1	1.1	25.0	0.03
[3]5/6/2008	5.3	0.5	120.0	80.0	1.8	1.3	260.0	0.45
[3]6/12/2008	2.6	6.0	140.0	100.0	1.9	0.8	100.0	1.10
[3]7/10/2008	1.0	60.0	110.0	10.0	1.4	1.4	25.0	0.03
[3]8/14/2008	2.3	44.0	80.0	10.0	1.1	1.1	25.0	0.03
[3]9/3/2008	3.1	13.0	80.0	20.0	1.0	1.0	80.0	0.03
[2]6/25/2009	1.6	38.0	74.3	4.5	1.5	1.5	50.0	0.03
[2]7/30/2009	2.9	7.0	34.2	4.5	1.3	1.3	50.0	0.03
[2]8/20/2009	3.5	2.5	28.0	4.5	1.2	1.2	220.0	0.03
[2]6/7/2010	1.0	30	78.8	4.0	2.0	2.01	68	0.03
[2]7/26/2010	2.9	7	43.0	4.0	0.3	0.25	68	0.03
[2]9/9/2010	0.8	29	80.4	4.0	1.5	1.47	68	0.03

[1] Ambient monitoring location = STORET ID 22400004
[2] ISU data
[3] SHL data
[4] Dashes (--) indicate no data was reported

Table C-2. Biomass sampling ([1]ambient location).

Date	Cyanobacteria Wet Mass (mg/L)	Phytoplankton Wet Mass (mg/L)	Zooplankton Dry Mass (mg/L)
[3]4/18/2007	0.0	9.1	165.8
[3]6/5/2007	4.0	11.9	350.8
[3]7/12/2007	3.0	31.1	122.4
[3]8/9/2007	25.0	36.7	367.8
[3]8/30/2007	6.0	13.4	140.6
[3]5/6/2008	0.0	0.2	969.9
[3]6/12/2008	2.0	2.6	155.1
[3]7/10/2008	37.0	36.7	183.4
[3]8/14/2008	3.0	1214.0	100.9
[3]9/3/2008	25.0	25.6	2539.1
[2]6/25/2009	23.7	1811.8	190.0
[2]7/30/2009	42.9	50.4	669.0
[2]8/20/2009	14.2	15.3	210.0
[2]6/7/2010	[4]--	77.74	238.97
[2]7/26/2010	[4]--	10.47	1006.77
[2]9/9/2010	[4]--	48.14	47.34

[1] Ambient monitoring location = STORET ID 22400004
[2] ISU data
[3] SHL data
[4] Dashes (--) indicate no data was reported

Table C-3. Water column profile data from 2005-2008 ([1]ambient location).

Date	Depth (m)	Temp (°C)	pH	Spec Cond (mS/cm)	TDS (g/L)	DO (% Sat)	DO (mg/L)	Turbidity (NTU)
6/8/2005	1	21.41	8.5	0.6	384	124.5	10.97	0.2
	2.1	21.16	8.49	0.602	385	128.1	11.34	0.3
	2.3	19.82	8.43	0.63	400	149.4	13.59	0.3
	3	16.05	8.4	0.695	444	191.5	18.81	4.2
	4	13.33	7.97	0.682	436	133	13.86	5.1
	5	11.68	7.61	0.666	426	61.2	6.6	12.7
	5.9	9.85	7.41	0.643	411	19.4	2.19	12.5
	7	8.95	7.36	0.632	404	14.5	1.62	8.7
	8	8.19	7.32	0.63	403	9.4	1.08	7.6
	9	8.09	7.3	0.631	403	8.2	0.96	7.1
7/19/2005	0	27.89	8.45	0.567	362.88	170.7	13.43	0
	1	27.75	8.47	0.561	359.04	167.6	13.22	0
	2	27.32	8.35	0.569	364.16	160.3	12.73	0.3
	3	22.48	7.25	0.68	435.2	12.8	1.11	5.9
	4	19.31	7.23	0.672	430.08	8.8	0.81	4.7
	5	15.98	7.27	0.668	427.52	5.9	0.58	5
	6	12.67	7.25	0.659	421.76	6	0.64	4.8
	7	10.58	7.21	0.654	418.56	5.9	0.66	5.1
	7.5	9.92	7.14	0.658	421.12	4.8	0.54	5.5
9/20/2005	0	23.21	8.44	0.446	285.44	162.4	13.96	[2]--
	1	22.81	8.47	0.446	285.44	171.4	14.85	[2]--
	2	22.26	8.38	0.463	296.32	151.1	13.24	[2]--
	3	21.96	8.05	0.478	305.92	87.2	7.68	[2]--
	4	21.47	7.45	0.499	319.36	3.1	0.27	[2]--

Table C-3. Water column profile data from 2005-2008 ([1]ambient location).

Date	Depth (m)	Temp (°C)	pH	Spec Cond (mS/cm)	TDS (g/L)	DO (% Sat)	DO (mg/L)	Turbidity (NTU)
9/20/2005	5	17.55	7.03	0.634	405.76	1.5	0.14	[2]--
	6	13.04	6.94	0.664	424.96	1.1	0.12	[2]--
	7	10.87	6.71	0.716	458.24	1.1	0.12	[2]--
	7.9	9.94	6.57	0.783	501.12	1	0.11	[2]--
5/10/2006	0.1	16.37	8.03	0.569	0.4	113	11.04	8.7
	0.9	15.83	8.08	0.57	0.4	111.7	11.04	8.6
	1.8	15.25	8.12	0.58	0.4	113.9	11.46	6.9
	2.5	14.96	8.1	0.584	0.4	118.6	11.95	4.5
	3.3	14.04	8.04	0.608	0.4	120.2	12.35	4.2
	4.2	12.79	7.78	0.649	0.4	125	13.2	4.8
	5	12.12	7.61	0.663	0.4	123.2	13.21	4.9
	5.8	11.71	7.56	0.665	0.4	118.6	12.83	5
	6.8	11.25	7.55	0.662	0.4	117.8	12.88	4.5
	7.4	10.94	7.53	0.656	0.4	116.7	12.85	4.7
	7.9	10.58	7.51	0.647	0.4	113.5	12.61	5999
6/26/2006	0.1	28.99	8.44	0.423	0.3	151.9	11.62	6.3
	0.7	27.64	8.67	0.42	0.3	170.9	13.44	10.2
	1.2	27.23	8.62	0.423	0.3	166.6	13.15	8.8
	1.5	26.99	8.5	0.425	0.3	153	12.17	6.5
	1.6	26.8	8.3	0.428	0.3	126.6	10.11	5.2
	1.7	26.73	8.2	0.433	0.3	116.6	9.3	4.7
	1.8	26.47	7.87	0.453	0.3	93.8	7.53	6.6
	1.9	25.8	7.42	0.518	0.3	44.8	3.68	8.7
	2.4	24.75	7.28	0.556	0.4	20.7	1.72	13.4
	3	22.3	7.18	0.601	0.4	10.4	0.9	13.4
	3.5	20.97	7.15	0.607	0.4	9.6	0.86	11.9
	4	19.77	7.13	0.618	0.4	8.9	0.81	11.1
	4.5	17.87	7.11	0.633	0.4	9.6	0.9	10.7
	5	16.68	7.1	0.633	0.4	10.5	1.02	10.7
	5.5	15.8	7.07	0.634	0.4	11.1	1.09	11.1
	6	14.62	7.06	0.641	0.4	12	1.22	11.9
	6.6	13.23	6.93	0.681	0.4	12.7	1.32	71.1
8/25/2006	0	26.56	8.56	0.337	0.2	164.5	13.2	35.2
	0.4	26.59	8.72	0.337	0.2	176.2	14.13	36.2
	0.8	26.57	8.79	0.337	0.2	177.9	14.29	35.1
	1.1	26.47	8.65	0.346	0.2	153.6	12.34	44.1
	1.2	26.43	8.63	0.346	0.2	141.6	11.41	41.1
	1.3	25.8	8.26	0.367	0.2	112.2	9.15	33.5
	1.5	25.46	8.04	0.375	0.2	85.5	7.04	24.2
	1.7	25.07	7.75	0.383	0.3	39.2	3.23	12.8
	2.1	24.55	7.67	0.392	0.3	21.5	1.79	9.2
	2.6	24.06	7.51	0.405	0.3	6.1	0.52	3.8
	3.1	23.49	7.38	0.439	0.3	4.6	0.4	5.3
	3.6	22.64	7.23	0.496	0.3	4.4	0.38	9.4
	4.2	19.94	7.13	0.58	0.4	4.5	0.41	11.7
	4.7	18.04	7.08	0.589	0.4	4.8	0.46	15.1
	5.2	16.37	7.02	0.598	0.4	5.4	0.53	15.4
	5.7	15.22	6.89	0.613	0.4	6	0.6	17.2
	6.2	14.27	6.86	0.627	0.4	6.2	0.64	15.7

Table C-3. Water column profile data from 2005-2008 (continued).

Date	Depth (m)	Temp (°C)	pH	Spec Cond (mS/cm)	TDS (g/L)	DO (% Sat)	DO (mg/L)	Turbidity (NTU)
8/25/2006	6.7	13.32	6.78	0.658	0.4	6.7	0.7	16.2
	7.2	12.78	6.69	0.679	0.4	6.9	0.73	17.2
	8	11.97	6.52	0.815	0.5	6.6	0.71	5999
4/18/2007	0.1	13.87	8	0.561	0.4	186.8	19.27	35.1
	0.6	13.59	8.03	0.561	0.4	190.1	19.69	30.2
	1.1	13.27	8.06	0.559	0.4	193.3	20.2	26.8
	1.6	12.87	8.08	0.559	0.4	192.7	20.33	23.8
	2.1	11.66	8.1	0.557	0.4	194.8	21.11	25.9
	2.6	9.28	7.98	0.575	0.4	179.3	20.51	37.5
	3.1	8.61	7.92	0.582	0.4	174.3	20.29	34.2
	3.6	7.57	7.89	0.586	0.4	171.3	20.53	32.9
	4.1	6.72	7.84	0.596	0.4	165	20.21	32.1
	4.6	6.05	7.77	0.605	0.4	141.8	17.58	31.2
	5.1	5.54	7.74	0.611	0.4	124.7	15.67	30
	5.6	5.38	7.71	0.614	0.4	109.9	13.86	27.6
	6.1	5.31	7.67	0.619	0.4	104.8	13.24	26.2
	6.6	5.29	7.61	0.622	0.4	92.1	11.73	22.9
	7.1	5.28	7.56	0.622	0.4	84	10.62	20.6
	7.6	5.28	7.55	0.622	0.4	82	10.38	5999
6/5/2007	0	22.47	8.5	0.456	0.3	103.9	8.99	9
	0.4	22.4	8.49	0.456	0.3	103.9	8.99	7.7
	1	22.23	8.47	0.456	0.3	105.1	9.14	7.4
	1.5	22.2	8.47	0.456	0.3	104.8	9.11	5.9
	2	22.03	8.47	0.457	0.3	104.2	9.09	6.6
	2.3	21.97	8.47	0.456	0.3	104.2	9.1	6
	2.6	21.89	8.42	0.457	0.3	99.8	8.75	7
	3	21.56	8.32	0.464	0.3	86.2	7.58	5.2
	3.3	20.96	8.12	0.477	0.3	66.1	5.89	4.3
	3.7	19.54	7.9	0.494	0.3	41.3	3.79	5.1
	4.2	17.45	7.68	0.521	0.3	8.8	0.83	9.7
	4.7	14.48	7.56	0.565	0.4	3.8	0.4	11.3
	5.3	11.33	7.5	0.61	0.4	2.1	0.23	17.3
	5.7	8.89	7.46	0.631	0.4	1.4	0.16	21.7
	6.3	7.72	7.41	0.643	0.4	1.1	0.13	23.4
	6.7	7.07	7.39	0.642	0.4	0.8	0.09	23.3
	7.2	6.69	7.35	0.651	0.4	0.9	0.1	22.5
	7.7	6.58	7.29	0.659	0.4	0.8	0.08	26.5
	7.8	6.56	7.18	0.659	0.4	0.7	0.08	5999
7/12/07	0.5	27.14	8.96	0.356	227.84	149.2	11.9	4.9
	1.1	26.98	8.97	0.355	227.2	150.1	11.95	5.3
	1.5	26.94	8.98	0.355	227.2	151.1	12.04	6.3
	2	26.71	9.03	0.353	225.92	153.9	12.31	15.4
	2.5	26.46	8.81	0.359	229.76	124.7	10.08	10.3
	2.9	26.16	8.55	0.373	238.72	95.5	7.72	7.4
	3.5	21.49	7.87	0.485	310.4	43.5	3.83	6.2
	4	18.63	7.7	0.524	335.36	34.1	3.2	5.9
	4.5	14.7	7.64	0.595	380.8	36.4	3.68	5.9
	5	11.69	7.63	0.635	406.4	40.8	4.4	3.8
	5.5	9.86	7.62	0.655	419.2	41.7	4.79	2.7

Table C-3. Water column profile data from 2005-2008 (continued).

Date	Depth (m)	Temp (°C)	pH	Spec Cond (mS/cm)	TDS (g/L)	DO (% Sat)	DO (mg/L)	Turbidity (NTU)
7/12/07	5.9	8.61	7.54	0.672	430.08	41.5	4.92	2.1
	6.5	7.82	7.42	0.693	443.52	40.6	4.81	2.9
	7	7.44	7.24	0.746	477.44	40.9	4.9	4.4
	7.4	7.24	7.13	0.795	508.8	40.4	4.86	4.8
8/9/2007	0.5	26.73	9.22	0.28	0.2	97.8	7.65	7.9
	0.7	26.63	9.09	0.284	0.2	75.4	6.2	9.4
	0.8	26.63	9.06	0.284	0.2	51	4.1	8.4
	0.9	26.6	9	0.286	0.2	45.4	3.64	8.2
	1.5	26.47	8.89	0.29	0.2	16.9	1.36	6.5
	2	26.38	8.86	0.294	0.2	13.3	1.06	5.1
	2.5	26.09	8.76	0.302	0.2	11.6	0.94	3.8
	3	25.63	8.42	0.322	0.2	10.8	0.89	4.3
	3.5	23.73	7.69	0.383	0.3	10.6	0.9	10.7
	4	19.95	7.3	0.484	0.3	10.9	0.99	11.9
	5	14.02	7.2	0.589	0.4	15.5	1.55	4.2
	6	9.97	7.13	0.651	0.4	23.3	2.63	2.3
	7	8.66	7	0.693	0.4	25.6	2.97	5999
8/30/2007	0.5	25.04	8.48	0.278	0.2	77.6	6.4	24.2
	1	25.04	8.6	0.278	0.2	78.2	6.46	22.3
	1.5	25.01	8.62	0.278	0.2	78.7	6.5	16.4
	2	24.99	8.63	0.278	0.2	82.7	6.82	13.2
	2.3	24.96	8.63	0.278	0.2	82.4	6.8	11.1
	2.6	24.91	8.57	0.28	0.2	71.9	5.94	8.2
	2.9	24.68	8.36	0.284	0.2	34.9	2.9	7.3
	3.2	24.25	8.07	0.289	0.2	2.8	0.24	3.5
	3.5	23.96	7.95	0.293	0.2	1.8	0.15	2.7
	4	22.95	7.82	0.328	0.2	1.7	0.14	3.1
	4.5	20.63	7.35	0.46	0.3	1.4	0.13	7.8
	5	17.21	7.14	0.549	0.4	1.2	0.12	12.9
	5.5	14.18	7.07	0.604	0.4	1	0.1	15.8
	6	12.41	6.97	0.641	0.4	1.1	0.11	19.7
	6.5	11.2	6.9	0.665	0.4	1	0.11	20.1
	7	10.34	6.82	0.681	0.4	0.8	0.09	20.5
	7.5	9.63	6.74	0.701	0.5	1	0.11	21.2
	8	9.33	6.69	0.708	0.5	0.9	0.1	20.6
5/6/2008	0	14.2	7.86	0.408	0.3	74.4	7.62	27.4
	0.5	14.11	7.92	0.407	0.3	75	7.7	24.8
	1.5	13.77	7.98	0.408	0.3	73.1	7.56	11.1
	2.5	13.36	7.98	0.406	0.3	71.3	7.46	10.4
	3.6	12.66	7.98	0.405	0.3	68.2	7.24	11.8
	4.5	11.84	7.98	0.407	0.3	62.8	6.78	17.1
	5.5	10.71	7.96	0.41	0.3	53.1	5.89	19.8
	6.5	9.95	7.92	0.412	0.3	39.8	4.48	22.1
	7.5	8.67	7.86	0.421	0.3	12.6	1.62	25.5
	8.5	8.07	7.78	0.431	0.3	3.3	0.39	30.1
6/12/2008	0	21.62	7.71	0.364	0.2	84.9	7.47	23.9
	0.5	21.59	7.82	0.362	0.2	84.1	7.4	26
	1.5	21.51	7.9	0.362	0.2	85.9	7.58	25.3
	2.5	21.5	7.94	0.364	0.2	87.1	7.68	22.6

Table C-3. Water column profile data from 2005-2008 (continued).

Date	Depth (m)	Temp (°C)	pH	Spec Cond (mS/cm)	TDS (g/L)	DO (% Sat)	DO (mg/L)	Turbidity (NTU)
	3.5	19.8	7.88	0.377	0.2	46.9	4.27	20.7
	4.5	17.33	7.79	0.423	0.3	18.4	1.76	34.4
	5.5	14.84	7.73	0.439	0.3	4.4	0.45	39
	6.5	11.71	7.7	0.458	0.3	2.1	0.23	49.1
	7.5	10.81	7.65	0.468	0.3	1.6	0.17	53.5
	8.5	10.43	7.58	0.472	0.3	1.2	0.13	52.3
	9	10.39	7.54	0.473	0.3	1.1	0.12	50.3
7/10/2008	0	25.05	9.2	0.263	0.2	136.2	11.24	28.6
	0.5	25.11	9.25	0.262	0.2	145	11.94	15.4
	1	25.11	9.27	0.263	0.2	142.9	11.77	12.1
	2	23.72	8.46	0.314	0.2	36.3	3.29	0
	3	22.28	8.05	0.349	0.2	7.6	0.67	0.3
	4	19.88	7.84	0.407	0.3	3.4	0.31	5.3
	5	17.31	7.79	0.471	0.3	3	0.29	13.2
	6	13.24	7.74	0.506	0.3	2.4	0.25	35
	7.1	11.44	7.64	0.539	0.3	2.2	0.24	36.2
	8	10.68	7.54	0.564	0.4	2	0.22	36.6
8/14/2008	0	26.84	9.2	0.243	0.2	140.8	11.24	18.1
	0.5	26.77	9.24	0.243	0.2	139.9	11.18	11.8
	1.5	25.92	9.25	0.243	0.2	124.9	10.14	2.8
	2.5	25.58	9.23	0.243	0.2	115.5	9.44	6.3
	3.5	23.92	8.39	0.335	0.2	4	0.36	2.4
	4.5	18.06	8.07	0.433	0.3	1.9	0.18	34.1
	5.5	14.46	7.88	0.481	0.3	1.4	0.15	30.5
	6.5	12.07	7.69	0.526	0.3	3.4	0.12	36.4
	7.5	10.81	7.5	0.582	0.4	0.9	0.1	45.9
9/3/2008	0	23.74	8.27	0.289	0.2	89.7	7.56	28.1
	0.5	23.75	8.48	0.289	0.2	87.3	7.37	29.7
	1.5	23.75	8.53	0.288	0.2	87.8	7.41	27.4
	2.5	23.73	8.58	0.289	0.2	86.3	7.29	23.6
	3.5	23.62	8.52	0.293	0.2	64.1	5.41	16.6
	4.5	20.51	7.82	0.442	0.3	2.9	0.26	55.5
	5.5	15.38	7.53	0.519	0.3	2.2	0.22	59.1
	6.5	12.31	7.32	0.577	0.4	1.8	0.19	59.6
	7.5	10.93	7.16	0.66	0.4	1.5	0.17	69.6

Note: Water column profile data from 2009 shown in Figure C-1 because readings were taken at extremely small depth intervals, which would result in hundreds of rows in table form.

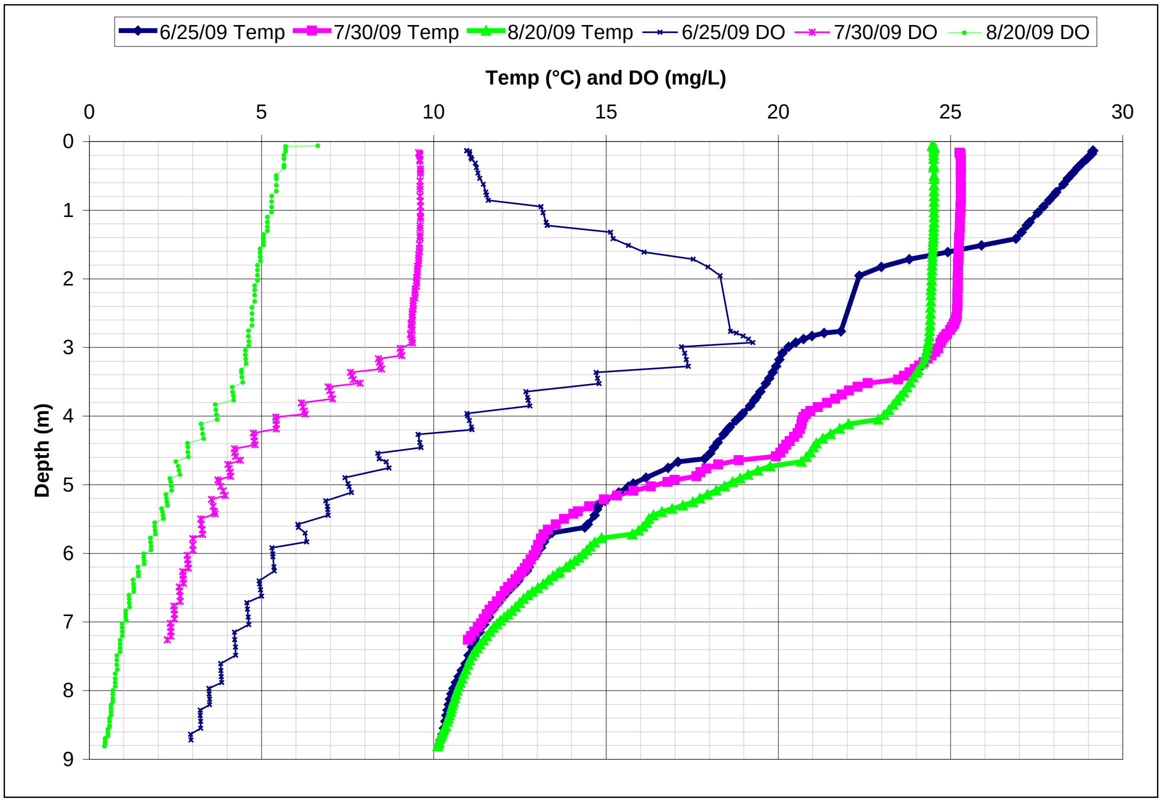


Figure C-1. Temperature and dissolved oxygen (DO) profiles.

Appendix D --- Watershed Model Development

Watershed and in-lake modeling were used in conjunction with observed water quality data to develop the Total Maximum Daily Load (TMDL) for the algae impairment to Briggs Woods Lake in Hamilton County, Iowa. IDNR anticipates that the TMDL for algae will also satisfy the organic enrichment/low dissolved oxygen (DO) impairment. The Spreadsheet Tool for Estimating Pollutant Load (STEPL), version 4.1, was utilized to simulate watershed hydrology and pollutant loading. In-lake water quality simulations were performed using BATHTUB 6.1, an empirical lake and reservoir eutrophication model. The integrated watershed and in-lake modeling approach allows the holistic analysis of hydrology and water quality in Briggs Woods Lake and its watershed. This section of the Water Quality Improvement Plan (WQIP) discusses development of the STEPL watershed model for Briggs Woods Lake. Development of the BATHTUB model is discussed in Appendix E.

D.1. STEPL Model Description

STEPL is a watershed-scale hydrology and water quality model developed for the U.S. Environmental Protection Agency (EPA) by Tetra Tech, Incorporated. STEPL is a long-term average annual model developed to assess the impacts of land use and best management practices on hydrology and pollutant loads. STEPL is capable of simulating a variety of pollutants, including sediment, nutrients (nitrogen and phosphorus), and 5-day biochemical oxygen demand (BOD5). Required input data is minimal if the use of county-wide soils and coarse precipitation information is acceptable to the user. If available, the user can modify soil and precipitation inputs with higher resolution and/or local soil and precipitation data. Precipitation inputs include average annual rainfall amount and rainfall correction factors that describe the intensity (i.e., runoff producing) characteristics of long-term precipitation. Land use characteristics that affect STEPL estimates of hydrology and pollutant loading include land cover types, presence/population of agricultural animals, wildlife populations, population served by septic systems, and characteristics of urban land uses. STEPL also quantifies the impacts of manure application and best management practices (BMPs). Almost all STEPL inputs can be customized if site-specific data is available and more detail is desired.

The Briggs Woods Lake watersheds was delineated into subbasins using ArcGIS (version 9.3) using a 3-meter resolution LiDAR data. The LiDAR-derived digital elevation model (DEM) was hydraulically reinforced to incorporate bridges and culverts using aerial imagery and a watershed site visit. The watershed was divided into five subbasins to help quantify the relative pollutant loads stemming from different areas of the watershed and to assist with targeting potential BMP locations. Hydrology and pollutant loadings are summarized for each subbasin and also aggregated as watershed totals.

D.2. Meteorological Input

Precipitation Data

There are eleven National Weather Service (NWS) COOP stations within 25 miles of the Briggs Woods Lake watershed with daily precipitation data available through the Iowa Environmental Mesonet (IEM). The three nearest stations are Webster City (4 miles northeast of watershed centroid), Jewell (10 miles), and Williams (12 miles). The Thiessen polygon method was employed to develop an area-weighted precipitation data set for the watershed using the closest weather stations. However, application of the Thiessen polygon method resulted in a polygon that included only the Webster City station. Therefore, rainfall data from the NWS COOP station at Webster City was used for modeling purposes.

The STEPL model includes a pre-defined set of weather stations from which the user must choose to obtain precipitation-related model inputs. Unfortunately, none of the NWS COOP stations within a 25-mile buffer of the watershed are included in the STEPL model. The Des Moines Airport and Waterloo Airport stations are the two closest stations included in the pre-defined weather stations. The Des Moines station is approximately 62 miles directly south of the centroid of the Briggs Woods Lake watershed, and the Waterloo station is approximately 70 miles to the east.

The STEPL model for the Briggs Woods Lake watershed utilizes average precipitation data obtained for the Webster City NWS station, even though it is not included in the STEPL model. Average annual precipitation (from 2007 to 2010) was 40.0 inches/year, which is higher than the long-term average. The STEPL precipitation correlation and rain day correction factors were calculated outside of STEPL and entered directly in the STEPL "Input" worksheet to override the available Des Moines or Waterloo airport data. Precipitation inputs are reported in Table D-1, which is copied from the "Input" worksheet of the Briggs Woods Lake STEPL model.

Table D-1. STEPL precipitation inputs.

Rain correction factors			
[1]0.896	[2]0.381		
[3]Annual Rainfall	[4]Rain Days	[5]Avg. Rain/Event	Input Notes/Descriptions
40.0	142.0	0.662	[1]The percent of rainfall that exceeds 5 mm per event
40.0	142.0	0.662	[2]The percent of rain events that generate runoff
40.0	142.0	0.662	[3]Annual average precipitation from 2007-2010 (in)
40.0	142.0	0.662	[4]Average days of precipitation per year (days)
40.0	142.0	0.662	[5]Average precipitation per event (in)

D.3. Watershed Characteristics

Topography
The Briggs Woods Lake watershed boundary was delineated in the ArcSWAT 2.3.4 Interface for SWAT2005 using a 1-meter resolution digital elevation model (DEM) developed by the Iowa Department of Natural Resources (IDNR) using (LiDAR) data. Use of LiDAR data for this purpose requires hydraulic "reinforcement" of the DEM to account for culverts, bridges, and other openings under roadways or other embankments. Preliminary reinforcement was conducted using aerial photography, and was field

verified during a watershed windshield survey conducted in February of 2011. Figure D-1 illustrates the differences between the historically referenced watershed boundary with the delineation developed using LiDAR data and hydraulic reinforcement.

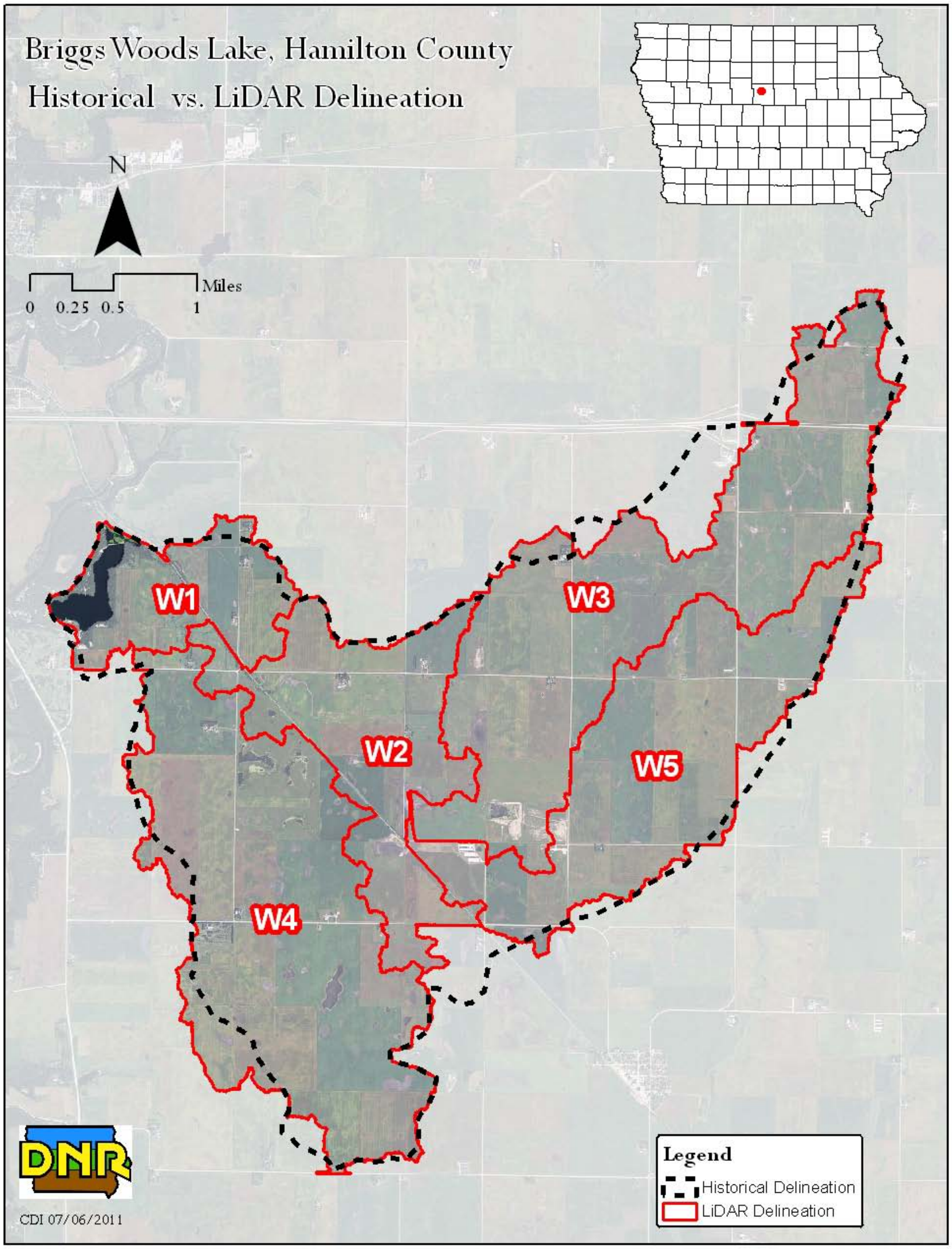


Figure D-1. Historical delineation and LiDAR delineation for STEPL model.

The resulting drainage area of the historical and LiDAR-based boundaries are 7,207.5 and 7,016.9 acres, respectively. The LiDAR-based watershed is 2.6 percent smaller than the previous boundary, a relatively insignificant difference. It should be noted, however, that many areas of this watershed drain to localized and contained depressions, with no observable overland flow to a channel. Thus, the effective drainage area for surface runoff is much smaller than the overall watershed. These depressions impact hydrology and sediment transport by increasing the time of concentration and decreasing sediment delivery ratio. However, the presence of tile drains throughout the watershed minimizes water retention in these depressions, and tile flow often behaves more like surface runoff than shallow groundwater flow. The STEPL model reflects the entire drainage area delineated using LiDAR data. To reflect the large influence of tile drainage, groundwater concentrations were modified from the STEPL defaults. These modifications are discussed under the *Tile Drainage* heading later in this section.

Land Use

A Geographic Information System (GIS) coverage of land use was developed based on high resolution data summarized for the entire Boone River watershed 2005. Land use information contained in this GIS coverage was developed for each common land unit (CLU), as defined in the United States Department of Agriculture – Farm Services Agency (USDA-FSA) Geospatial Data Gateway. Land cover type for each CLU was modified and/or verified by the Center for Agricultural and Rural Development (CARD) at Iowa State University via aerial photography and field visits conducted in 2005. Iowa DNR verified land cover data in this coverage by conducting a windshield survey in February of 2011, when there was no snow covering the land surface and the previous year's crop residue was still visible. Some CLUs were modified by dividing them further to better reflect field boundaries, and in a few isolated cases, correcting land cover based on the windshield survey.

Land use and land cover is described in detail in Section 2.2 of this WQIP. Individual land uses of similar type were aggregated into a more general classification for watershed modeling in STEPL. The STEPL land cover classifications are reported in Table D-2, which was copied from the STEPL "Input" worksheet. The STEPL land use distribution is illustrated in pie-chart form in Figure D-2.

Table D-2. STEPL land use inputs.

1. Input watershed land use area (ac) and precipitation (in)						
Watershed	Urban	Cropland	Pastureland	Forest	[1]User Defined	Feedlots
W1	28.47	329.07	0.00	2.47	147.91	0.00
W2	68.53	783.25	0.00	0.98	155.40	0.00
W3	142.72	1715.15	0.00	0.00	120.75	0.00
W4	68.57	1704.54	28.97	0.00	248.42	0.00
W5	106.74	1253.31	0.00	0.00	50.00	0.00

[1]User-defined includes all ungrazed grassland and hay

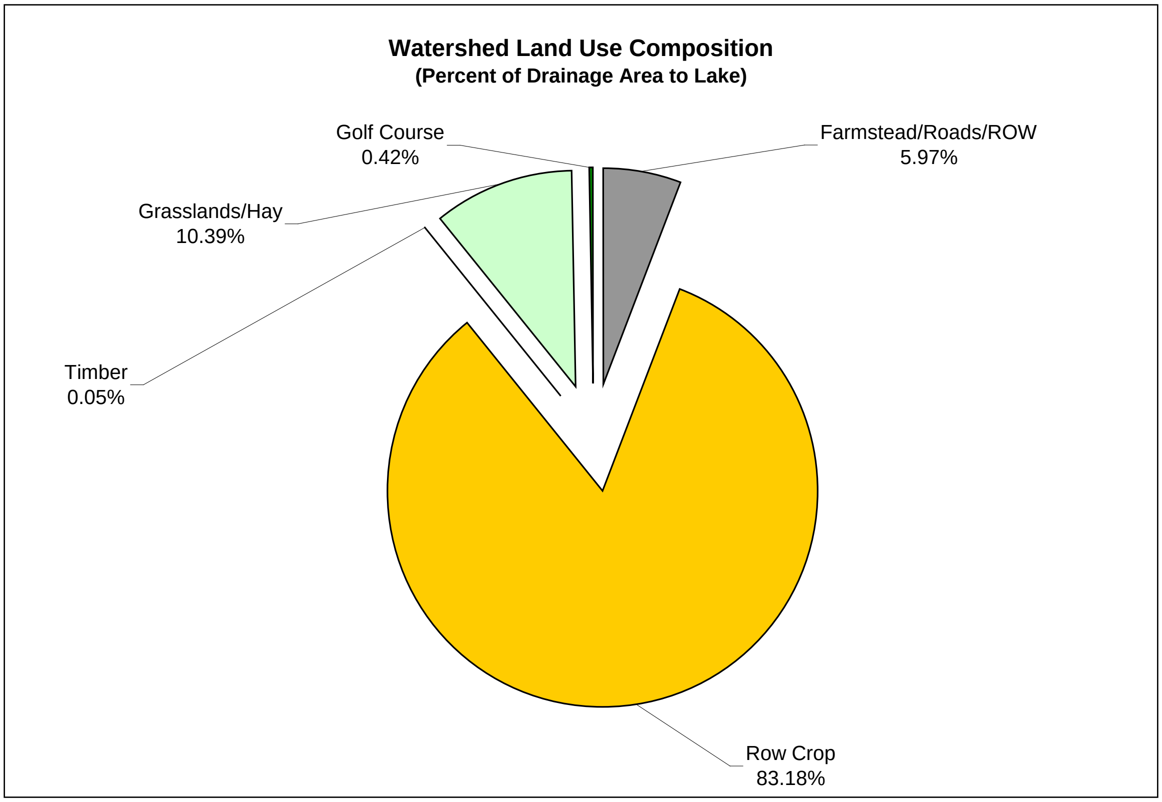


Figure D-2. Relative land cover composition in STEPL watershed model.

Land cover parameters critical for STEPL simulation include the Universal Soil Loss Equation (USLE) C-factor and P-factor for each land cover classification. C-factor and P-factors developed for a previous watershed assessment conducted by IDNR were input for each land use in the STEPL model. All P-factors were left at the default value of 1.0. C-factors vary widely depending on land use, with row crops having a C-factor of 0.155 and ungrazed grasslands having a very low C-factor of 0.001. C- and P-factors for each landuse are entered into the “Input” worksheet in the STEPL model.

Soils

Soils are discussed in detail in Section 2.2 of this WQIP. The hydrologic soil group (HSG) and the USLE K-factor are the critical soil parameters in the STEPL model. Watershed soils are predominantly HSG type B soils. USLE inputs were obtained from a previous RUSLE assessment completed for the Briggs Woods Lake watershed. USLE K-factors vary between 0.234 in Subwatershed W1 to 0.257 in Subwatershed W5. K-factors for each subwatershed are entered into the “Input” worksheet in the STEPL model.

Slopes

Slopes are described in more detail in Section 2.2 of this WQIP. USLE land slope (LS) factors were obtained from a previous RUSLE assessment, and were area-weighted to each STEPL subwatershed. LS-factors vary between 0.365 and 0.890, with Subwatershed W1 being the steepest (LS = 0.890) and Subwatershed W5, an upland watershed, being the flattest (LS = 0.365). LS-factors for each subwatershed are entered into the “Input” worksheet in the STEPL model.

Curve Numbers

The STEPL model includes default curve numbers (CNs) selected automatically based on HSG and land use inputs entered into the model. In Iowa, and particularly in the Des Moines Lobe Ecoregion, watershed modeling professionals across multiple agencies have found that standard NRCS curve numbers result in overestimation of surface runoff and flow (IDNR and ISU, unpublished data). Therefore, the HSG Type B CNs were modified to better reflect conditions on the Des Moines Lobe. Adjusted CNs were entered in the "Input" worksheet of STEPL, and are reported in Table D-3.

Table D-3. STEPL curve numbers (CNs).

Land use	Default CN	Adjusted CN
[1]Urban	89	65
Cropland	78	68
Pastureland	69	60
Forest	60	59
[2]User Defined	70	58

[1]Land use designated as urban in STEPL includes Farmsteads and roads/ROW
[2]User-defined includes all ungrazed grassland and hay

Sediment Delivery Ratio

The total sediment load to the lake is much smaller than total sheet and rill erosion because much of the eroded material is deposited in depressions, ditches, or streams before it reaches the watershed outlet (i.e., the lake). The sediment delivery ratio (SDR) is the portion of sheet and rill erosion that is transported to the watershed outlet. STEPL calculates SDR using a simple empirical formula based on drainage area (i.e., watershed size). This value was adjusted using guidance developed by the United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS) for each ecoregion in Iowa. The NRCS technical guide includes separate relationships between area and SDR for each ecoregion, and results in an SDR of 0.045, or 4.5 percent, for the Briggs Woods Lake watershed.

Tile Drainage

Like most land in agricultural production in the Des Moines Lobe ecoregion, Briggs Woods Lake watershed is heavily tile drained. To account for higher dissolved nutrient concentrations frequently observed in tile drainage, the STEPL default nutrient concentrations for shallow groundwater were increased, based on tile drain sampling data collected in the Briggs Woods Lake watershed and analyzed by the United States Department of Agriculture (USDA) National Laboratory for Agriculture and the Environment (previously known as the Soil Tilth Lab). The nitrogen concentration was increased to 27.2 mg/L, and the phosphorus concentration increased to 0.22 mg/L, the area-weighted mean values for two tile drains sampled regularly between 2001 and 2002. The adjustments were made in the "Input" worksheet of the Briggs Woods Lake STEPL model.

D.4. Animals

Agricultural Animals and Manure Application
The STEPL model utilizes livestock population data and the amount of time (in months) that manure is applied to account for nutrient loading from livestock manure sources. Over 8,900 hogs are raised in or near the watershed, resulting in application of the manure produced at these facilities. There are no significant beef, dairy, or poultry operations. The number of hogs in each subwatershed are entered into the "Input" worksheet of the STEPL model, and manure application is assumed to occur in 3 months of the year. STEPL utilizes these inputs to estimate nutrient concentrations in runoff, as reported in the "Animal" worksheet of the STEPL model.

Livestock Grazing
There are no significant livestock grazing operations in the Briggs Woods Lake watershed.

Open Feedlots
There are no open feedlots in the Briggs Woods Lake watershed in the IDNR Animal Feeding Operations Database. Feedlot operators are not required to report open feedlot information to IDNR for feedlots with less than 500 animal units (AUs). No active open feedlot operations were observed during the February 2011 windshield survey.

Wildlife
The estimated deer density in Hamilton County, based on road kill rates, is approximately two deer per square mile (Willie Suchy, IDNR, June 30, 2011, personal communication). In forested areas, deer density could be as high as ten deer per square mile. There is very little forested area in the Briggs Woods watershed, but a conservative estimate of 10 deer per square mile of watershed was entered into the "Animals" worksheet of the STEPL model to conservatively account for other wildlife (e.g., raccoons and other furbearers, upland birds, etc.) for which data is lacking.

Pollutant contributions from waterfowl included nutrients and bacteria contained in feces deposited in and near the lake by Canada geese. Estimates of goose populations at Briggs Woods Lake were provided by IDNR waterfowl biologists (Guy Zenner, IDNR, April 19, 2009, personal communication). Estimates consider the changes in the goose population throughout the year due to migratory patterns, nesting season, and number of resident geese. Calculations also consider the amount of time geese spend on land versus in the lake. On an annual average basis, there are 69 geese residing at the lake. This estimated population was entered on a "per square mile" basis of 7 geese per square mile in the "Animals" worksheet of the STEPL model.

STEPL uses animal population data to adjust the nutrient concentration in runoff. The relatively low wildlife populations in the Briggs Woods watershed were not enough to affect nutrient inputs in STEPL, and are considered insignificant (in terms of nutrient loading to the lake).

D.5. Septic Systems

Septic Systems
A GIS coverage of rural residences with private onsite wastewater treatment systems (e.g., septic systems) was developed using aerial images and anecdotal data from various state, county, and local agencies. This procedure resulted in the identification of 30 septic systems in this sparsely populated watershed. It is estimated that 10 percent of these systems are not functioning adequately (i.e., are ponding or leaching), but that 50 percent of them drain directly to agricultural tile drains and subsequently, to streams. This is a fairly common occurrence in some rural parts of the state. This information is included in the “Inputs” worksheet of the STEPL model for Briggs Woods Lake.

Appendix E --- Water Quality Model Development

A combination of modeling software packages were used to develop the Total Maximum Daily Load (TMDL) for Briggs Woods Lake. Watershed hydrology and pollutant loading was simulated using the Spreadsheet Tool for Estimating Pollutant Load (STEPL), version 4.1. STEPL model development was described in detail in Appendix D of this Water Quality Improvement Plan (WQIP).

In-lake water quality simulations were performed using BATHTUB 6.1, an empirical lake and reservoir eutrophication model. This appendix of the WQIP discusses development of the BATHTUB model. The integrated watershed and in-lake modeling approach allows the holistic analysis of hydrology and water quality in Briggs Woods Lake and its watershed.

E.1. Lake Hydrology

As described in Section 2.1 of this WQIP, water movement through Briggs Woods Lake is complex. Flow from the watershed enters a shallow inlet area of the lake in the northeast corner. Inflow is “split” in two directions in the inlet area, with high flows bypassing the lake over 40-ft wide ogee spillway that flows to the Boone River (Figure 2-5). Lower, more typical flows exit the inlet area and enter the main body of the lake through a culvert/weir structure located in a diversion berm across the north end of the lake (Figure 2-6). Once flow enters the main body of the lake, water moves through the lake and exits through a concrete riser structure with two small weir openings (Figure 2-4). The flow paths are illustrated on an aerial image of the lake in Figure 2-7.

The water movement resulting from multiple outlets and the diversion berm prevents a significant amount of flow and pollutant load from entering the lake on an annual average basis. The water quality model must account for this, otherwise pollutant loads will be dramatically over-estimated. Rating curves were developed for each outlet structure as well as the culvert/weir structure in the diversion berm. The rating curves are based on the design geometry of each structure, which was obtained from IDNR and Hamilton County Conservation records. The rating curves were used to estimate the amount of flow, on a “per acre basis,” that bypasses and enters the lake at various water levels.

Stream flow for the Boone River was obtained from a USGS gage (Station 05481000, Boone River near Webster City). Stream flows were also normalized per acre, so that stream records could be used in conjunction with the rating curves previously described to estimate the amount of flow that enters the lake (and is bypassed directly to the Boone River) from the inlet area.

The rating curve in Table E-1 shows the percent of flow that enters the lake, as well as the percent that bypasses through the ogee spillway, at various total flows (cfs/acre). These data were used to construct an equation that was used in conjunction with per acre flow data from the USGS gage to estimate the total percent of flow that entered the main body of the lake during the simulation period (2007-2010). This predictive equation is included in Table E-1, and reveals that less than half (47.6 percent) of the total flow to the inlet area enters the main body of the lake. This information was used to control the inflow and outflow predictions in two BATHTUB models – one for the inlet area and one for the main body of Briggs Woods Lake.

Table E-1. Rating curve for flows into main body of lake.

Total Flow (cfs/acre)	Lake Inflow (%)	Bypass Flow (%)
0.000	--	--
0.001	100.0	0.0
0.027	13.3	86.7
0.077	12.1	87.9
0.147	11.2	88.8
0.231	9.6	90.4
0.324	8.2	91.8
0.493	6.2	93.8
0.921	3.7	96.3
1.551	2.4	97.6
2.367	1.7	98.3
Resulting equation: Lake Inflow = 3.6131 x (Total Flow)$^{-0.4636}$		

E.2. BATHTUB Model Description

BATHTUB is a steady-state water quality model developed by the U.S. Army Corps of Engineers that performs empirical eutrophication simulations in lakes and reservoirs (Walker, 1999). Eutrophication-related parameters are expressed in terms of total phosphorus (TP), total nitrogen (TN), chlorophyll a (chl-a), and transparency. The model can distinguish between organic and inorganic forms of phosphorus and nitrogen, and simulates hypolimnetic oxygen depletion rates, if applicable/desired. Water quality predictions are based on empirical models that have been calibrated and tested for lake and reservoir applications (Walker, 1985). Control pathways for nutrient levels and water quality response are illustrated in Figure E-1.

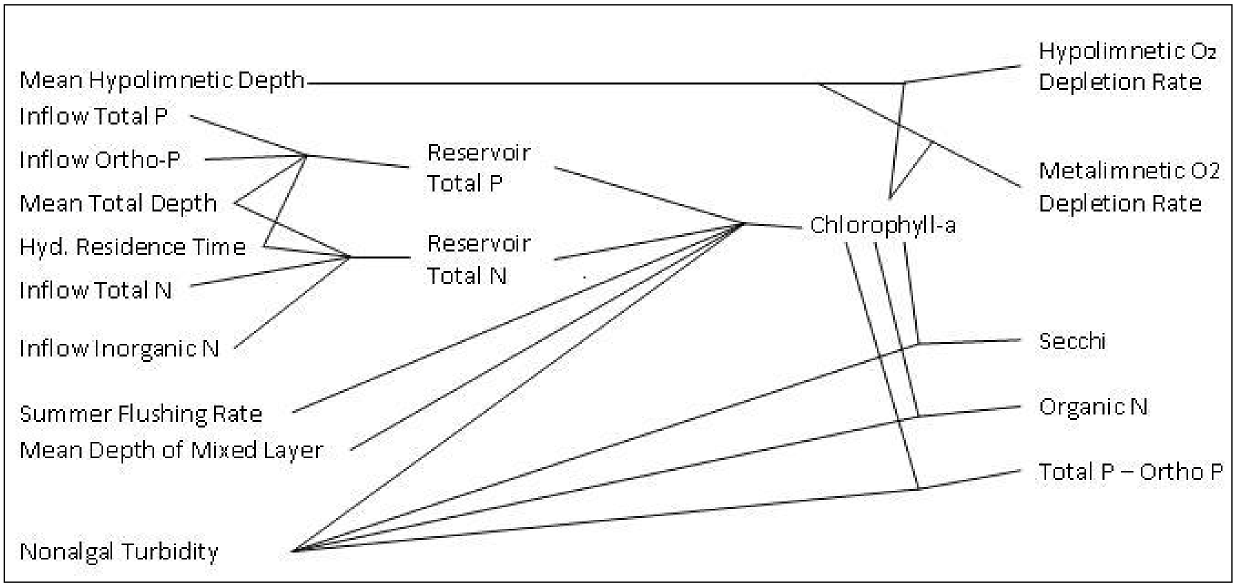


Figure E-1. Eutrophication control pathways in BATHTUB (Walker, 1999).

E.3. Model Parameterization

BATHTUB includes several data input menus/modules to describe lake characteristics, simulation equations, and external (i.e., watershed) inputs. Data menus utilized to develop the BATHTUB model for Briggs Woods Lake include: model selections, global variables, segment data, and tributary data. The model selections menu allows the user to specify which modeling equations (i.e., empirical relationships) are to be used in the simulation of in-lake nitrogen, phosphorus, chlorophyll-a, transparency, and other parameters. The global variables menu describes parameters consistent throughout the lake such as precipitation, evaporation, and atmospheric deposition. The segment data menu is used to describe lake morphometry, observed water quality, calibration factors, and internal loads in each segment of the lake/reservoir. The tributary data menu specifies nutrient loads to each segment using mean flow and concentration in the averaging period. The following sub-sections describe the development of the Briggs Woods Lake BATHTUB model and report input parameters for each menu.

Model Selections
BATHTUB includes several models/empirical relationships for simulating in-lake nutrients and eutrophication response. For TP, TN, chlorophyll-a, and transparency, Models 1 and 2 are the most general formulations, based upon model testing results (Walker, 1999). Alternative models are provided in BATHTUB to allow the user to evaluate other common eutrophication models, evaluate sensitivity of each model, and allow water quality simulation in light of potential data constraints.

Table E-2 reports the models selected for each parameter used to simulate eutrophication response in Briggs Woods Lake. Preference was given to Models 1 and 2 during evaluation of model performance and calibration of the Briggs Woods Lake model. Final selection of model type was based on applicability to lake characteristics, availability of data, and agreement between predicted and observed data. Model performance is discussed in more detail in Appendix F.

Table E-2. Model selections for Briggs Woods Lake.

Parameter	Model No.	Model Description
Total Phosphorus	01	2nd order*
Total Nitrogen	01	2nd order
Chlorophyll-a	02	P, Light, T *
Transparency	01	vs. Chl-a & Turbidity *
Longitudinal Dispersion	01	Fischer-Numeric *
Phosphorus Calibration	01	Decay rates *
Nitrogen Calibration	01	Decay rates *
Availability Factors	00	Ignore *

* Asterisks indicate BATHTUB defaults

Global Variables

Global variables are independent of watershed hydrology or lake morphometry, but affect the water balance and nutrient cycling of the lake. The first global input is the averaging period. Both seasonal and annual averaging periods are appropriate, depending on site-specific conditions. An annual averaging period was utilized to quantify existing loads and in-lake water quality, and to develop TMDL targets for Briggs Woods Lake.

Precipitation was obtained for the simulation period (2007-2010) from the Webster City NWS COOP station (IEM, 2011a). Potential evapotranspiration data for the same period was obtained from the Gilbert weather station via the ISU Ag Climate database (IEM, 2011b). Net change in reservoir storage was assumed to be zero. These data were summarized and converted to BATHTUB units (meters) and entered in the global data menu. Atmospheric deposition rates were obtained from a regional study (Anderson and Downing, 2006). Nutrient deposition rates are assumed constant from year to year. Global input data for Briggs Woods Lake is reported in Table E-3.

Table E-3. Global variables data for Briggs Woods Lake BATHTUB model.

Parameter	Observed Data	BATHTUB Input
Averaging Period	Annual	1.0 year
[1]Precipitation	40 in	1.016 m
[2]Evaporation	44 in	1.118 m
[3]Increase in Storage	0	0
[4]Atmospheric Loads:		
TP	0.3 kg/ha-yr	30 mg/m^2-yr
TN	7.7 kg/ha-yr	770.3 mg/m^2-yr

[1]Annual average for 2007-2010, NWS COOP station for Webster City, IA.
[2] Annual average for 2007-2010, ISU AgClimate data for Gilbert, IA.
[3]Change in lake volume from beginning to end of simulation period.
[4]From Anderson and Downing, 2006.

Segment Data

Lake morphometry, observed water quality, calibration factors, and internal loads are all included in the segment data menu of the BATHTUB model. Separate inputs can be made for each segment of the lake or reservoir system that the user wishes to simulate. In lakes with simple morphometry and one primary tributary, simulation of the entire lake as one segment is often acceptable. This configuration is described as a "single reservoir, spatially averaged" in the BATHTUB user guidance. Assessment and calibration of model performance for Briggs Woods utilizes two models: one single-segment model for the small inlet area on the north end of the lake, and a three-segment model for the main body of the lake.

The single reservoir, spatially averaged inlet model simulates the inlet wetland area created by construction of a diversion berm and culvert structure across the north end of the lake in 2006. Flows and loads into the inlet model are taken from STEPL output. The main body of the lake was divided into three segments to allow higher resolution and distinction of varying lake depth and to better simulate the advective transport of nutrients through the elongated lake. Segment 3 includes the ambient lake monitoring location (STORET ID 22400004). Both model configurations are illustrated in Figure E-2. Morphometric data for each segment of both models is listed in Tables E-4 and E-5.

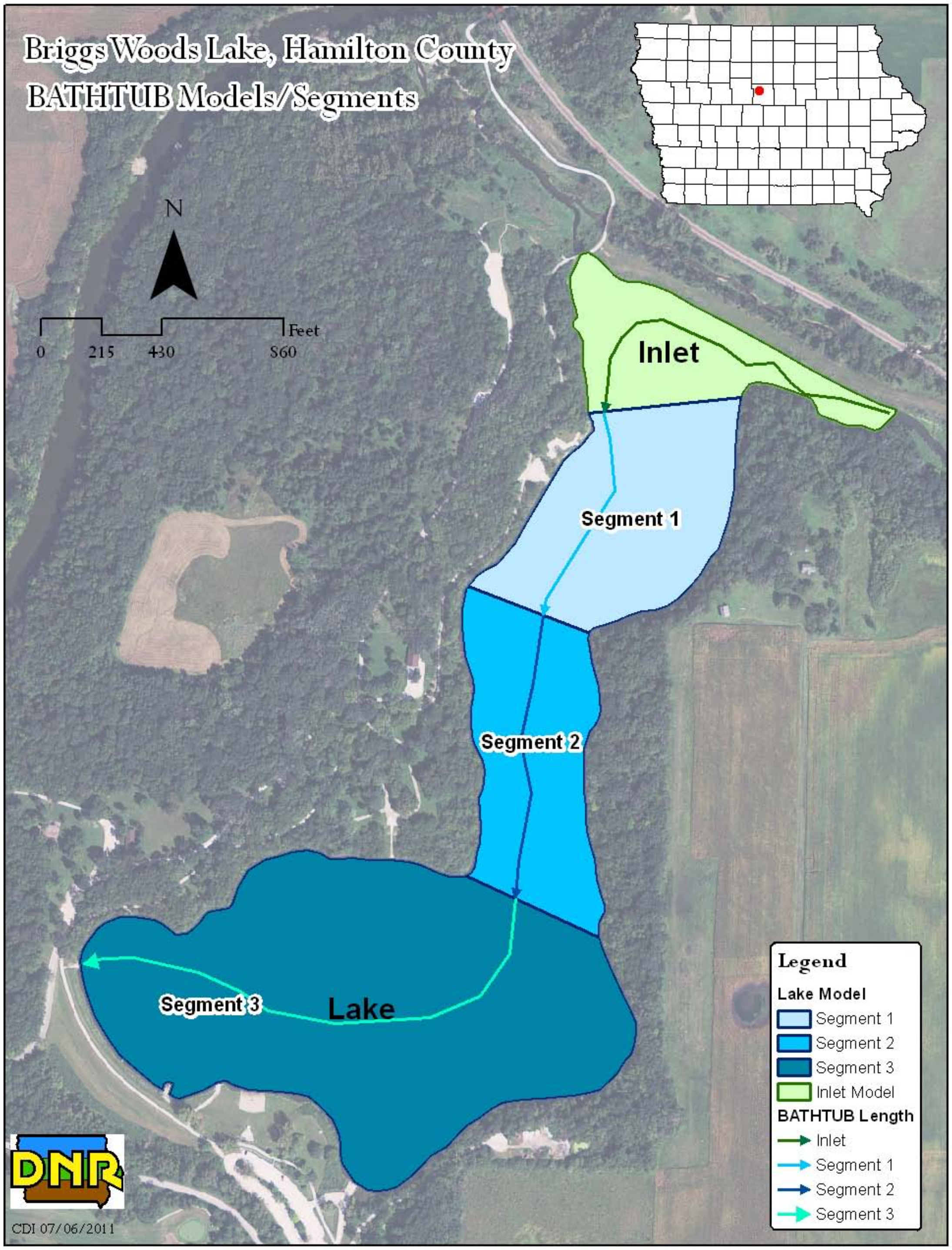


Figure E-2. Segmentation of Briggs Woods Lake and inlet BATHTUB models.

Table E-4. Segment morphometry for the inlet model.

Parameter	Measured or Monitored Data	BATHTUB Input
Lake Surface Area	7.0 ac	0.03 km^2
Mean Depth	3.75 ft	1.14 m
[1]Reservoir Length	410 m	0.41 km
Mixed Layer Depth	3.8 ft	1.14 m
Hypolimnetic Depth	0.0 ft	0.0 m

[1] Estimated using GIS

Table E-5. Segment morphometry for each segment of the lake model.

Parameter	Measured or Monitored Data	BATHTUB Input
Segment 1		
Lake Surface Area	11.3 ac	0.05 km^2
Mean Depth	6.0 ft	1.83 m
[1]Reservoir Length	241 m	0.24 km
Mixed Layer Depth	6.0 ft	1.83 m
Hypolimnetic Depth	0.0 ft	0.0 m
Segment 2		
Lake Surface Area	10.2 ac	0.04 km^2
Mean Depth	7.0 ft	2.13 m
[1]Reservoir Length	311 m	0.31 km
Mixed Layer Depth	7.0 ft	2.13 m
Hypolimnetic Depth	0.0 ft	0.0 m
Segment 3		
Lake Surface Area	33.2 ac	0.13 km^2
Mean Depth	15.0 ft	4.57 m
[1]Reservoir Length	562 m	0.56 km
Mixed Layer Depth	11.7 ft	3.56 m
Hypolimnetic Depth	5.7 ft	1.74 m

[1] Estimated using GIS

The BATHTUB model developed for Briggs Woods Lake does not simulate dynamic conditions associated with storm events or even between individual growing seasons. Rather, the model predicts average annual conditions from 2007 to 2010. There are two primary reasons for this. First, STEPL is a long term average annual model, and cannot provide hydrology and pollutant loading information on short time scales. Second, construction of the diversion berm and culvert structure across the north end of the lake in 2006 changed the lake's behavior, and it's likely that data collected prior to this no longer reflects conditions in the lake. Additionally, data that described previous hydrology and outlet structure manipulation (using stop logs) is lacking, therefore calibration using data collected prior to 2006 was not possible.

Observed water quality data for the lake is included in Appendix C – Water Quality Data. Mean water quality parameters observed for the 2007-2010 growing seasons are reported in Table E-6. These data were compared to output in Segment 3 of the

BATHTUB lake model to evaluate model performance and calibrate the BATHUB and STEPL models. Lack of data prevented a thorough validation of the models. Calibration of the STEPL and BATHTUB models was performed in tandem, and is described in further detail in Appendix F.

Table E-6. Observed water quality (2007-2010 growing season means).

Parameter	Measured or Monitored Data	[1]BATHTUB Input
Total Phosphorus	75.5 ug/L	75.5 ppb
Total Nitrogen	2.344 mg/L	2,344 ppb
Chlorophyll-a	27.8 ug/L	27.8 ppb
Secchi Depth	2.14 m	2.14 m
Ammonia	73 ug/L	[2]N/A
Nitrate/Nitrite	1.17 mg/L	[2]N/A
Organic Nitrogen	1.10 mg/L	1,101 ppb
Ortho P	18 ug/L	[2]N/A
TP – Ortho P	57 ug/L	57 ppb

[1] Measured or monitored data converted to units required by BATHTUB
ppb = parts per billion = micrograms per liter (ug/L)
[2] Used to calculate organic form of nutrient, not an input parameter

Tributary Data
The empirical eutrophication relationships in the BATHTUB model are influenced by the global and segment parameters previously described, but are heavily driven by flow and nutrient loads from the contributing drainage area (watershed). Flow and nutrient loads can be input to the BATHTUB model in a number of ways. The FLUX component of BATHTUB allows the user to estimate flow and nutrient loads based on a tributary monitoring network. However, tributary data was available for less than one calendar year and did not include flow, which limits reliability and increases the uncertainty associated with water quality predictions.

Flow and nutrient loads used in the development of the Briggs Woods Lake BATHTUB models utilize watershed hydrology and nutrient loads predicted using the STEPL model described in Appendix D. Output from STEPL includes annual average flow and nutrient loads. STEPL output requires conversion into forms compatible with BATHTUB. This includes units conversion and converting STEPL nutrient loads and flow into mean concentrations and flow for BATHTUB input. Because of the complex nature of flow into and out of Briggs Woods Lake, with outlets at both the north and south end of the lake separated by a diversion berm, two separate BATHTUB models were developed, as described previously. The STEPL output provides tributary inputs for the inlet model, which are reported in Table E-7. Tributary inputs for the lake model are obtained from the "out of reservoir" output of the inlet model. This output was driven by the rating curve developed in Section E.1 to predict flows that enter the main body of the lake from the inlet. Lake model inputs are listed in Table E-8.

Table E-7. Tributary data for inlet model (2007-2010 annual averages).

Parameter	STEPL Output	[1]BATHTUB Input
Flow	8,948 ac-ft	[2]11.0 hm^3/yr
Total P	9,797 lb	402.6 ppb
Ortho P	[3]NA	[3]NA
Total N	551,010 lb	22,646 ppb
Inorganic N	[3]NA	[3]NA

[1]STEPL output converted to units required by BATHTUB
[2]hm^3/yr = cubic hectometers per year
[3]Ortho P and Inorganic N not applicable, bioavailability ignored in BATHTUB

Table E-8. Tributary data for lake model (2007-2010 annual averages).

Parameter	Inlet Model Output	[1]Lake Model Input
Flow	[2]5.2 hm^3/yr	[2]5.2 hm^3/yr
Total P	307 ppb	307 ppb
Ortho P	[3]NA	[3]NA
Total N	14,270 ppb	14,270 ppb
Inorganic N	[3]NA	[3]NA

[1]Lake Model Inputs = Inlet Model Outputs
[2]Flow out of inlet to main body of lake is 47.6% of total flow, as determined using rating curve and stream flow records described in Section E.1.
[3]Ortho P and Inorganic N not applicable, bioavailability ignored in BATHTUB

E.4. References

Anderson, K., and J. Downing. 2006. Dry and wet atmospheric deposition of nitrogen, phosphorus, and silicon in an agricultural region. Water, Air, and Soil Pollution, 176:351-374.

Walker, W. 1985. Empirical methods for predicting eutrophication in impoundments; Report 4, Phase III: Applications manual, “Technical Report E-81-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Walker, W. 1996 (Updated 1999). Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. US Army Corps of Engineers Waterways Experiment Station. Instruction Report W-96-2.

Appendix F --- Model Performance and Calibration

The Briggs Woods Lake watershed and water quality models were calibrated by comparing simulated and observed local and regional data. The primary source of calibration data is the ambient lake monitoring data collected by Iowa State University (ISU) and the University of Iowa State Hygienic Laboratory (SHL) between 2007 and 2010. Literature values and results from regional studies regarding sediment and phosphorus exports in similar watersheds were also utilized to evaluate and calibrate model performance. Calibration was an iterative process that involved running both the watershed model (STEPL) and in-lake model (BATHTUB), and refining inputs to (1) produce simulated values that were within reasonable ranges according to similar studies, and (2) provide good agreement with observed water quality in Briggs Woods Lake.

F.1. STEPL Performance and Calibration

The STEPL model is a long-term average annual simulation model, and is incapable of simulating storm events or short-term fluctuations in hydrology and nutrient loads. There is little to no long-term monitoring data for tributaries or tile drains in the Briggs Woods Lake watershed, therefore model calibration relied heavily upon sediment and phosphorus exports reported in similar watersheds in the region. Table F-1 reports estimated sheet and rill erosion rates found in several Iowa watersheds that lie within the Des Moines Lobe ecoregion, which is characterized by flat upland areas draining to depressions, also called potholes. This landscape has been heavily impacted by tile drainage, which has allowed for high production agriculture. Regional watershed erosion estimates in Table F-1 include a previous RUSLE assessment conducted in the Briggs Woods Lake watershed.

Table F-1. Sheet and rill erosion rates of Des Moines Lobe watersheds.

Watershed	County	Area (acres)	Distance (miles)	Erosion (tons/acre)
[1]Briggs Woods Lake	**Hamilton**	**7,210**	**--**	**1.6**
Lost Island Lake	Palo Alto	6,270	72	2.2
Silver Lake	Dickinson	17,019	103	1.6
Brushy Creek Lake	Webster	56,930	6	0.8
Little Clear Lake	Pocahontas	365	60	1.7
Marrowbone Creek	Carroll	8,916	45	2.4
[2]Briggs Woods Lake	**Hamilton**	**[3]6,955**	**--**	**2.5**

[1]Previous erosion study conducted in the Briggs Woods Lake watershed by IDNR.
[2]Annual erosion estimated for this WQIP using STEPL (2007-2010)
[3]Drainage area based on LiDAR delineation and excludes surface area of lake.

The Briggs Woods Lake STEPL model predicts sheet and rill erosion rates that are similar to rates predicted by IDNR for other lakes in the ecoregion. The 2007-2010 simulated annual average rate was 2.5 tons/acre, slightly higher than the range observed in other watersheds (0.8 to 2.4 tons/acre), and nearly one ton higher than the previous RUSLE estimate for the Briggs Woods Lake watershed. This is likely due to the four-year period (2007-2010) being extremely wet, with an unusually high number of runoff events compared to previous years. This increased rainfall intensity would increase both observed and simulated sheet and rill erosion rates.

Table F-2 compares the annual average TP export simulated by the Briggs Woods Lake STEPL model with study results in other tile-drained watersheds in the Midwest. TP export in the Briggs Woods Lake watershed is at the upper end of the range of literature values, but closely matches average TP export predicted for four other watersheds in Iowa. Because the STEPL model predicted sediment and phosphorus loads similar in magnitude to estimates developed for other local and regional watersheds, IDNR has determined the STEPL model to be adequate for estimation of phosphorus loads to Briggs Woods Lake for development of TMDLs and implementation planning.

Table F-2. Comparison of TP exports in tile-drained watersheds.

Watershed/Location	Source	TP Export (lb/ac)
East Central Illinois	Royer et al., 2006	0.1-1.9
South Fork Iowa River	Tomer et al., 2008	0.4-0.6
Skunk River at Augusta, IA	USGS, 2001	2.5
Iowa River at Wapello, IA	USGS, 2001	0.88
Lake Geode, Henry Co.	IDNR (Previous TMDL)	1.38
Silver Lake, Dickinson Co.	IDNR (Previous TMDL)	0.7
Other Study Average	**4 studies above**	**[1]1.4**
Briggs Woods Lake	**STEPL Model (Current TMDL)**	**[2]1.4**

[1] Average annual TP export: Skunk River, Iowa River, Lake Geode, and Silver Lake
[2] Annual average TP export, 2007-2010, Briggs Woods Lake watershed

F.2. BATHTUB Model Performance

Performance of the BATHTUB model was assessed by comparing predicted water quality with observed data collected in Briggs Woods Lake from 2007 to 2010. Simulation of TP concentration was critical for TMDL development, as was chlorophyll-a and transparency predictions. Nitrogen constituents are less important because Briggs Woods Lake is not nitrogen limited.

Calibration
Table F-3 reports observed and simulated annual average TP and chlorophyll-a in the open water area of Briggs Woods Lake between 2007 and 2010. This area is represented by Segment 3 in the BATHTUB model of the lake. Calibration was not possible in Segments 1 or 2 of the lake model, or in the inlet model, due to lack of observed data. Some adjustment of the calibration factors was necessary to obtain good agreement between simulated and observed water quality in Segment 3. The adjusted factors listed alongside the simulated values in Table F-3 were entered for each segment of both BATHTUB models (i.e., the inlet and lake models). The adjusted calibration factors are within the recommended range according to the BATHTUB user guidance (Walker, 1996). Agreement between observed and simulated concentrations (in Segment 3) was possible after calibration.

Table F-3. In-lake water quality parameters and calibration factors.

Parameter	[1]Observed	[2]Simulated	Calibration Factor
Total Phosphorus (ug/L)	76	76	2
Chlorophyll-a (ug/L)	28	28	0.96
Secchi depth (m)	2.1	2.1	1.6

[1]Average concentration observed at ambient monitoring location, 2007-2010
[2]Average annual concentration simulated in Segment 3 of BATHTUB lake model

F.3. References

Royer, T., M. David, and L. Gentry. 2006. Timing of Riverine Export of Nitrate and Phosphorus from Agricultural Watersheds in Illinois: Implications for Reducing Nutrient Loading to the Mississippi River. Environ. Sci. Technol (40) 4126-4131.

Tomer, M., T. Moorman, and C. Rossi. 2008. Assessment of the Iowa River's South Fork Watershed: Part 1. Water Quality. Jour. Of Soil and Water Cons. Vol 63, No.6, pp. 360-370.

U.S. Geological Survey (USGS), 2001. Water Quality Assessment of the Eastern Iowa Basins – Nitrogen, Phosphorus, Suspended Sediment, and Organic Carbon in Surface Waters, 1996-98. Water Resources Investigations Report 01-4175. Iowa City, Iowa.

Walker, W. 1996 (Updated 1999). Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. US Army Corps of Engineers Waterways Experiment Station. Instruction Report W-96-2.

Appendix G --- Expressing Average Loads as Daily Maximums

In November of 2006, The U.S. Environmental Protection Agency (EPA) issued a memorandum entitled *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits.* In the context of the memorandum, EPA

> *"…recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increments. In addition, TMDL submissions may include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards…"*

Per the EPA recommendations, the loading capacity of Briggs Woods Lake for TP is expressed as both a maximum annual average and a daily maximum load. The annual average load is more applicable to the assessment of in-lake water quality and water quality improvement actions, whereas the daily maximum load expression satisfies the legal uncertainty addressed in the EPA memorandum. The allowable annual average was derived using the BATHTUB model described in Appendix F, and is 8,515 lbs/season.

The maximum daily load was estimated from the allowable annual average using a statistical approach. The methodology for this approach is taken directly from the follow-up guidance document titled *Options for Expressing Daily Loads in TMDLs* (EPA, 2007), which was issued shortly after the November 2006 memorandum cited previously. This methodology can also be found in EPA's 1991 *Technical Support Document for Water Quality Based Toxics Control.*

The *Options for Expressing Daily Loads in TMDLs* document presents a similar case study in which a statistical approach is considered the best option for identifying a maximum daily load (MDL) that corresponds to the allowable average load. The method calculates the daily maximum based on a long-term average and considers variation. This method is represented by the equation:

$$MDL = LTA \times e^{[z\sigma - 0.5\sigma^2]}$$

Where:
- MDL = maximum daily limit
- LTA = long term average
- z = z statistic of the probability of occurrence
- $\sigma^2 = \ln(CV^2 + 1)$
- CV = coefficient of variation

The allowable annual average of 8,515 lbs/year is equivalent to a long-term average (LTA) daily of 23 lbs/day. The LTA is the allowable annual load divided by the 365-day averaging period. The average annual allowable load must be converted to a MDL. The 365-day averaging period equates to a recurrence interval of 99.7 percent and corresponding z statistic of 2.778, as reported in Table G-1. The coefficient of variation

(CV) is the ratio of the standard deviation to the mean. However, there is insufficient data to calculate a CV as it relates to TP loads to the lake, because the models are based on annual averages over several years. In cases where data necessary for calculating a CV is lacking, EPA recommends using a CV of 0.6 (EPA, 1991). The resulting σ^2 value is 0.31. This yields a TMDL of 93 lbs/day. The TMDL calculation is summarized in Table G-2.

Because there are no permitted/regulated point source discharges in the watershed, the WLA is zero. An explicit 10 percent (9 lbs/day) MOS is applied to the TMDL equation. The resulting TMDL, expressed as a daily maximum, is:

TMDL = LC = Σ WLA (0 lbs-TP/day) + Σ LA (84 lbs-TP/day)
+ MOS (9 lbs-TP/day) = **93 lbs-TP/day**

Table G-1. Multipliers used to convert a LTA to an MDL.

Averaging Period (days)	Recurrence Interval	Z-score	Coefficient of Variation								
			0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
30	96.8%	1.849	1.41	1.89	2.39	2.87	3.30	3.67	3.99	4.26	4.48
60	98.4%	2.135	1.50	2.11	2.80	3.50	4.18	4.81	5.37	5.87	6.32
90	98.9%	2.291	1.54	2.24	3.05	3.91	4.76	5.57	6.32	7.00	7.62
120	99.2%	2.397	1.58	2.34	3.24	4.21	5.20	6.16	7.05	7.89	8.66
180	99.4%	2.541	1.62	2.47	3.51	4.66	5.87	7.06	8.20	9.29	10.3
210	99.5%	2.594	1.64	2.52	3.61	4.84	6.13	7.42	8.67	9.86	11.0
365	99.7%	2.778	1.70	2.71	4.00	5.51	7.15	8.83	10.5	12.1	13.7

Table G-2. Summary of LTA to MDL calculation for the TMDL.

Parameter	Value	Description
LTA	23 lbs/day	Annual average (10,011 lbs/ 365 days)
Z Statistic	2.778	Based on 365-day averaging period
CV	0.6	EPA recommendation (EPA, 1991)
σ^2	0.31	ln (CV^2 + 1)
MDL	**93 lbs/day**	**TMDL expressed as daily load**

Appendix H --- 2010 305(b) Water Quality Assessment

Segment Summary

Waterbody ID Code: IA 04-UDM-01880-L_0
Location: Hamilton County, S17,T88N,R25W near Webster City.
Waterbody Type: Lake
Segment Size: 59 Acres
This is a Significant Publically Owned Lake
Segment Classes: Class A1, Class B(LW), Class HH

Assessment Comments

Assessment is based on: (1) results of the statewide survey of Iowa lakes conducted from 2004 through 2007 by Iowa State University (ISU), (2) results of the statewide ambient lake monitoring program conducted from 2005 through 2008 by the State Hygienic Laboratory (SHL), (3) information from the IDNR Fisheries Bureau, (4) results of the IDNR-county voluntary beach monitoring program in 2004 and 2005, (5) results of a fish kill investigation in June 2005, and (6) results of IDNR/U.S. EPA fish tissue monitoring (RAFT) in 2005.

Assessment Summary and Beneficial Use Support

Overall Use Support - Partial	Assessment Type: Evaluated Integrated Report Category: 5a
Aquatic Life Support - Partial	Water is impaired or a declining water quality trend is evident, and a TMDL is needed.
Fish Consumption - Fully	Trend: Stable
Primary Contact Recreation - Partial	Trophic Level: Eutrophic

Basis for Assessment and Comments

SUMMARY: The Class A1 (primary contact recreation) uses are assessed (monitored) as “partially supported” due to high levels of algae (chlorophyll a) that violate the Iowa's narrative water quality standard protecting against aesthetically objectionable conditions. Violations of the state's water quality criteria for indicator bacteria also contribute to the impairment at this lake. The Class B(LW) (aquatic life) uses are assessed (monitored) as “partially supported” due to a fish kill in 2005. Fish consumption uses are assessed (monitored) as “fully supported.” Sources of data for this assessment include (1) results of the statewide survey of Iowa lakes conducted from 2004 through 2007 by Iowa State University (ISU), (2) results of the statewide ambient lake monitoring program conducted from 2005 through 2008 by the State Hygienic Laboratory (SHL), (3) information from the IDNR Fisheries Bureau, (4) results of the IDNR-county voluntary beach monitoring program in 2004 and 2005, (5) results of a fish kill investigation in June 2005, and (6) results of IDNR/U.S. EPA fish tissue monitoring (RAFT) in 2005.

EXPLANATION: Results of IDNR county beach monitoring from 2004 through 2005 suggest that the Class A1 uses are assessed (evaluated) as "partially supported." Levels of indicator bacteria at Briggs Woods Lake beach were monitored approximately once per week during the primary contact recreation seasons (May through August) of 2004 (22 samples) and 2005 (23 samples) as part of the IDNR county beach monitoring program. Because only two years of data were collected as part of this program these data are considered not sufficient to accurately characterize current water quality conditions, therefore the assessment category is considered “evaluated” (indicating an assessment with relatively lower confidence) as opposed to "monitored" (indicating an assessment with relatively higher confidence). According to IDNR’s assessment methodology, two conditions need to be met for results of beach monitoring to indicate “full support” of the Class A1 (primary contact recreation) uses: (1) all thirty-day geometric means for the three-year assessment period are less than the state’s geometric mean criterion of 126 E. coli orgs/100 ml and (2) not more than 10 % of the samples during any one recreation season exceeds the state’s single-sample maximum value of 235 E. coli orgs/100 ml. If a 5-sample, 30-day geometric mean exceeds the state criterion of 126 orgs/100 ml during the three-year assessment period, the Class A1 uses should be assessed as “not supported.” Also, if significantly more than 10% of the samples in any one of the three recreation seasons exceed Iowa’s single-sample maximum value of 235 E. coli orgs/100 ml, the Class A1 uses should be assessed as “partially supported.” This assessment approach is based on U.S. EPA guidelines (see pgs 3-33 to 3-35 of U.S. EPA 1997b).

At Briggs Woods Lake beach, the geometric mean of 1 thirty-day period during the summer recreation seasons of 2004 and 2005 exceeded the Iowa water quality standard of 126 E. coli orgs/100 ml: 0 of 6 geometric means violated in 2004, and 1 of 12 geometric means violated in 2005. The percentage of samples exceeding Iowa’s single-sample maximum criterion (235 E. coli orgs/100 ml) was not significantly greater than 10% in either of the following recreation seasons: 2004: 14%, 2005: 13%. According to IDNR’s assessment methodology and U.S. EPA guidelines, these results suggest impairment (nonsupport/evaluated) of the Class A1 (primary contact recreation) uses.

Results from the ISU and SHL lake surveys suggest that the Class A1 uses at Briggs Woods Lake are assessed (monitored) as “partially supported.” Using the median values from these surveys from 2004 through 2008 (approximately 23 samples), Carlson’s (1977) trophic state indices for Secchi depth, chlorophyll a, and total phosphorus were 50, 66, and 64 respectively for Briggs Woods Lake. According to Carlson (1977) the Secchi depth index value places Briggs Woods Lake at the lower end of the eutrophic category. The index values for chlorophyll a and total phosphorus place Briggs Woods Lake in between the eutrophic and hypereutrophic categories. These values suggest high levels of chlorophyll a and suspended algae in the water, very good water transparency, and moderately high levels of phosphorus in the water column.

The levels of inorganic suspended solids at this lake were low and do not suggest problems due to non-algal turbidity. The median level of inorganic suspended solids in Briggs Woods Lake (1.0 mg/L) was the 3rd lowest median of the 132 lakes sampled by the ISU and SHL surveys.

Data from the 2004-2008 ISU and SHL surveys also suggest that a small population of cyanobacteria exists at Briggs Woods Lake. These data show that cyanobacteria comprised only 27% of the phytoplankton wet mass at this lake. The median cyanobacteria wet mass (4.0 mg/L) was also the 23rd lowest of the 132 lakes sampled.

The Class B(LW) (aquatic life) uses for Briggs Woods Lake are assessed (monitored) as "partially supported" due to a fish kill in 2005. A fish kill occurred on June 1, 2005 and was attributed to low levels of dissolved oxygen related to the excessive growth of submergent aquatic vegetation in the lake. An estimated 1,000 bluegill of a variety of sizes were killed. Because the kill affected immature as well as adult fish, the kill was attributed to an oxygen sag rather than spawning stress. This was only a partial kill: many live fish were observed and anglers were catching fish during the IDNR investigation. According to IDNR's assessment/listing methodology, the occurrence of a single pollutant-caused fish kill, or a fish kill of unknown origin, on a waterbody or waterbody reach during the most recent assessment period (2006-2009) indicates a severe stress to the aquatic community and suggests that the aquatic life uses should be assessed as "impaired." If a cause of the kill was not identified during the IDNR investigation, or if the kill was attributed to non-pollutant causes (e.g., winterkill), the assessment type will be considered "evaluated." Such assessments, although suitable for Section 305(b) reporting, lack the degree of confidence to support addition to the state Section 303(d) list of impaired waters (IR Category 5). Waterbodies affected by such fish kills will be placed in IR subcategories 2b or 3b and will be added to the state list of waters in need of further investigation.

Results from the ISU and SHL lake surveys, however, suggest good chemical water quality at Briggs Woods Lake. The ISU and SHL lake surveys data from 2004-2008 show no violations of the Class B(LW) criterion for ammonia in 23 samples, or dissolved oxygen in 23 samples. There were 3 violations of the Class A1,B(LW) criteria for pH in 23 samples. Based on IDNR's assessment methodology these violations are not significantly greater than 10% of the samples and therefore do not constitute an impairment of the Class A1,B(LW) uses. Therefore, these results suggest "full support" of the Class B(LW) uses. Information from the IDNR Fisheries Bureau also suggests that water clarity has been good recently, but nutrient inputs and siltation remain concerns.

Fish consumption uses were assessed (monitored) as "fully supported" based on results of U.S. EPA/IDNR fish contaminant (RAFT) monitoring at Briggs Woods Lake in 2005. The composite samples of fillets from channel catfish and largemouth bass had low levels of contaminants. Levels of primary contaminants in the composite sample of channel catfish fillets were as follows: mercury: 0.0194 ppm; total PCBs: <0.09 ppm; and technical chlordane: <0.03 ppm. Levels of primary contaminants in the composite sample of largemouth bass fillets were as follows: mercury: 0.0568 ppm; total PCBs: <0.09 ppm; and technical chlordane: <0.03 ppm. The existence of, or potential for, a fish consumption advisory is the basis for Section 305(b) assessments of the degree to which Iowa's lakes and rivers support their fish consumption uses. The fish contaminant data generated from the 2005 RAFT sampling conducted at Briggs Woods Lake show that the levels of contaminants do not exceed any of the advisory trigger levels, thus indicating no justification for issuance of a consumption advisory for this waterbody.

Monitoring and Methods

Assessment Key Dates

6/7/2004 Fixed Monitoring Start Date

6/1/2005 Fishkill

8/10/2005 Fish Tissue Monitoring

9/3/2008 Fixed Monitoring End Date

Methods

- Surveys of fish and game biologists/other professionals
- Incidence of spills and/or fish kills
- Non-fixed-station monitoring (conventional during key seasons and flows)
- Primary producer surveys (phytoplankton/periphyton/macrophyton)
- Water column surveys (e.g. fecal coliform)
- Fish tissue analysis

Causes and Sources of Impairment

Causes	Use Support	Cause Magnitude	Sources	Source Magnitude
Algal Growth/Chlorophyll a	Primary Contact Recreation	Moderate	Internal nutrient cycling (primarily lakes)	Moderate
Organic enrichment/Low DO	Aquatic Life Support	Slight	Other	Slight
Pathogens	Primary Contact Recreation	Not Impairing	Source Unknown	Not Impairing
Noxious aquatic plants	Primary Contact Recreation	Not Impairing	Internal nutrient cycling (primarily lakes)	Not Impairing
Nutrients	Aquatic Life Support	Not Impairing	Agriculture Natural Sources	Not Impairing Not Impairing

Appendix I --- Public Comments

The Iowa Department of Natural Resources (IDNR) received no public comments on the Briggs Woods Lake TMDL.

January 20, 2021

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

Subject: Submittal of Final Briggs Woods Lake, Hamilton County, pH Addendum for EPA approval

Dear Mr. Robichaud:

The Final Briggs Woods Lake pH Addendum document completed by the Iowa Department of Natural Resources is enclosed. Iowa DNR previously completed a TMDL on this lake for organic enrichment/low DO and algae in 2012. Subsequently, analysis of monitoring data added a pH impairment to the lake. The attached addendum, which will be added to the original 2012 document upon EPA approval, ties the pH impairment to the 2012 TMDL target of Phosphorus. Included is:

- Briggs Woods Lake, TMDL Addendum for pH (IA 04-UDM-1255)

The draft TMDL was posted on the Iowa Department of Natural Resources website on December 17, 2020 and comments were accepted from December 17, 2020 to January 19, 2021. A video recording of a standard public meeting presentation was posted to the DNR website coincident with the opening of the Public Notice period and was available for viewing throughout. The Iowa DNR received no public comments on the draft.

Please accept this document as the addendum for pH for Briggs Woods Lake, Hamilton County.

Sincerely,

Allen Bonini Digitally signed by Allen Bonini Date: 2021.01.20 12:09:26 -06'00'

Allen P. Bonini, Supervisor
Watershed Improvement Section

Enclosure

Addendum to the Water Quality Improvement Plan for

Briggs Woods Lake

Hamilton County, Iowa

Total Maximum Daily Load for:
Organic Enrichment/Low DO and Algae
Addendum to include pH

Prepared by:
James A. Hallmark, P.E.

clean water starts with you.
IOWA DNR WATERSHED IMPROVEMENT

Iowa Department of Natural Resources
Watershed Improvement Section
2021

GENERAL REPORT SUMMARY

What is the purpose of this report?
This report serves as an addendum to the Briggs Woods Lake Water Quality Improvement Plan (WQIP), dated July 2012, which was previously prepared by the Iowa Department of Natural Resources (Iowa DNR), submitted and subsequently approved by the EPA. The WQIP addressed the Total Maximum Daily Load (TMDL) for Organic Enrichment, Low DO, and Algae. The approval letter was received by the Iowa Department of Natural Resources on August 30, 2012. A copy of this letter is attached for convenience. Subsequent to this approval, the lake was placed on the 2012 303(d) list for a pH impairment.

During photosynthesis, algae blooms remove carbon dioxide from the water, inhibiting the natural carbon cycle to produce carbonic acid. This results in a more alkaline system with a higher pH. High pH levels, like algae, can be tied to excessive nutrient levels, specifically phosphorus. Consequently, the solution to both impairments (algae and pH) is the same, which is to remove and reduce nutrients to the lake, specifically phosphorus.

What can be done to improve Briggs Woods Lake?
To improve the water quality and overall health of Briggs Woods Lake, the amount of nutrients entering the lake must be reduced. Phosphorus is of particular concern because it is the limiting nutrient for excess algae and aquatic plant growth and in turn high pH. A combination of land and animal management practices must be implemented in the watershed to obtain required reductions. Reducing nutrient loss from row crops through strategic timing and methods of manure and fertilizer application, increasing use of conservation tillage methods, and implementing structural BMPs such as terraces, grass waterways, and constructed wetlands in beneficial locations will significantly reduce nutrient loads to the lake. Targeted in-lake dredging and ongoing maintenance of the sediment basin and wetland immediately upstream of the lake will improve and protect water quality in the lake. Preventing waterfowl from gathering at the beach and ensuring septic systems throughout the watershed are functioning properly will also benefit water clarity and reduce the amount of nutrients (and bacteria) that enters the lake.

Total Maximum Daily Load (TMDL) for pH

A Total Maximum Daily Load (TMDL) is required for Briggs Woods Lake by the Federal Clean Water Act. The WQIP for Briggs Woods Lake quantified the maximum amount of total phosphorus (TP) the lake can assimilate and still support primary contract recreation and aquatic life in the lake. It is assumed the TMDL for algae will also address the pH impairment since both are attributed to excess nutrients, particularly phosphorus. As a result, the amendment will not revisit the allowable TP load to the lake but refer to the 2012 WQIP for allowable phosphorus loads.

Problem Identification
Briggs Woods Lake is a Significant Publicly Owned Lake and is protected for the following designated uses:

Primary contact recreation – Class A1
Aquatic life – Class B(LW)
Fish consumption – Class HH

The 2018 Section 305(b) Water Quality Assessment Report states that primary contact and aquatic life designated uses in Briggs Woods Lake are assessed as “not supported” due to frequent violations of the state criterion for pH based on information from the ISU lake survey. The 2018 assessment can be accessed at https://programs.iowadnr.gov/adbnet/Segments/1255/Assessment/2018.

Applicable Water Quality Standards
Iowa Administrative Code (IAC) 567.61.3 states that for Class A and Class B waters "The pH shall not be less than 6.5 nor greater than 9.0." Water quality data and subsequent analysis suggest that addressing the algae impairment in Briggs Woods Lake will also address the pH impairment. It is excess nutrients, particularly phosphorus that leads to eutrophic conditions associated with both impairments.

Interpreting Briggs Woods Lake Data
The 2018 305(b) assessment was based on results of the ambient monitoring program conducted from 2012-2016 by Iowa State University (ISU). Figure 1 shows that pH exceeded the maximum criterion of nine (9) regularly from 2010-2016. Values that exceeded the maximum criterion of nine (9) are contained with the red shaded area. Elevated pH is often related to and a direct result of algal blooms, which affect the lake's carbonate chemistry and hence, pH.

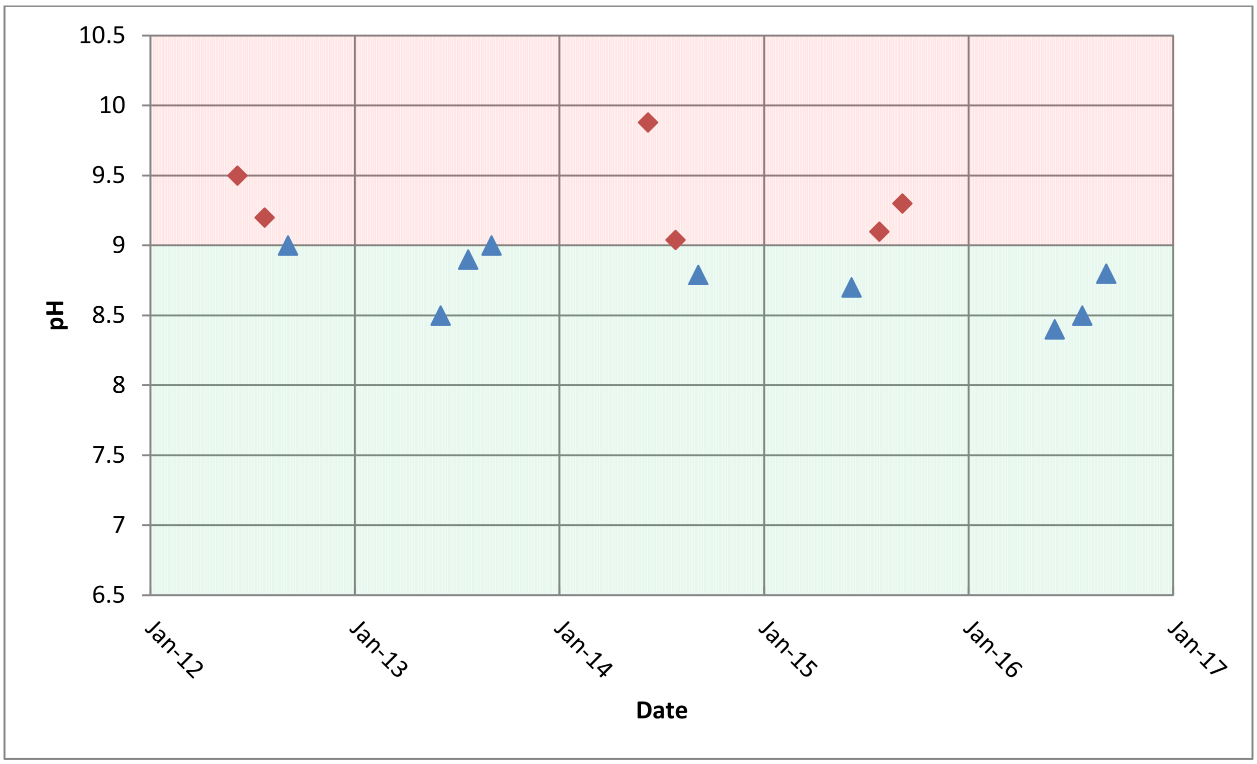


Figure 1. pH Levels in Briggs Woods Lake, From 2012-2016.

Phosphorus that enters the lake and becomes available for uptake allows for the establishment of algal blooms. Through photosynthesis the blooms alter the carbon cycle and increase daytime pH levels. Figure 2 shows the relationship between chlorophyll-a TSI values and pH, which implies that reducing algal blooms should also reduce pH.

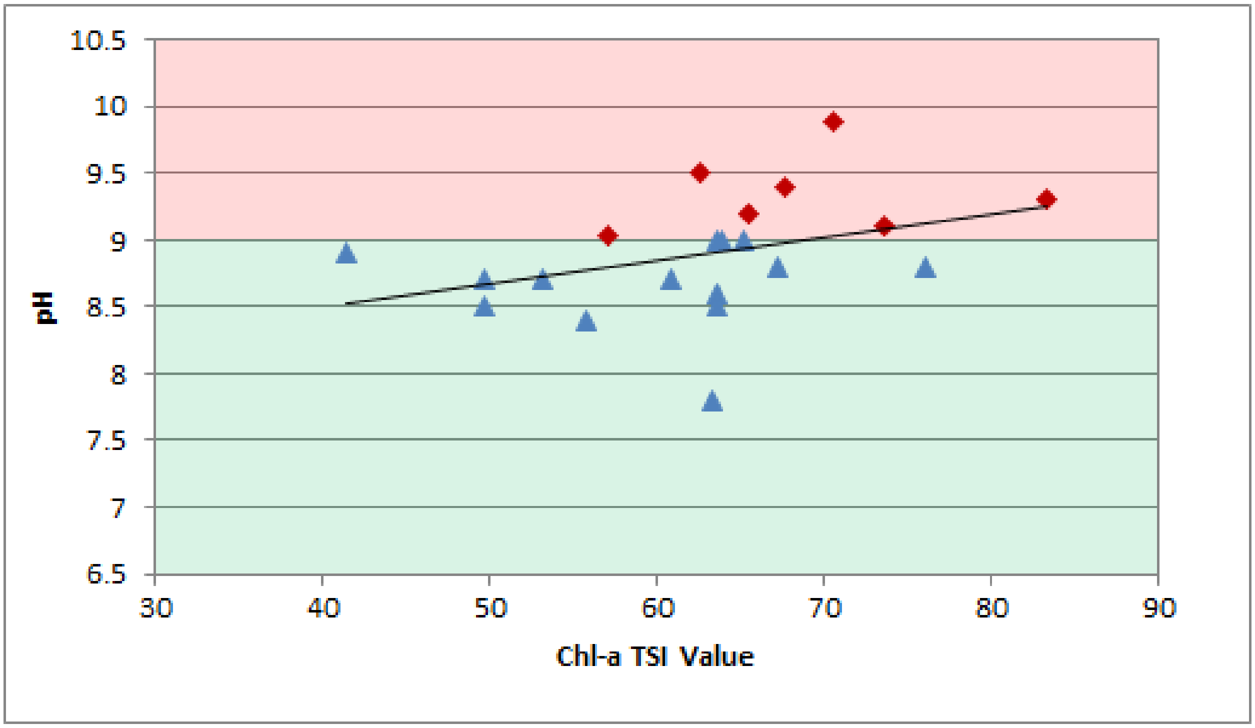


Figure 2. pH vs Chl-a TSI Values Briggs Woods Lake, From 2010-2016.

TMDL Target

The target for pH is a value no greater than nine (9) and the target for chlorophyll-a is a TSI value of 63. Using data from 2008-2018, Figure 3 shows the relationship between pH to chlorophyll-a. It shows that when chl-a TSI values are below 63 that pH values will also be consistently less than nine (9).

Between 2008 and 2018 there were a total of 35 samples collected. Of these samples, 15 had a chl-a TSI value of 63 or less and of these samples, only two (2) had a pH greater than nine (9). Based on Iowa DNR's assessment methodology these violations are not significantly greater than 10% of the samples and therefore would suggest no impairment. This information is shown graphically in Figure 3 where the red diamonds represent pH values greater than 9, the blue triangles represent pH values less than or equal to 9, the green vertical line represents a chl-a TSI value of 63, the horizontal green line represents a pH of 9, the green shaded area represents chl-a TSI values less than 63, the red shaded area represents chl-a TSI values greater than and equal to 63, and the black line represents a trend line showing that as the chl-a TSI values decrease so does the pH.

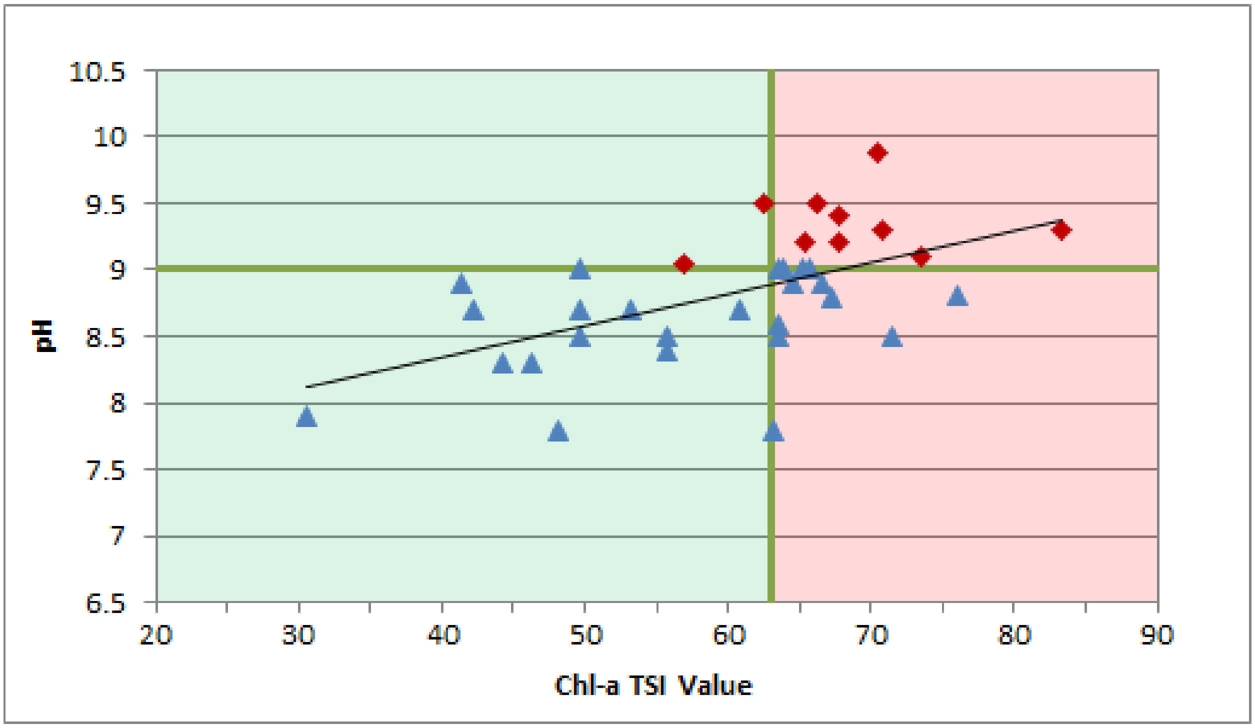


Figure 3. pH vs Chl-a TSI Value Briggs Woods Lake, From 2008-2018.

For convenience, a summary of the TMDL targets presented in the 2012 WQIP will be provided here. For a full discussion please see the 2012 Briggs Woods Lake WQIP.

Briggs Woods Lake is impaired for algae and pH. This is caused by excess phosphorus entering the system.

There are no numeric criteria associated with water clarity however, there are narrative requirements in the IAC 567-61 protecting against “aesthetically objectionable conditions.” Based on the Iowa DNR assessment methodology aesthetically objectionable conditions are present in a waterbody when the median summer chlorophyll-a or Secchi depth Trophic State Index (TSI) exceeds 65. In order to de-list a lake impaired by algae from the 303(d) list, the median growing season chlorophyll-a TSI must not exceed 63 in two consecutive listing cycles, per Iowa DNR de-listing methodology. Consequently, the TSI target for chlorophyll-a is 63.

The allowable in-lake chlorophyll-a target of 63 was translated to the TP loading by performing water quality simulations using the BATHTUB model. Based on these models the allowable annual loading capacity for TP is 8,515 lbs/year and the allowable maximum daily load is 93 lbs/day.

Pollution Source Assessment
Existing annual loads were determined using the STEPL model. Using STEPL the average annual TP load to Briggs Woods Lake from 2007-201 was estimated to be 10,011 lbs/year.

The target TP load, as previously indicated, is 8,515 lbs/year. To meet the target loads a reduction of 15 percent of the TP load is required. This will require BMPs. For a full discussion of possible BMPs see the 2012 WQIP.

Identification of Pollutant Sources

There are no known additional sources, natural or manmade, contributing to elevated pH. Sources that would contribute to an elevated pH are the same as those contributing to the phosphorus load as described in the 2012 WQIP.

TMDL Summary

The following general equation represents the total maximum daily load (TMDL) calculation and its components:

$$\text{TMDL} = \text{LC} = \Sigma\ \text{WLA} + \Sigma\ \text{LA} + \text{MOS}$$

Where:

TMDL	= total maximum daily load
LC	= loading capacity
Σ WLA	= sum of wasteload allocations (point sources)
Σ LA	= sum of load allocations (nonpoint sources)
MOS	= margin of safety (to account for uncertainty)

Once the loading capacity, wasteload allocations, load allocations, and margin of safety have all been determined for the Briggs Woods Lake watershed, the general equation above can be expressed for the Briggs Woods Lake algae TMDL.

Expressed as the allowable annual average, which is helpful for water quality assessment and watershed management:

TMDL = LC = Σ WLA (0 lbs-TP/year) + Σ LA (7,663 lbs-TP/year)
+ MOS (852 lbs-TP/year) = **8,515 lbs-TP/year**

Expressed as the maximum daily load:

TMDL = LC = Σ WLA (0 lbs-TP/day) + Σ LA (84 lbs-TP/day)
+ MOS (9 lbs-TP/day) = **93 lbs-TP/day**

Table 1. Water Quality Data, From 2008-2018.

Date	Chl-a (µg/L)	Chl-a TSI	pH
5/6/2008	1.0	30.6	7.9
6/12/2008	6.0	48.1	7.8
7/10/2008	60.0	70.7	9.3
8/14/2008	44.0	67.7	9.2
9/3/2008	13.0	55.7	8.5
6/25/2009	38.0	66.3	9.5
7/30/2009	7.0	49.7	9.0
8/20/2009	5.0	46.4	8.3
6/7/2010	30.0	63.9	9.0
7/26/2010	7.0	49.7	8.7
9/9/2010	29.0	63.6	8.6
6/6/2011	10.0	53.2	8.7
7/25/2011	44.0	67.7	9.4
9/6/2011	28.0	63.3	7.8
6/4/2012	26.0	62.5	9.5
7/23/2012	35.0	65.4	9.2
9/3/2012	29.0	63.6	9.0
6/3/2013	7.0	49.7	8.5
7/22/2013	3.0	41.3	8.9
9/2/2013	34.0	65.2	9.0
6/9/2014	58.6	70.5	9.9
7/28/2014	14.8	57.0	9.0
9/7/2014	42.2	67.3	8.8
6/8/2015	22.0	60.9	8.7
7/28/2015	80.0	73.6	9.1
9/7/2015	215.0	83.3	9.3
6/6/2016	13.0	55.7	8.4
7/25/2016	29.0	63.6	8.5
9/6/2016	103.0	76.0	8.8
6/12/2017	4.0	44.2	8.3
7/31/2017	3.3	42.3	8.7
9/11/2017	39.0	66.5	8.9
6/19/2018	32.0	64.6	8.9
8/7/2018	36.0	65.7	9.0
9/19/2018	65.0	71.5	8.5

Public Participation

Public involvement is important in the Total Maximum Daily Load (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 Briggs Woods Lake.

Public Meeting
A public presentation was posted on the Iowa DNR's YouTube channel for public viewing on December 17, 2020. The presentation was available for viewing through the public comment period.

Written Comments
A press release was issued on December 17, 2020 to begin a 30-day public comment period, which ended on January 19, 2021. No public comments were received during the public comment period.

Public Comments
The Iowa Department of Natural Resources received no public comments on the Briggs Woods Lake TMDL Addendum for pH.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 7
901 NORTH 5TH STREET
KANSAS CITY, KANSAS 66101

AUG 30 2012

Mr. Chuck Gipp
Director
Iowa Department of Natural Resources
Henry A. Wallace Building
502 East 9th Street
Des Moines, Iowa 50319

Dear Mr. Gipp:

RE: Approval of TMDLs for Briggs Woods Lake

This letter responds to the submission from the Iowa Department of Natural Resources originally received by the U.S. Environmental Protection Agency, Region 7, on September 27, 2011, for a Total Maximum Daily Load document that contained TMDLs for organic enrichment, low dissolved oxygen and algae. Briggs Woods Lake was identified on the 2010 Iowa Section 303(d) List as impaired. This submission fulfills the Clean Water Act statutory requirement to develop TMDLs for impairments listed on a state's § 303(d) List. The specific impairments (water body segment and pollutants) are:

Water Body Name	WBID	Pollutants
Briggs Woods Lake	IA 04-UDM-01880-L_0	Organic Enrichment Low Dissolved Oxygen Algae

The EPA has completed its review of the TMDLs with supporting documentation and information. By this letter, the EPA approves the submitted TMDL document. Enclosed with this letter is the Region 7 TMDL Decision Document which summarizes the rationale for the EPA's approval of the TMDLs. The EPA believes the separate elements of the TMDLs described in the enclosed form adequately address the pollutants of concern, taking into consideration seasonal variation and a margin of safety. 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 a TMDL and determine if future revisions are necessary or appropriate to meet applicable water quality standards.

The EPA is currently in consultation under Section 7 of the Endangered Species Act with the U. S. Fish and Wildlife Service regarding this TMDL document. While we are approving these TMDLs at the present time, we may decide that changes to the TMDL document are warranted based upon the results of the consultation when it is completed.

The EPA appreciates the thoughtful effort that the IDNR has put into these TMDLs. We will continue to cooperate with and assist, as appropriate, in future efforts by the IDNR to develop remaining TMDLs.

Sincerely,

Karen A. Flournoy
Director
Water, Wetlands and Pesticides Division

Enclosure

cc: Mr. William Ehm, Administrator, Division of Environmental Services, IDNR
Mr. Allen Bonini, Supervisor, Watershed Improvement Program, IDNR
Mr. Mike Coffey, U.S. Fish and Wildlife Service