Water Quality Improvement Plan
for

Volga Lake

Fayette County, Iowa

Total Maximum Daily Load
for Algae and Non-Algal Turbidity

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General Report Summary

What is the purpose of this report?

This report serves two major purposes. First, this report satisfies the Federal Clean Water Act requirement to develop a Total Maximum Daily Load (TMDL) report for all impaired 303(d) waterbodies. Second, this report should serve as a resource for locally-driven water quality improvements to Volga Lake in an effort to improve the water quality and successfully restore the lake.

What's wrong with Volga Lake?

Results from the Iowa State University (ISU) and State Hygienic Laboratory (SHL) lake surveys suggest that the Class A1 (primary contact recreation) uses at Volga Lake are "partially supported" due to elevated chlorophyll-a (algae) levels and high levels of turbidity.

Algal blooms occur when large quantities phosphorus enter the lake and provide the blooms with ample supplies to develop. The algae proliferate quickly but are also short lived so the bloom dies off. The decaying mass can also lead to decreased water clarity. Algal blooms are aesthetically objectionable and can make swimming or wading hazardous.

The phosphorus enters the lake attached to sediment. Phosphorus that enters from the watershed is called the external load. Some of the phosphorus is immediately released from the sediment and is used in creating blooms. Some of the sediment settles to the bottom and becomes an internal load of phosphorus. The settled sediment can be resuspended by rough fish and wind driven waves. This leads to the non-algal turbidity impairment.

Turbidity is the properties of a water column that cause allow light to pass through the water. Simply put, the water in Volga Lake is often cloudy.

The controls and measures used to reduce phosphorus in the lake will also target the bottom sediment and its sources. Therefore, by targeting phosphorus overall, both impairments will be addressed.

What is causing the problem?

Volga Lake is subject to aesthetically objectionable conditions caused by poor water transparency caused by algae blooms and non-algal turbidity. Water quality data suggest very high levels of chlorophyll-a and suspended algae in the water, poor water transparency, suspended inorganic particles and very high levels of phosphorus in the water column.

What can be done to improve Volga Lake?

Reducing phosphorus loads entering the lake it the most important step in the right direction. Until the water entering the lake contains less phosphorus, other remediation steps will not be cost effective since the initial source will still remain. However, once watershed issues are addressed, it becomes necessary to directly address phosphorus previously accumulated within the lake, which can lead to algal blooms. To improve Volga Lake water quality in the short term, a physical mechanism (such as dredging) that removes phosphorus from the lake must be considered in addition to reductions from watershed sources, because it will take many years for the system to process all the phosphorus that has accumulated in the lake sediment over time.

Who is responsible for a cleaner Volga Lake?

Everyone who lives and works nearby, or wishes to utilize a healthy Volga Lake, has an important role to play in improving and maintaining the lake. The future of Volga Lake depends on citizens and landowners adopting land use changes. The best chance for success in improving Volga Lake lies with private citizens working with government agencies that can provide technical, and in some cases, financial support for improvement efforts. Citizens interested in making a difference in Volga Lake should contact their local soil and water conservation district or the Iowa DNR Watershed Improvement Section for information on how to get involved.

Technical Elements of the TMDL

Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:	Waterbody Id: IA 01-VOL-00130-L_0 Volga Lake Fayette County, S3,T93N,R8W, 4 mi. NNE of Fayette
Surface water classification and designated uses:	Class A1 Primary Contact Recreation Class B(LW) Aquatic Life Class HH Human Health
Impaired beneficial uses:	Class A1 Primary Contact Recreation
Identification of the pollutant and applicable water quality standards:	The Class A1 (primary contact recreation) uses are assessed (monitored) as "partially supported" due to aesthetically objectionable conditions caused by poor water transparency caused by algae blooms and high levels of turbidity that violate aesthetically objectionable conditions.
Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:	Excess algae blooms and subsequent chlorophyll-a concentrations and high levels of turbidity are attributed to total phosphorus (TP). The allowable average annual TP load = 2,396.4 lbs/year; the maximum daily TP load = 26.4 lbs/day. Sources of non-algal turbidity can be remediated by phosphorus control measures.
Quantification of the amount or degree by which the current pollutant load in the waterbody, including the pollutant from upstream sources that is being accounted for as background loading, deviates from the pollutant load needed to attain and maintain water quality standards:	The existing annual load of 6,774.1 lbs/year must be reduced by 4,377.7 lbs/year to meet the allowable TP load. This is a reduction of 65 percent.
Identification of pollution source categories:	There are no permitted or regulated point source discharges of phosphorus or other turbidity causing sources in the watershed.

	Nonpoint sources of phosphorus include fertilizer and manure from row crops, sheet and rill erosion, waterfowl, other wildlife and atmospheric deposition.
Wasteload allocations for pollutants from point sources:	There are no permitted or regulated point source discharges in the watershed. Therefore the WLA in this TMDL is zero.
Load allocations for pollutants from nonpoint sources:	The allowable annual average TP LA is 2,156.76 lbs/year, and the allowable maximum daily LA is 23.76 lbs/day, resulting in a 68 percent reduction from existing conditions.
A margin of safety:	An explicit MOS of 10 percent is incorporated into this TMDL. The annual MOS is 239.64 lbs of P and the daily MOS is 2.64 lbs of P.
Consideration of seasonal variation:	The TMDL is based on annual TP loading. Although daily maximum loads are provided to address legal requirements, the average annual loads are critical to in-lake water quality and lake/watershed management decisions.
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 are 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 a list of impaired waterbodies that do not meet water quality standards (WQS) and support designated uses. This list of impaired waterbodies is referred to as the state's 303(d) listA Total Maximum Daily Load (TMDL) 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 Volga Lake, located in Fayette County in northeast Iowa, is to provide a TMDL for algae and non-algal turbidity. The second purpose of the plan is to provide local stakeholders and watershed managers with a tool to promote awareness of water quality issues, develop a watershed management plan, and implement water quality improvement projects. Both impairments, algae and non-algal turbidity, impair primary contact recreation and are addressed by development of a TMDL that limits total phosphorus (TP) loads to the lake.

This 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 phosphorus that the lake can receive is the loading capacity, or the TMDL target load.

The plan includes a description of potential solutions to the impairments. The solutions are a system of best management practices (BMPs) that will improve water quality in Volga Lake, with the goal of meeting water quality standards and supporting designated uses. These BMPs are outlined in the Section 4 Implementation Plan.

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 (i.e., monitoring) will help ensure 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.

This plan 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 plan for stakeholder use and is committed to providing ongoing technical support for the improvement of water quality in Volga Lake.

2. Description and History of Volga Lake

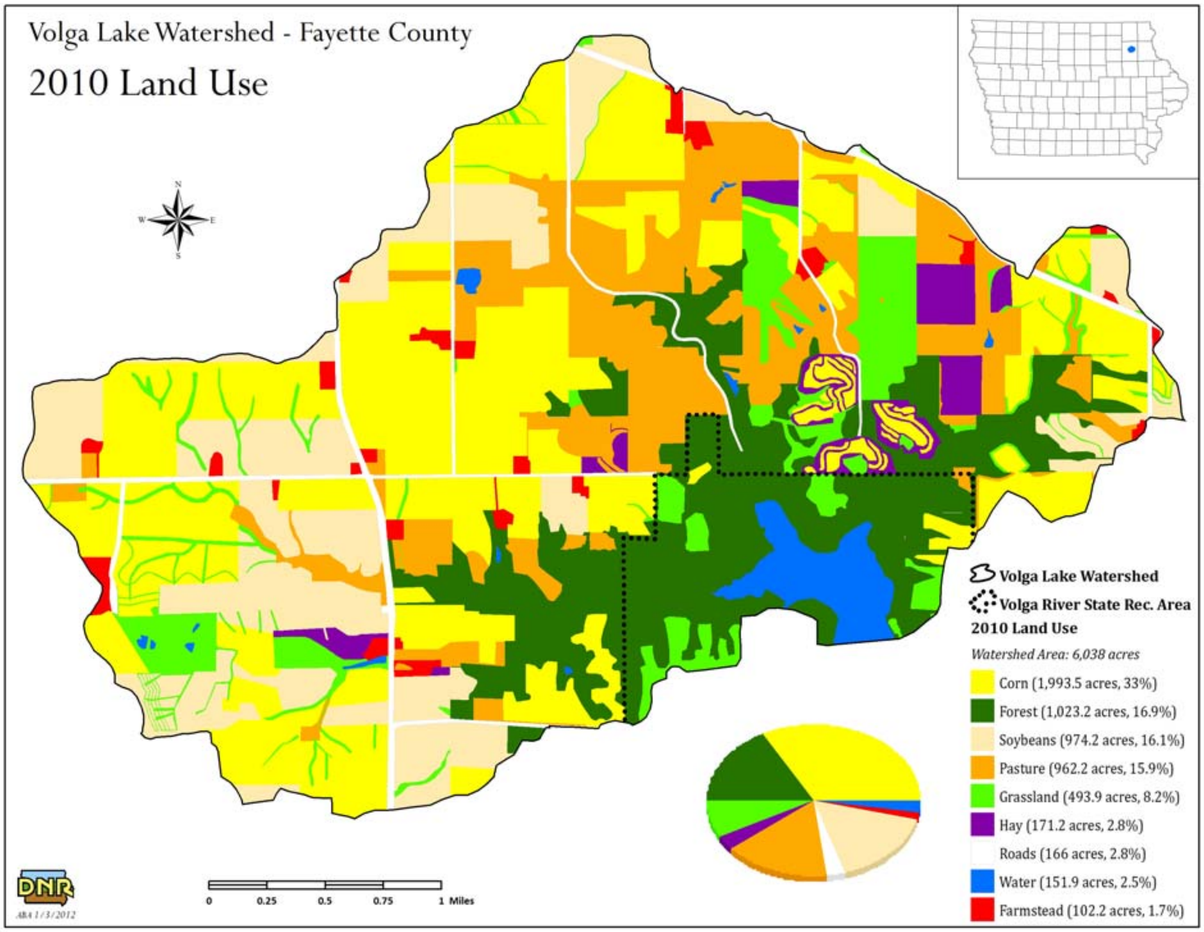

Figure 2.1. Volga Lake watershed and landuse.

Volga Lake is a 146 acre (2010 LiDAR) manmade lake surrounded by a approx 5,870 acre watershed in Fayette County (Figure 2.1). The lake was constructed between the years 1978 to 1979. Due to the karst topography of the area, there were concerns about leakage from the lake into sink holes. Therefore, the bottom of the lake was lined with bentonite to serve as a seal and maintain water levels. Currently, the lake is about 23.8 feet deep at the deepest point, with an average depth of 10.5 feet(Figure 2.2). The park was constructed around the lake and offers camping and recreation along with a hunting preserve.

Major landuses within the Volga Lake watershed are 49.1 percent row crop (corn 33 percent and soybean 16.1 percent), 26.9 percent grassland (grazed, ungrazed and hay) 2.5 percent water, 16.9 percent forest and 4.5 percent roads and farmstead. There are no permitted discharges within this watershed. Further discussion of the impacts of these landuses when combined with the natural landscape on Volga Lake water quality can be found in Section 4 of this report. The watershed to lake ratio is 41.4 to 1. This indicates landuse around the lake has a potentially high impact on water quality.

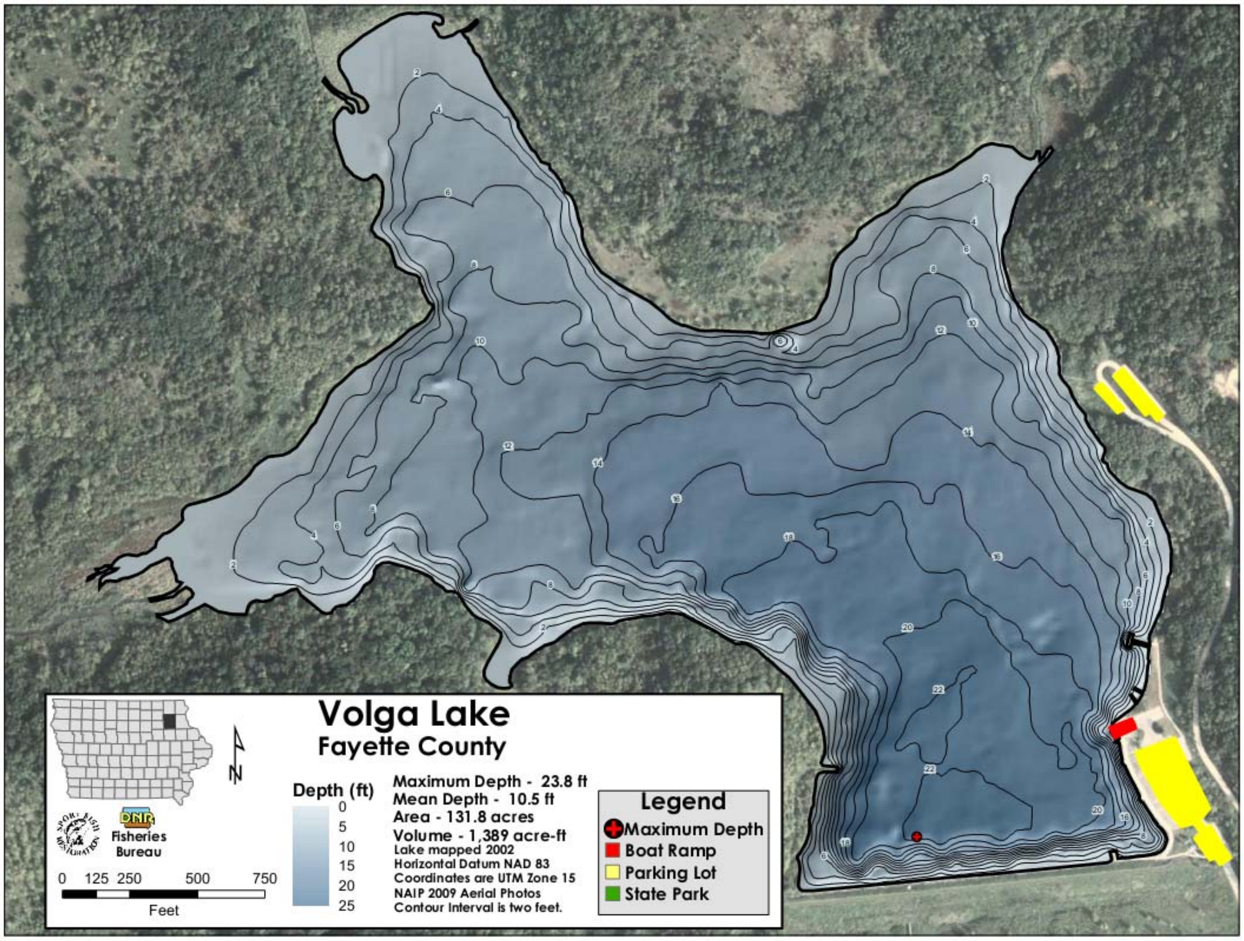

Figure 2.2. Bathymetric map of Volga Lake.
*Note lake area is listed at 131.8 acres but watershed delineation using updated LiDAR (Light Detection and Ranging) calculated the lake at 146 acres.

2.1. Volga Lake Watershed

Climate. The mean annual precipitation for the watershed from 2002-2009 was 39.4 inches of precipitation per year with a growing season average of 29.1 inches occurring between April and September (Figure 2.3). The driest month is January with an average of 1.0 inch of precipitation and the wettest month is June with an average of 4.4 inches of precipitation. The lowest mean temperature occurs in January at 19 degrees Fahrenheit and the highest mean temperature occurs in July with a mean of 74 degrees Fahrenheit.

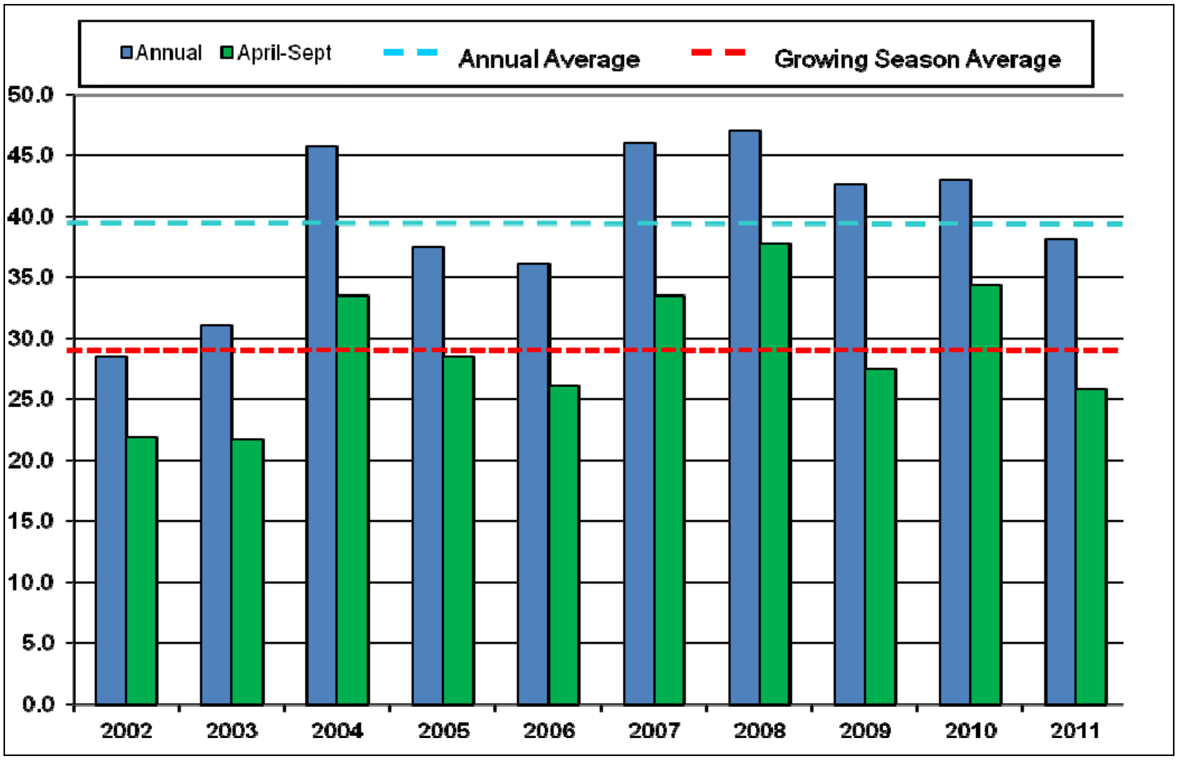

Figure 2.3. Annual and growing season precipitation at Fayette, Iowa.

Morphometry & Substrate. Volga Lake is on the transitional area between the Iowan Surface and Paleozoic Plateau regions. The Iowan Surface region was last covered by glaciers from 2.2 million to 500,000 years ago, then heavily eroded during the last glacial period from 21,000-16,500 years ago. The Iowan Surface today is characterized by gently rolling topography and low relief land.

The Paleozoic Plateau is nearly absent of glacial deposits. Fossil-bearing strata originated as sediment on tropical sea floors between 300 and 550 million years ago. Rock layers vary in resistance to erosion, producing bluffs, waterfalls, and rapids. Shallow limestone coupled with the dissolving action of groundwater yields numerous caves, springs, and sinkholes.

The general soils within the region are the Fayette-Nordess-Rock outcrop associations, which are moderately sloping to very steep, well to excessively drained soils that form in loess overlying limestone bedrock in the uplands. In the flood plain of the Volga and the land directly adjacent to the lake the general soils are the Dorchester-Saude-Waspsi association, which are well drained soils formed in silty and loamy alluvial sediment.

2.2. Usage and economic impact.

The Iowa Lakes Valuation Project, completed by the Center for Agricultural and Rural Development (CARD) at Iowa State University (http://www.card.iastate.edu/lakes/), found that Volga Lake typically meets or exceeds the state average for household visits to state lakes (Figure 2.4). This lake is the only substantial recreational lake within Fayette county averaging over 80,000 household visits per year.

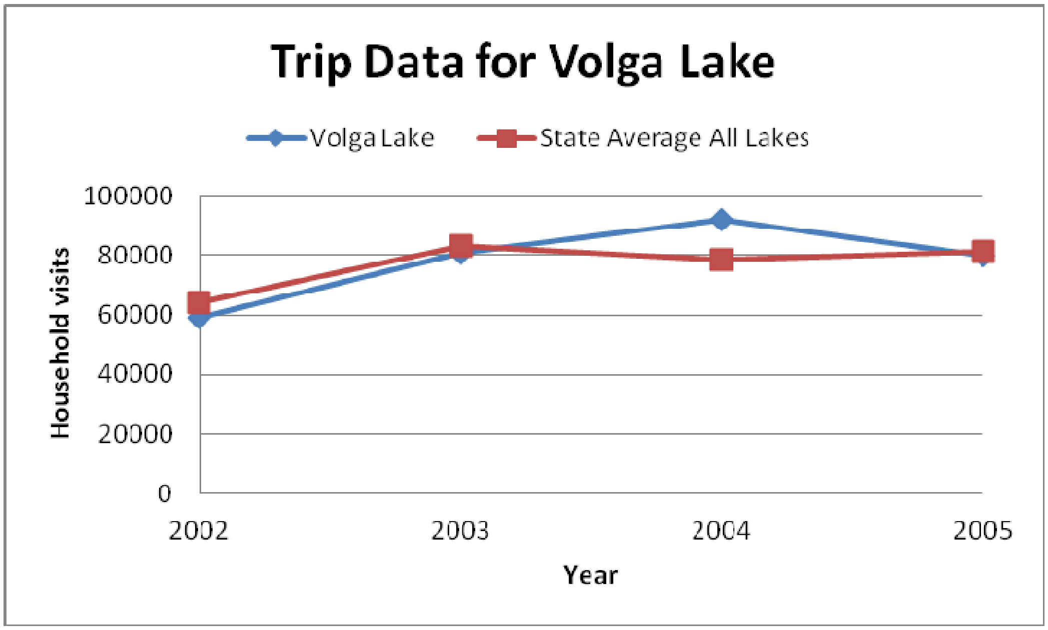

Figure 2.4. Trip data for Volga Lake from 2002-2005 as reported by CARD.

3. Total Maximum Daily Load (TMDL) for Algae and Non-Algal Turbidity

A Total Maximum Daily Load (TMDL) is required for Volga Lake by the Federal Clean Water Act. This section of the Water Quality Improvement Plan (WQIP) describes the pollutant, in this case phosphorus, leading to the algal and non-algal turbidity impairments and the maximum amount of total phosphorus (TP) the lake can assimilate and still support primary contact recreation in Volga Lake.

3.1. Problem Identification

As previously stated, the Class A1 (primary contact recreation) uses at Volga Lake are "partially supported" due to elevated chlorophyll-a (algae) levels and high levels of turbidity. This is a two-fold problem that requires analyzing the algal component and the non-algal component separately and then understanding how they are intertwined, especially in remediation efforts. Table 3.1 outlines the common terminology used when discussing turbidity in lakes.

Table 3.1. Turbidity and related parameters.

Parameter	Physical Meaning
Turbidity	Properties of the water column that cause light to be scattered and absorbed, primarily caused by algal and inorganic total suspended solids (TSS)
Secchi Depth, meters	Measures water column transparency and used as a translator for turbidity
TSS mg/l	Total Suspended Solids: Solid residue captured on a 0.45 um filter and dried at 105º C
ISS, mg/l	Solids residue remaining after heating at 550º C. Approximates inorganic suspended solids in the water column. **This is generally referred to as non-algal turbidity.**
VSS, mg/l	Volatile Suspended Solids: Weight loss after heating, VSS is the difference between TSS and ISS. In a lake most of the VSS will be the algae
Chlorophyll-a, mg/l	Because Chlorophyll-a is produced during photosynthesis, it can be used to measure algae concentration in the water column. Usually, chlorophyll-a and VSS will show a strong relationship.
Total Phosphorus, mg/l	Total phosphorus is often the limiting factor in algal blooms, or simply, this is usually what algae will run out of first. By controlling phosphorus levels, algal activity can be reduced.

Phosphorus cycle and algal blooms.
Most phosphorus enters lakes attached to sediment that washes in from surface erosion and runoff. The erosion and runoff is precipitation driven but can vary largely due to slope and landuse. As the phosphorus enters the lake it becomes available for algae within the lake to use in their own lifecycle processes. In general for algae to really flourish three things are needed: light, nitrogen and phosphorus. Of these three, phosphorus is usually the limiting factor. Therefore, when excess phosphorus is introduced into a lake, there is nothing keeping algal growth in check. By limiting phosphorus, algal growth is also limited.

Algae proliferate quickly but are also short lived so the bloom dies off and the decaying mass can also lead to decreased water clarity. Algal blooms are aesthetically objectionable and can make swimming or wading hazardous. Additionally, the blooms can lead to additional water quality issues.

Non-algal turbidity is composed of inorganic particles, which in most lakes is sediment. The sediment washes into the lake and settles at the bottom. However, in shallow lakes this can be re-suspended by wind driven waves and rough fish such as carp.

The controls and measures used to reduce phosphorus in the lake will also target the bottom sediment and its sources. Therefore, by targeting phosphorus overall, both impairments will be addressed.

303(d) listing for aesthetically objectionable conditions.

These narrative criteria require that waters be free from "aesthetically objectionable conditions."

61.3(2) *General water quality criteria. The following criteria are applicable to all surface waters including general use and designated use waters, at all places and at all times for the uses described in 61.3(1)"a."*
c. Such waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor or other aesthetically objectionable conditions.

The WQS can be accessed on the web at
http://www.legis.iowa.gov/DOCS/ACO/IAC/LINC/Chapter.567.61.pdf

For 303(d) listing the Carlson Trophic State Index (TSI) is used to evaluate the water quality. Since there are no numeric water quality parameters that can be invoked, this analysis offers a metric with which to compare lakes and water quality. A trophic state is the level of ecosystem productivity, typically measured in terms of algal biomass. The Carlson Trophic State Index takes this a step further. This is 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. Therefore, the higher the TSI value for Secchi Depth, phosphorus or chlorophyll-a, the worse the water quality.

Understanding how TSI describes the overall lake system and not just the water clarity requires introducing the additional concept of eutrophication. This is the process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These typically promote excessive growth of algae (Art 1993). Table 3.2 ties TSI values to their corresponding eutrophication state and gives additional details of impacts on the lake system, impacts to recreation and to aquatic life.

In Iowa the listing/de-listing of Iowa lakes is tied to the TSI values for Secchi Depth and Chlorophyll-a. Addition to the 303(d) list occurs when the median summer TSI for either parameter exceeds 65. In order to de-list, the median TSI must not exceed 63 in two consecutive listing cycles. Two consecutive cycles would include 7-8 sampling years.

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).

Interpreting Volga Lake Data.
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 Table 3.3.

Table 3.3. List of data/sources.

Precipitation	• NWS COOP at Fayette (2001-2011)
In-Lake Water Quality	• Ambient lake data (2001-2011)
Land Cover/Landuse	• USDA NASS and CLU coverages
Topography	• 10m DEM from Iowa DNR GIS library
Lake Bathymetry	• Iowa DNR mapping in 2009 and 1986

From 2002-2011, annual median TSI(Chl-a) exceeded the listing threshold of 65 a total of eight years and TSI(Secchi) exceeded a total of four years (Figure 3.1). Additionally, this figure depicts a relationship between TSI(TP) and the other two TSI parameters. A higher TSI(TP) directly correlates to a higher TP concentration.

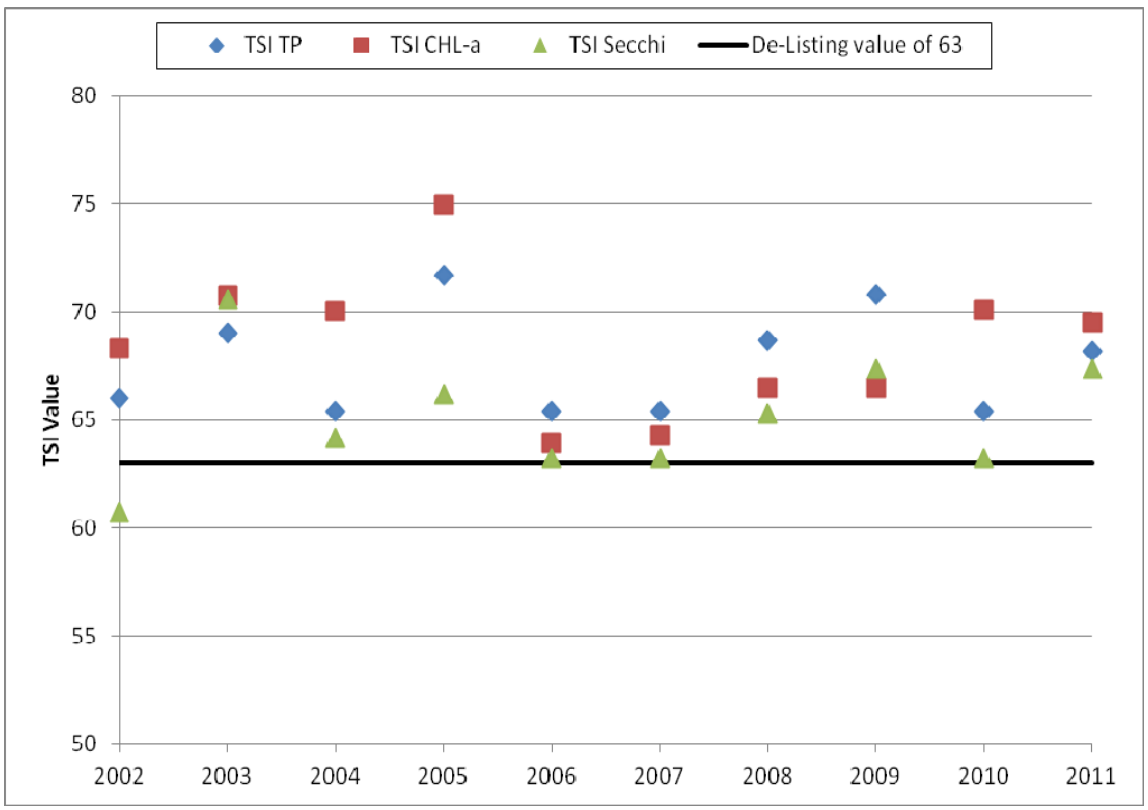

Figure 3.1. TSI annual medians over time.

Determining what part algae plays in reduced visibility verses ISS can be diffucult to quantify. Both parameters can be compared against observed Secchi depth to determine if there is a relationship. Many times any observed correlation will be weak. In Volga Lake the relationship between Secchi depth verses chlorophyll-a, TSS and ISS were made. A higher R-square value corresponds to a stronger correlation.

Not surprisingly, the strongest relationship was between TSS and Secchi depth. Since the TSS is composed of both organic and inorganic particles this would represent both algal and non-algal turbidity (Figure 3.2). The relationship between Secchi Depth to ISS and Secchi Depth to Chlorophyll-a were much weaker (Figures 3.3 and 3.4). This supports the assessment findings that algal bloom activity is the primary cause of decreased clarity with non-algal turbidity playing a smaller secondary role. This also supports the approach of targeting phosphorus entering the lake.

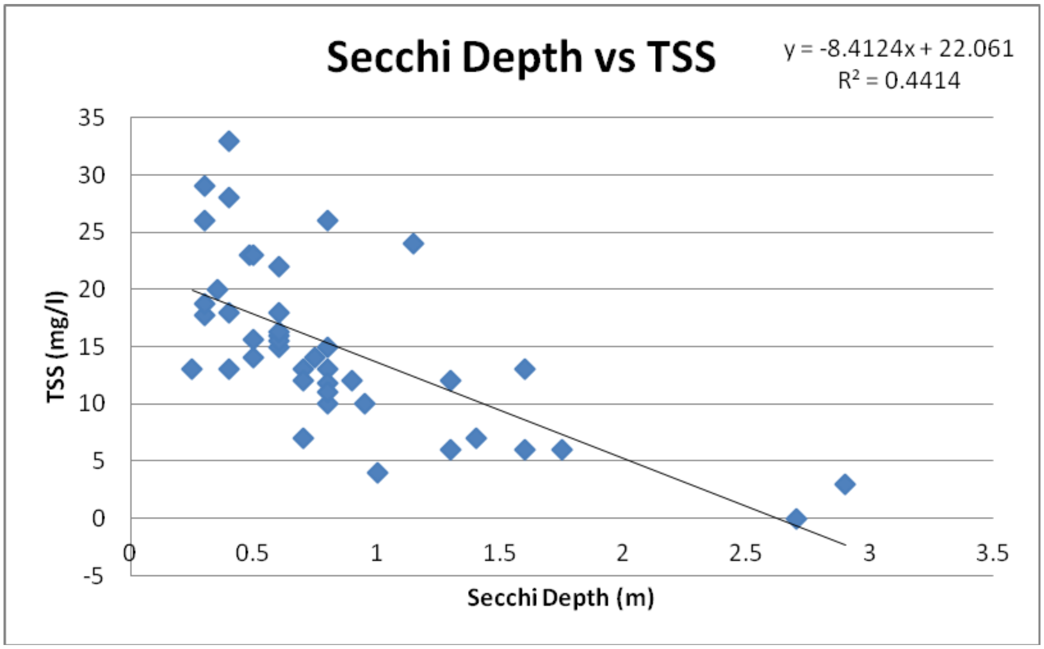

Figure 3.2. The relationship between Secchi depth and TSS.

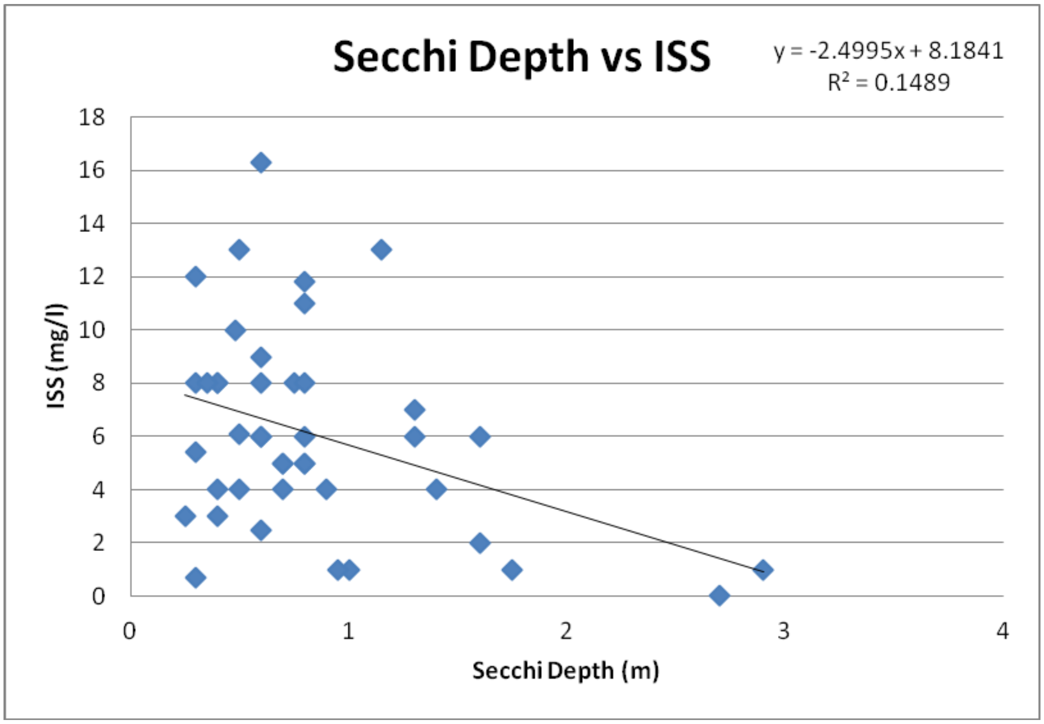

Figure 3.3. The relationship between Secchi depth and ISS.

In both cases it is clear that as TSS and ISS increase, Secchi depth decreases and water clarity worsens.

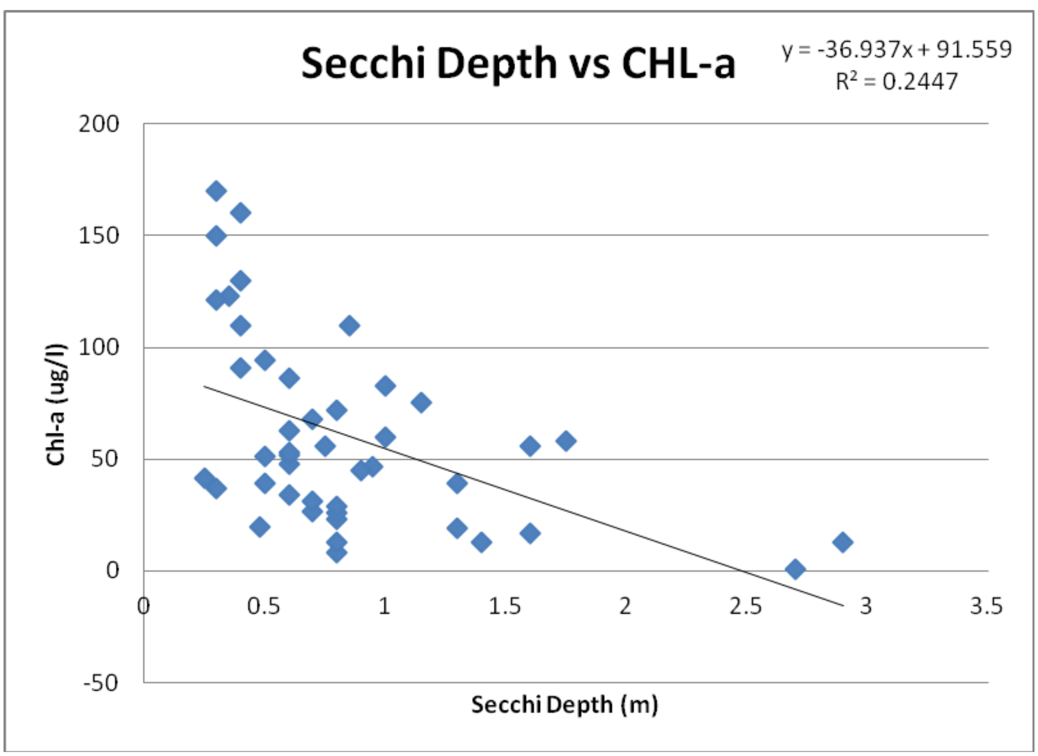

Figure 3.4. The relationship between Secchi depth and Chlorophyll-a.

3.2. TMDL Target

General description of the pollutants. As established in the previous sections, Volga Lake is impaired for excessive algal growth and turbidity. These are both caused by excess phosphorus entering the system. Beginning with this section, the primary focus of this document will be quantifying and reducing phosphorus loads to remediate the water clarity issues. The TMDLs for algae and non-algal turbidity are based on in-lake phosphorus targets. Phosphorus is an appropriate surrogate pollutant because measures to control phosphorus will target both the watershed sources and the in-lake sources that also lead to non-algal turbidity issues through re-suspension.

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 contribute to blooms regardless of when phosphorus first enters the lake. 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 Volga Lake are expressed as annual averages. Phosphorus loads are also expressed as daily maximums to comply with EPA guidance.

Decision criteria for water quality standards attainment. The narrative criteria in the water quality standards require that Volga 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 chlorophyll-a TSI of no greater than 63, which corresponds to a chlorophyll-a concentration of 27 ug/L. IDNR will de-list the impairment if the chlorophyll-a TSI is 63 or less in two consecutive 303(d) listing cycles, per the methodology Iowa DNR uses to develop the Integrated Report.

Additionally, non-algal turbidity corresponding to a Secchi TSI target of no greater than 63 (0.8 m) must also be met. Meeting the Chl-a TSI target resulted in a Secchi depth of 1.6 meters, which is well above the required 0.8 meters needed to meet a Secchi TSI of 63. Therefore, measures taken to reduce TP to meet the Chl-a TSI target will also result in reducing non-algal turbidity to meet that target.

3.3. Pollution Source Assessment

Existing load. Average annual simulations 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 and BATHTUB, the average annual TP load to Volga Lake from 2002-2011, including watershed, internal, and atmospheric loading was estimated to be 6,774lbs/yr.

Departure from load capacity. The target TP load, also referred to as the load capacity, for Volga Lake is 2,396 lbs. To meet the target loads, an overall reduction of 65 percent of the TP load is required. This will require BMPs in addition to those already implemented during previous watershed improvement efforts. The implementation plan included in Section 4 describes potential BMPs, potential TP reductions, and considerations for targeted selection and location of BMPs.

Identification of pollutant sources. The existing TP load to Volga 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 and resulting water quality based on the STEPL and BATHTUB simulation of 2002-2011 conditions.

There is an animal feeding operation within the watershed. This operation does not require a permit from the Iowa Department of Natural Resources nor does it meet EPA's definition of a CAFO because it does not meet any of the discharge criteria for medium sized CAFOs (source link: http://www.epa.gov/npdes/pubs/cafo_permitmanual_chapter2.pdf). Under Iowa law, animal feeding operations cannot discharge. Therefore, this operation does not require a WLA.

Livestock, wildlife, and manure application were accounted for in the STEPL model. A windshield assessment of this watershed identified only minor gully formation and is not considered a significant source or phosphorus. Numbers of livestock, geese, raccoons, beavers, and deer can be found in Appendix D. Additionally, traditional fall and spring manure applications were addressed within STEPL. None of these sources accounted for significant loads to the lake.

The two largest inputs appear to be coming from cropland (51 percent of the external load) along with the significant internal load already within the lake (28 percent of the total load). Table 3.4 and Table 3.5 depict the loads as they correspond to the total load and then the percent of the individual landuse contributions to the external load. Figure 3.5 breaks down the percent of landuse inputs.

The BATHTUB model developed for the TMDL accesses landuse inputs of phosphorus and allows for quantification of inputs. Figure 3.5 quantifies percentage of the phosphorus load per land use. This will allow for better targeting when considering phosphorus reduction strategies. Section 4 of this document will further discuss strategies to reduce phosphorus.

Table 3.4. Average Annual TP input.

Parameter	Value	Unit
Phosphorus	6774	lbs/yr
(External)*	4874	lbs/yr
(Internal)	1900	lbs/yr
Chlorophyll-a	61	ug/l
Secchi	0.8	m
TSI (TP)	70.4	
TSI (Chl-a)	70.7	
TSI (Secchi)	63.9	

*includes atmospheric load of 39.02 lb/yr

Table 3.5. Average annual TP external loads from each source.

Source	Description	lbs/yr	Percent
Cropland	Corn and Soybean	2466	50.6
Forest	Ungrazed timber includes shrub	822	16.9
Pasture	Grazed and ungrazed private	822	16.9
Grassland	Public parkland, ungrazed private	532	10.9
Urban	City, town, farmstead, road	193	4.0
Atmosphere	Wind and rain	39	0.8
Total		**4874**	**100**

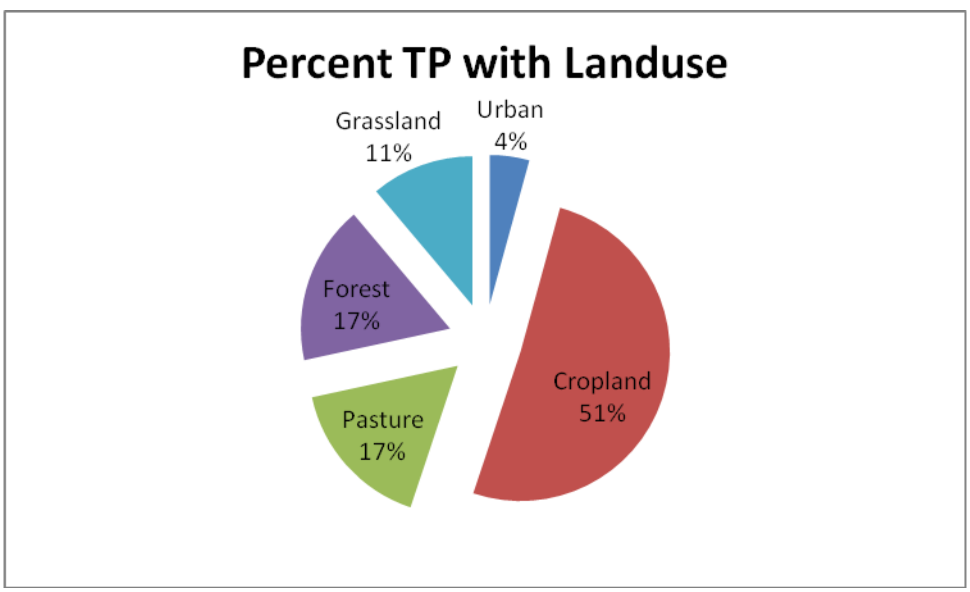

Figure 3.5. Percentage of the phosphorus load per land use.

Allowance for increases in pollutant loads. There is no allowance for increased phosphorus loading included as part of this TMDL. 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.

3.4. Pollutant Allocation

Wasteload allocation. There are no permitted point source dischargers of phosphorus in the Volga Lake watershed. Therefore, the wasteload allocation (WLA) is zero.

Load allocation. Nonpoint sources to Volga Lake include loads from agricultural land uses, internal recycling in the lake, and natural/background sources in the watershed, including wildlife and atmospheric deposition (from dust and rain). Changes in agricultural land management, implementation of structural best management practices (BMPs), and in-lake restoration techniques can reduce phosphorus loads and improve water quality in Volga Lake.

The load allocation for this lake is:

Annual = LA 2,156.76 lbs-TP/year

TMDL (daily)= LA 23.76 lbs-TP/day

Margin of safety. To account for uncertainties in data and modeling, a margin of safety (MOS) is a required component of all TMDLs. An explicit MOS of ten percent was utilized in the development of this TMDL. MOS for this lake is:

Annual = MOS 239.64 lbs-TP/year

TMDL (daily) = MOS 2.64 lbs TP-day

3.5. TMDL Summary

The following equation represents the total maximum daily load (TMDL) and its components for Volga Lake:

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

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)

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

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

Annual = LC = Σ WLA (0 lbs-TP/year) + Σ LA (2,156.76 lbs-TP/year)
+ MOS (239.64 lbs-TP/year) = **2,396.4 lbs-TP/year**

Expressed as the allowable maximum daily load as required by EPA:

TMDL= LC = Σ WLA (0 lbs-TP/day) + Σ LA (23.76 lbs-TP/day)
+ MOS (2.64 lbs TP-day) = **26.4 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 likely that only a portion of BMPs included in this plan will be feasible for implementation in the Volga Lake watershed. Additionally, there may be potential BMPs not discussed that should be considered. This implementation plan should be used as a guide or foundation for detailed and comprehensive management/restoration plan development by local stakeholders.

Collaboration and action by residents, landowners, lake patrons, and local agencies will be essential to improve water quality in Volga 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 Volga 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.

The primary focus of this implementation plan will be reducing phosphorus loads to remediate the water clarity issues. Phosphorus is an appropriate surrogate pollutant because measures to control phosphorus will target both the watershed sources and the in-lake sources, which also lead to non-algal turbidity issues through re-suspension.

4.1. General Approach & Reasonable Timeline

Watershed management and BMP implementation to reduce algae and non-algal turbidity in the lake should utilize a phased approach to improving water quality. The preliminary phase(s) should consist of planning and implementation of watershed BMPs required to meet water quality standards (WQS).

A reasonable timeline for long term watershed projects aimed at improving water quality is usually measured in years or decades. Not only will the watershed BMPs take time to construct but in-lake phosphorus must also be allowed to be worked through the system.

The general approach must take into account this is really a twofold problem. The Load Allocation (LA) is the portion of the TMDL that must be addressed through non-point source controls. The LA is really comprised of three main parts: the external and internal loads along with an atmospheric load see table 4.1.

Table 4.1. Source assessment for implementation prioritization.

	Load (lbs/yr)
LA	2156.76
Atmospheric	39.02
Non-point External	1452.64
Non-point Internal	666.15
WLA	0
MOS	239.64
TMDL	2396.4

The general approach should first take into account the non-point source load via the best management practices described below. Once the external load is controlled the lake will want to be assessed for the need of in-lake restoration also discussed within this section.

4.2. Watershed Best Management Practices

Best management practices are dictated by landscape. Both the installation and effectiveness of any practice is entirely dependent on being installed within the right area and landuse. The Volga Lake watershed sits on a divide between two ecoregions in Iowa. The soils and slopes of each ecoregion largely determine the erosion rates of soils in natural landscapes.

Highly erodible land (HEL) is classified by the Natural Resource Conservation Service (NRCS) as land, which if used to produce an agricultural commodity, would have an excessive annual rate of erosion as determined by the Universal Soil Loss Equation (USLE). Figure 4.1 depicts the HEL lands within the Volga Lake watershed. There is a clear pattern of HEL land within the eastern half of the watershed where soils associated with the Paleozoic Plateau are found.

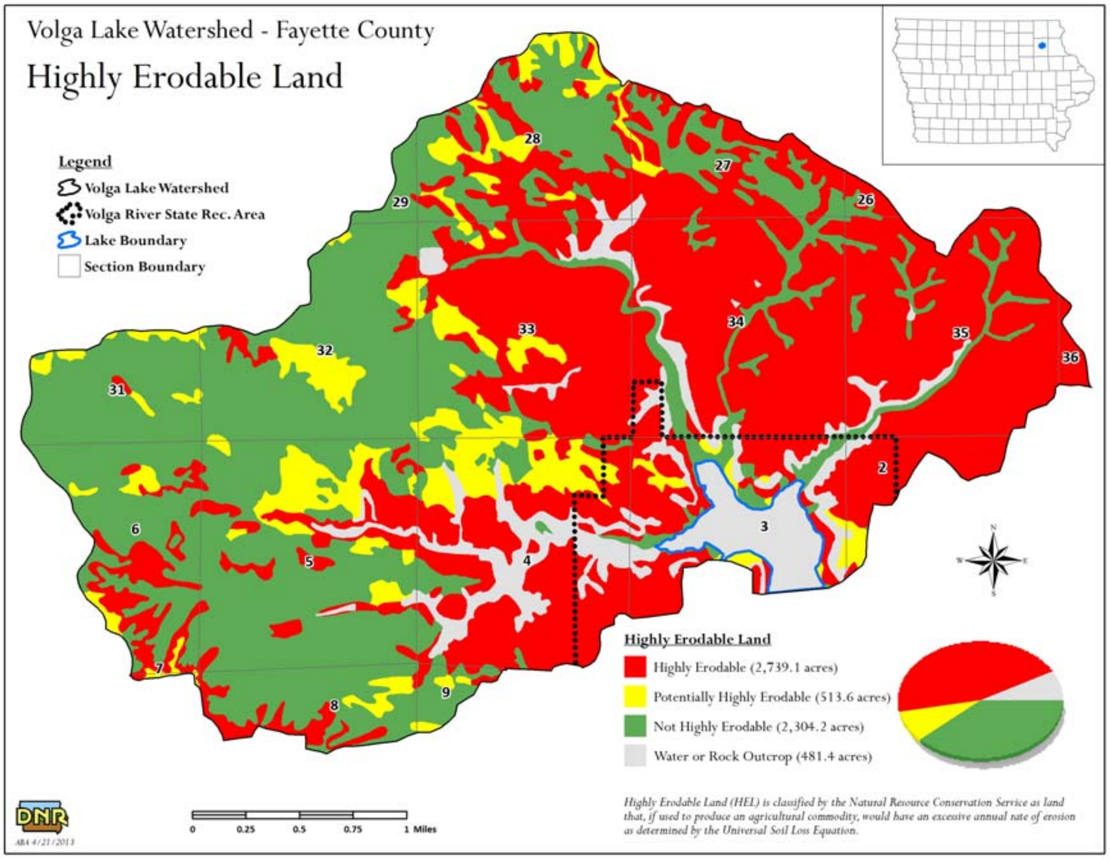

Figure 4.1. The highly erodible land within the Volga Lake Watershed.

Figure 4.2 overlays where row crops are planted within the watershed. Areas of HEL that are row cropped represent areas that should be considered high priority for watershed BMPs. These BMPs would include structural BMPs such as terraces in high slopes, grass waterways and sediment control structures or wetlands. Best management practices could also be operational such as conservation tillage, perennial strips, cover crops, and nutrient applications strategies. Ultimately, a combination of structural and operational BMPs will yield the best results in reducing phosphorus. Tables 4.2 and 4.3 give more detailed information on structural and operational BMPs.

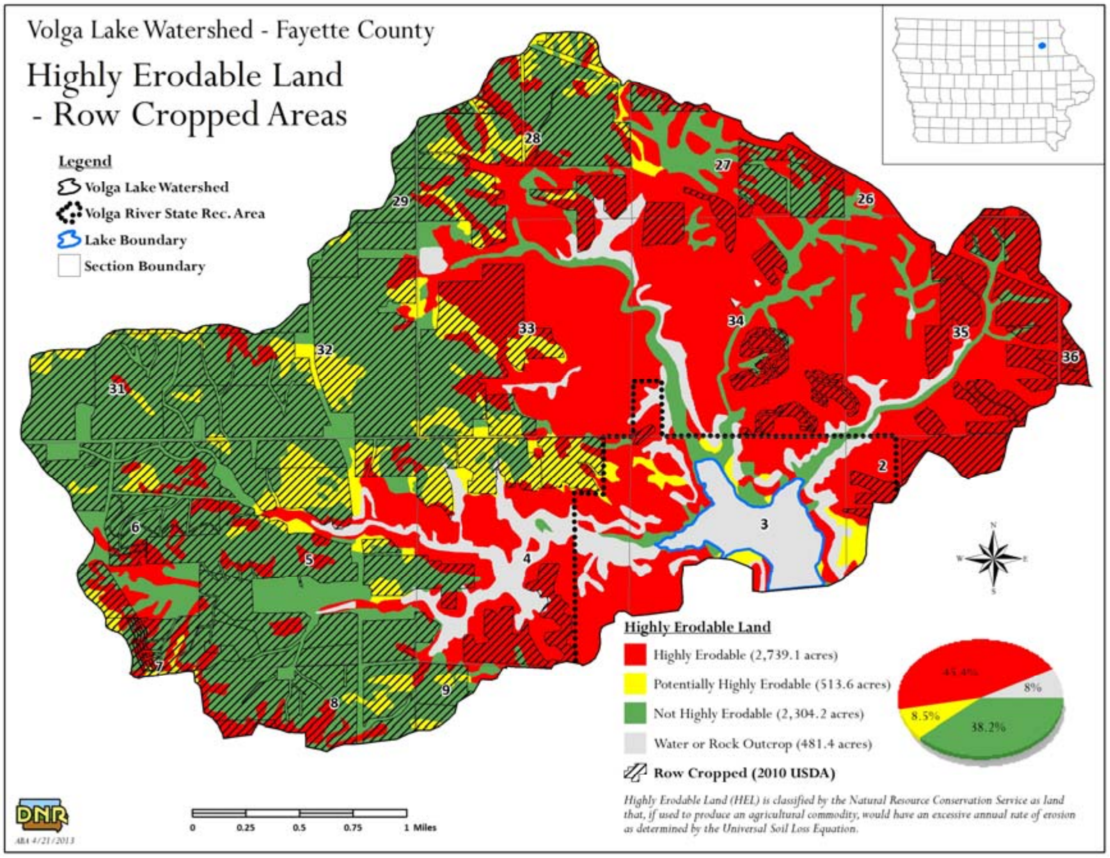

Figure 4.2. Row cropped land within the watershed. Row cropped HEL should be considered high priority for BMPs.

Table 4.2. Structural BMPs.

BMP or Activity	Secondary Benefits	[1] Potential TP Reduction
Terraces	Soil conservation, prevent in-field gullies, prevent wash-outs	50%
[2]Sediment Control Structures	Some ecological services, gully prevention	85%
[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] Reductions reported by Section 2:Nonpoint Source Nutrient Reduction Science Assessment (2012), Iowa Nutrient Reduction Strategy.
[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

Table 4.3. Potential land management BMPs.

BMP or Activity	[1] Potential TP Reduction
Conservation Tillage: Moderate vs. Intensive Tillage No-Till vs. Intensive Tillage No-Till vs. Moderate Tillage	 50% 70% 45%
Cover Crops	50%
Diversified Cropping Systems	50%
In-Field Vegetative Buffers	50%
Phosphorus Nutrient Application Techniques Knife/Injection Incorporation vs. Surface Broadcast	 35%
Phosphorus Nutrient Application Timing and Rates: Spring vs. Fall Application Soil-Test P Rate vs. Over-Application Rates Application: 1-month prior to runoff event vs. 1-day	 30% 40% 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.

4.3. In Lake Best Management Practices

As the watershed sources are remediated, focus should shift to in-lake approaches that could be used. Phosphorus recycled between the bottom sediment and water column of the lake is, at times, an important contributor of bioavailable phosphorus to Volga Lake. While smaller than watershed loads on an annualized basis, internal loads can be the primary driver of eutrophication in dry years with little surface runoff to the lake. Phosphorus exported from the watershed to the lake bottom sediments may become readily available through resuspension of the internal load. 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 and when monitoring shows that the external watershed load has been reduced / controlled, then additional in-lake measures may be warranted.

Assessing shorelines in spring and fall for unstable slumping areas and then stabilizing these with vegetation may possibly help with controlling in-lake concentrations of phosphorus. While not considered a source in this TMDL, shorelines are constantly changing and shifting due to natural processes and the large amount of use they get from people. Making sure these are armored and stable on a regular basis is important. Additionally, direct removal of phosphorus by dredging of lake bottom sediment might be a possibility. However, as mentioned in Section 2 this is a bentonite lined lake which might present difficulty since breaking the lining could lead to leakage. If dredging is a desired alternative and adequate funding is available, technical analysis for watershed management and lake restoration planning should evaluate the impact of increased mean depth on in-lake water quality. Table 4.4 outlines potential in-lake and near shore BMPs.

Table 4.4. Potential in-lake BMPs for water quality improvement.

In-Lake BMPs	Comments	[1]Relative TP Reduction
Targeted dredging	Targeted dredging in shallow inlet areas would create pockets of deep-water habitat for predatory fish that would help control rough fish populations. Strategic dredging would also increase the sediment capacity of the inlet areas, thereby reducing sediment loads to the larger, open water area of the lake	Med
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. A cost benefit analysis may be necessary to examine the feasibility of large-scale dredging in Volga Lake.	Med-High
Shoreline stabilization (public areas)	Helps establish and sustain vegetation, which provides local erosion protection and 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 Volga Lake is publicly owned, making this alternative possible in all areas of the lake.	Low

[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 Volga 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. Monitoring Plan to Track TMDL Effectiveness

Future data collection in Volga Lake to assess water quality trends and compliance with water quality standards (WQS) is expected to include monitoring conducted as part of the Iowa DNR Ambient Lake Monitoring Program. Unless there is local interest in collecting additional water quality data, future sampling efforts will be limited to this basic monitoring program.

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

5.2. Expanded Monitoring for Detailed Assessment and Planning

Data available from the Iowa DNR 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. Figure 5.1 depicts where the ambient lake monitoring samples will be gathered along with tributary sites that would be helpful in monitoring the effectiveness of BMPs and the water quality entering the upper portion of the lake. Section 5.3 will further describe tributary monitoring.

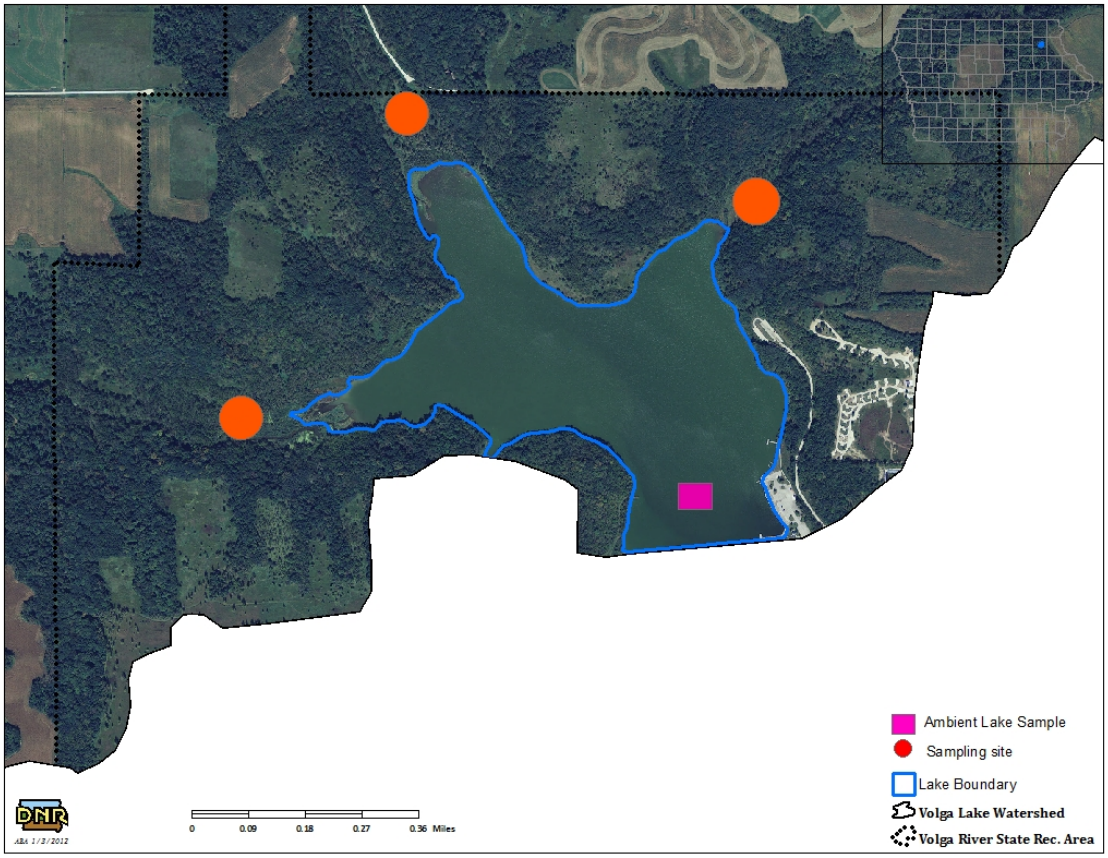

Figure 5.1. Sample locations for Volga Lake monitoring.

Monitoring of these sites might result in the decision to add additional sites further upstream in the watershed if better quantification of tributary load becomes necessary. Additional sites within the lake might also be desired in the future.

5.3. Idealized Plan for Future Watershed Projects

Table 5.2 outlines the detailed 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 expanded plan can be used to help identify and prioritize monitoring data needs.

Table 5.2. Expanded 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	Ambient and Tributaries
Continuous flow	15-60 minute	April through October	Lake Outfall
Continuous pH, DO, turbidity and temperature	15-60 minute	April through October	Ambient and Tributaries
Runoff event flow, TSS/ISS, P, and N	Continuous flow, composite WQ	3 events between April and October	Tributaries
Event or continuous flow, turbidity N, and P sampling	15-60 minute	10 to 14-day wet weather periods if continuous sampling is not feasible	Tributaries

[1]Final location of tributary sites should be based on BMP placement, landowner permission, and access/installation feasibility.

Routine weekly or bi-weekly grab sampling with concurrent in-lake and tributary data (ambient location and tributaries in Figure 5.1) would help identify long-term trends in water quality and nutrient loading. Particularly, grab samples both upstream and downstream of BMPs to assess efficiency of each structure would be helpful in assessing the overall watershed. Data collection should commence before additional BMPs are implemented in the watershed to establish baseline conditions. 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 in the tributaries and at the outlet (i.e., spillway) of the lake would improve the predictive ability and accuracy of modeling tools, such as those used to develop the TMDL for Volga 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 the ambient monitoring location and possibly in tributaries 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.

The proposed expanded 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 Iowa DNR Watershed Improvement Section can provide technical support to locally led efforts in collecting further water quality and flow monitoring data in the Volga 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 Volga Lake. During the development of this TMDL, efforts were made to ensure that local stakeholders were involved in the decision-making process to agree on feasible and achievable goals for the water quality in Volga Lake.

6.1. Public Meetings

Prior to TMDL development, park officials were contacted to give input on lake history and conditions via telephone in July of 2012. Additionally there were primary contacts with park officials for input on where to place monitoring equipment for additional outfall monitoring performed the summer of 2010.

A public meeting presenting the WIQP was held on Thursday, October 17th, 2013 at the Iowa State University Extension office in Fayette, Iowa. The meeting was attended by Iowa DNR Fisheries, park management, private landowners and county officials.

6.2. Written Comments

One comment was received during the public comment period. The comment and Iowa DNR’s response is included in Appendix G.

7. References

Art, H.W., 1993, Eutrophication, *in* Art, H.W., ed., A dictionary of ecology and environmental science (1st ed.): New York, New York, Henry Holt and Company, p. 196.

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

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). 1978. Soil Survey of Fayette 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.

Modeling 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.

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 water bodies are judged when determining the health and quality of our aquatic ecosystems. These standards vary depending on the type of water body (lakes vs. rivers) and the assigned uses (general use vs. designated uses) of the water body that is being dealt with. This appendix is intended to provide information about how Iowa's water bodies 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 water body.

General Use Segments

A general use segment water body is one which 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 which 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 water body, 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 water bodies which maintain flow throughout the year, or at least hold pools of water which 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 a total of thirteen different designated use classes (Table B.1) which may apply, and a water body 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 water bodies.

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

Appendix C --- Water Quality Data

Parameter: Depth		
Date	**Value**	**Unit**
06/12/02	6.8	m
07/17/02	6.7	m
08/13/02	6.7	m
06/11/03	7.2	m
07/10/03	6.7	m
07/15/03	6.9	m
07/22/03	6.3	m
08/05/03	6.7	m
08/13/03	6.9	m
08/19/03	6.9	m
09/16/03	6.7	m
09/30/03	6.9	m
06/09/04	7.1	m
07/14/04	6.8	m
08/10/04	7	m
05/24/05	6.8	m
06/14/05	7	m
07/19/05	6.7	m
07/28/05	6.7	m
08/09/05	6.9	m
09/22/05	6.7	m
05/24/06	6.8	m
06/22/06	6.7	m
08/02/06	6.4	m
09/07/06	6.5	m
05/14/07	6.8	m
07/17/07	6.6	m
09/04/07	6.6	m
05/20/08	6.7	m
07/14/08	6.5	m
06/23/09	6.6	m
07/28/09	6.7	m
08/19/09	6.5	m
05/05/10	6.4	m
06/08/10	6.5	m
06/10/10	6.6	m
07/08/10	6.6	m
07/27/10	6.6	m
08/03/10	6.6	m
09/01/10	6.5	m
06/07/11	6.5	m
07/26/11	6.4	m
09/20/11	6.4	m

Parameter: Total Phosphorus		
Date	Value	Unit
06/12/02	66	ug/l
07/17/02	73	ug/l
08/13/02	104	ug/l
06/11/03	68	ug/l
07/10/03	70	ug/l
07/15/03	81	ug/l
07/22/03	90	ug/l
08/05/03	70	ug/l
08/13/03	128	ug/l
08/19/03	120	ug/l
09/16/03	190	ug/l
09/30/03	160	ug/l
06/09/04	70	ug/l
07/14/04	95	ug/l
08/10/04	64	ug/l
05/24/05	90	ug/l
06/14/05	49	ug/l
07/19/05	77	ug/l
07/28/05	130	ug/l
08/09/05	158	ug/l
09/22/05	210	ug/l
05/24/06	60	ug/l
06/22/06	70	ug/l
08/02/06	480	ug/l
09/07/06	70	ug/l
05/14/07	80	ug/l
07/17/07	70	ug/l
09/04/07	60	ug/l
05/20/08	70	ug/l
07/14/08	110	ug/l
06/23/09	45.5	ug/l
07/28/09	106	ug/l
08/19/09	101.7	ug/l
05/05/10	50	ug/l
06/08/10	51.9	ug/l
06/10/10	70	ug/l
07/08/10	70	ug/l
07/27/10	119.4	ug/l
08/03/10	130	ug/l
09/01/10	120	ug/l
06/07/11	24.9	ug/l
07/26/11	85	ug/l
09/20/11	115.3	ug/l

Parameter: Chlorophyll-a		
Date	Value	Unit
06/12/02	82.6	ug/l
07/17/02	46.8	ug/l
08/13/02	26.7	ug/l
06/11/03	33.9	ug/l
07/10/03	60	ug/l
07/15/03	19.9	ug/l
07/22/03	160	ug/l
08/05/03	170	ug/l
08/13/03	41.6	ug/l
08/19/03	110	ug/l
09/16/03	68	ug/l
09/30/03	17	ug/l
06/09/04	75.6	ug/l
07/14/04	55.6	ug/l
08/10/04	48	ug/l
05/24/05	13	ug/l
06/14/05	58.2	ug/l
07/19/05	109.5	ug/l
07/28/05	94	ug/l
08/09/05	122.9	ug/l
09/22/05	91	ug/l
05/24/06	39	ug/l
06/22/06	8	ug/l
08/02/06	86	ug/l
09/07/06	23	ug/l
05/14/07	26	ug/l
07/17/07	31	ug/l
09/04/07	45	ug/l
05/20/08	52	ug/l
07/14/08	29	ug/l
06/23/09	19	ug/l
07/28/09	63	ug/l
08/19/09	39	ug/l
05/05/10	13	ug/l
06/08/10	13	ug/l
06/10/10	72	ug/l
07/08/10	56	ug/l
07/27/10	37	ug/l
08/03/10	150	ug/l
09/01/10	130	ug/l
06/07/11	0.5	ug/l
07/26/11	121	ug/l
09/20/11	53	ug/l

Parameter: Secchi Depth		
Date	**Value**	**Unit**
06/12/02	1	m
07/17/02	0.95	m
08/13/02	0.7	m
06/11/03	0.6	m
07/10/03	1	m
07/15/03	0.48	m
07/22/03	0.4	m
08/05/03	0.3	m
08/13/03	0.25	m
08/19/03	0.4	m
09/16/03	0.7	m
09/30/03	1.6	m
06/09/04	1.15	m
07/14/04	0.75	m
08/10/04	0.6	m
05/24/05	2.9	m
06/14/05	1.75	m
07/19/05	0.85	m
07/28/05	0.5	m
08/09/05	0.35	m
09/22/05	0.4	m
05/24/06	1.3	m
06/22/06	0.8	m
08/02/06	0.6	m
09/07/06	0.8	m
05/14/07	0.8	m
07/17/07	0.7	m
09/04/07	0.9	m
05/20/08	0.6	m
07/14/08	0.8	m
06/23/09	1.3	m
07/28/09	0.6	m
08/19/09	0.5	m
05/05/10	1.4	m
06/08/10	0.8	m
06/10/10	0.8	m
07/08/10	1.6	m
07/27/10	0.3	m
08/03/10	0.3	m
09/01/10	0.4	m
06/07/11	2.7	m
07/26/11	0.3	m
09/20/11	0.6	m

Parameter: pH		
Date	**Value**	**Unit**
06/12/02	9.1	n/a
07/17/02	9.2	n/a
08/13/02	8.7	n/a
06/11/03	8.9	n/a
07/10/03	8.7	n/a
07/15/03	9.2	n/a
07/22/03	9.3	n/a
08/05/03	9.8	n/a
08/13/03	9.1	n/a
08/19/03	8.6	n/a
09/16/03	7.5	n/a
09/30/03	7.5	n/a
06/09/04	8.8	n/a
07/14/04	9	n/a
08/10/04	8.1	n/a
05/24/05	8.2	n/a
06/14/05	8.4	n/a
07/19/05	9.7	n/a
07/28/05	8.3	n/a
08/09/05	9	n/a
09/22/05	8.6	n/a
05/24/06	8.5	n/a
06/22/06	8.6	n/a
08/02/06	9	n/a
09/07/06	8.9	n/a
05/14/07	8.4	n/a
07/17/07	8.5	n/a
09/04/07	8.6	n/a
05/20/08	8.7	n/a
07/14/08	9.1	n/a
06/23/09	8.5	n/a
07/28/09	9.2	n/a
08/19/09	8.3	n/a
05/05/10	8.8	n/a
06/08/10	7.9	n/a
06/10/10	8.1	n/a
07/08/10	9	n/a
07/27/10	7.7	n/a
08/03/10	8.6	n/a
09/01/10	8.5	n/a
06/07/11	8.5	n/a
07/26/11	8.7	n/a
09/20/11	7.6	n/a

Parameter: Total Nitrogen		
Date	**Value**	**Unit**
06/12/02	5580	ug/l
07/17/02	1310	ug/l
08/13/02	1330	ug/l
06/11/03	2050	ug/l
07/10/03	2160	ug/l
07/15/03	2780	ug/l
07/22/03	2900	ug/l
08/05/03	2600	ug/l
08/13/03	2010	ug/l
08/19/03	2100	ug/l
09/16/03	2400	ug/l
09/30/03	2300	ug/l
06/09/04	13160	ug/l
07/14/04	9143	ug/l
08/10/04	7650	ug/l
05/24/05	1550	ug/l
06/14/05	920	ug/l
07/19/05	940	ug/l
07/28/05	1400	ug/l
08/09/05	1390	ug/l
09/22/05	1200	ug/l
05/24/06	4700	ug/l
06/22/06	3600	ug/l
08/02/06	1620	ug/l
09/07/06	800	ug/l
05/14/07	5500	ug/l
07/17/07	3100	ug/l
09/04/07	2600	ug/l
05/20/08	5200	ug/l
07/14/08	5300	ug/l
06/23/09	5160	ug/l
07/28/09	1760	ug/l
08/19/09	1300	ug/l
05/05/10	3300	ug/l
06/08/10	990	ug/l
06/10/10	4300	ug/l
07/08/10	4600	ug/l
07/27/10	5370	ug/l
08/03/10	4700	ug/l
09/01/10	2680	ug/l
06/07/11	4830	ug/l
07/26/11	4650	ug/l
09/20/11	2920	ug/l

Parameter: TSI (TP)		
Date	Value	Unit
06/12/02	65	n/a
07/17/02	66	n/a
08/13/02	71	n/a
06/11/03	65	n/a
07/10/03	65	n/a
07/15/03	68	n/a
07/22/03	69	n/a
08/05/03	65	n/a
08/13/03	74	n/a
08/19/03	73	n/a
09/16/03	80	n/a
09/30/03	77	n/a
06/09/04	65	n/a
07/14/04	70	n/a
08/10/04	64	n/a
05/24/05	69	n/a
06/14/05	60	n/a
07/19/05	67	n/a
07/28/05	74	n/a
08/09/05	77	n/a
09/22/05	81	n/a
05/24/06	63	n/a
06/22/06	65	n/a
08/02/06	93	n/a
09/07/06	65	n/a
05/14/07	67	n/a
07/17/07	65	n/a
09/04/07	63	n/a
05/20/08	65	n/a
07/14/08	72	n/a
06/23/09	59	n/a
07/28/09	71	n/a
08/19/09	71	n/a
05/05/10	61	n/a
06/08/10	61	n/a
06/10/10	65	n/a
07/08/10	65	n/a
07/27/10	73	n/a
08/03/10	74	n/a
09/01/10	73	n/a
06/07/11	51	n/a
07/26/11	68	n/a
09/20/11	73	n/a

Parameter: TSI (Chl-a)		
Date	**Value**	**Unit**
06/12/02	74	n/a
07/17/02	68	n/a
08/13/02	63	n/a
06/11/03	65	n/a
07/10/03	71	n/a
07/15/03	60	n/a
07/22/03	80	n/a
08/05/03	81	n/a
08/13/03	67	n/a
08/19/03	77	n/a
09/16/03	72	n/a
09/30/03	58	n/a
06/09/04	73	n/a
07/14/04	70	n/a
08/10/04	69	n/a
05/24/05	56	n/a
06/14/05	70	n/a
07/19/05	77	n/a
07/28/05	75	n/a
08/09/05	78	n/a
09/22/05	75	n/a
05/24/06	67	n/a
06/22/06	51	n/a
08/02/06	74	n/a
09/07/06	61	n/a
05/14/07	63	n/a
07/17/07	64	n/a
09/04/07	68	n/a
05/20/08	69	n/a
07/14/08	64	n/a
06/23/09	59	n/a
07/28/09	71	n/a
08/19/09	67	n/a
05/05/10	56	n/a
06/08/10	56	n/a
06/10/10	73	n/a
07/08/10	70	n/a
07/27/10	66	n/a
08/03/10	80	n/a
09/01/10	78	n/a
06/07/11	24	n/a
07/26/11	78	n/a
09/20/11	70	n/a

Parameter: TSI (Secchi)		
Date	**Value**	**Unit**
06/12/02	60	n/a
07/17/02	61	n/a
08/13/02	65	n/a
06/11/03	67	n/a
07/10/03	60	n/a
07/15/03	71	n/a
07/22/03	73	n/a
08/05/03	77	n/a
08/13/03	80	n/a
08/19/03	73	n/a
09/16/03	65	n/a
09/30/03	53	n/a
06/09/04	58	n/a
07/14/04	64	n/a
08/10/04	67	n/a
05/24/05	45	n/a
06/14/05	52	n/a
07/19/05	62	n/a
07/28/05	70	n/a
08/09/05	75	n/a
09/22/05	73	n/a
05/24/06	56	n/a
06/22/06	63	n/a
08/02/06	67	n/a
09/07/06	63	n/a
05/14/07	63	n/a
07/17/07	65	n/a
09/04/07	62	n/a
05/20/08	67	n/a
07/14/08	63	n/a
06/23/09	56	n/a
07/28/09	67	n/a
08/19/09	70	n/a
05/05/10	55	n/a
06/08/10	63	n/a
06/10/10	63	n/a
07/08/10	53	n/a
07/27/10	77	n/a
08/03/10	77	n/a
09/01/10	73	n/a
06/07/11	46	n/a
07/26/11	77	n/a
09/20/11	67	n/a

Parameter: Total Suspended Solids		
Date	Value	Unit
06/12/02	4	mg/l
07/17/02	10	mg/l
08/13/02	13	mg/l
06/11/03	22	mg/l
07/10/03	49	mg/l
07/15/03	23	mg/l
07/22/03	28	mg/l
08/05/03	26	mg/l
08/13/03	13	mg/l
08/19/03	33	mg/l
09/16/03	7	mg/l
09/30/03	6	mg/l
06/09/04	24	mg/l
07/14/04	14	mg/l
08/10/04	15	mg/l
05/24/05	3	mg/l
06/14/05	6	mg/l
07/19/05	14	mg/l
07/28/05	20	mg/l
08/09/05	13	mg/l
09/22/05	12	mg/l
05/24/06	10	mg/l
06/22/06	18	mg/l
08/02/06	15	mg/l
09/07/06	13	mg/l
05/14/07	12	mg/l
07/17/07	12	mg/l
09/04/07	16	mg/l
05/20/08	26	mg/l
07/14/08	6	mg/l
06/23/09	15.5	mg/l
07/28/09	15.6	mg/l
08/19/09	7	mg/l
05/05/10	11.8	mg/l
06/08/10	11	mg/l
06/10/10	13	mg/l
07/08/10	17.7	mg/l
07/27/10	29	mg/l
08/03/10	18	mg/l
09/01/10	23	mg/l
06/07/11	0	mg/l
07/26/11	18.7	mg/l
09/20/11	16.3	mg/l

Parameter: Total Volatile Solids		
Date	Value	Unit
06/12/02	3	mg/l
07/17/02	9	mg/l
08/13/02	8	mg/l
06/11/03	16	mg/l
07/10/03	9	mg/l
07/15/03	13	mg/l
07/22/03	20	mg/l
08/05/03	18	mg/l
08/13/03	10	mg/l
08/19/03	25	mg/l
09/16/03	3	mg/l
09/30/03	4	mg/l
06/09/04	11	mg/l
07/14/04	6	mg/l
08/10/04	9	mg/l
05/24/05	2	mg/l
06/14/05	5	mg/l
07/19/05	10	mg/l
07/28/05	12	mg/l
08/09/05	9	mg/l
09/22/05	5	mg/l
05/24/06	5	mg/l
06/22/06	10	mg/l
08/02/06	9	mg/l
09/07/06	5	mg/l
05/14/07	7	mg/l
07/17/07	8	mg/l
09/04/07	7	mg/l
05/20/08	15	mg/l
07/14/08	0	mg/l
06/23/09	13	mg/l
07/28/09	9.5	mg/l
08/19/09	3	mg/l
05/05/10	0	mg/l
06/08/10	6	mg/l
06/10/10	7	mg/l
07/08/10	12.3	mg/l
07/27/10	17	mg/l
08/03/10	15	mg/l
09/01/10	10	mg/l
06/07/11	0	mg/l
07/26/11	18	mg/l
09/20/11	0	mg/l

Appendix D --- Watershed Modeling Methodology

Watershed and in-lake modeling were used in conjunction with observed water quality data to develop the Total Maximum Daily Load (TMDL) for phosphorus as the primary cause for the algae and non-algal turbidity impairments to Volga Lake in Fayette County, Iowa. 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 6.14, 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 Volga Lake and its watershed. This section of the Water Quality Improvement Plan (WQIP) discusses the overall modeling approach, as well as the development of the STEPL watershed model.

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 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 Volga Lake watershed was delineated into subbasins based on LiDAR. The watershed was divided into six subbasins to help quantify the relative pollutant loads stemming from different areas of the watershed and to assist with assessing current BMPs and targeting potential future BMP locations. Hydrology and pollutant loadings are summarized for each subbasin and also aggregated as watershed totals.

D.2. Meteorological Input

Precipitation Data.
The STEPL model includes a pre-defined set of weather stations from which the user must choose to obtain precipitation-related model inputs. For the purpose of Volga Lake, the STEP-L default Waterloo station was chosen but then data from the Fayette station for the 2002-2011 sampling period was input. This resulted in an annual average rainfall of 39.35 inches to be used in the STEPL model and also within BATHTUB.

D.3. Watershed Characteristics

Delineation.
The Volga Lake watershed boundary was delineated based on LiDAR using the Soil Water Assessment Tool (SWAT) watershed delineation feature in GIS. Figure D.1 illustrates the watershed and subbasin boundaries.

Soils and Slopes and Curve Numbers.
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 Volga Lake watershed.

USLE K-factors vary spatially and by land use. K-factors for each landuse and subwatershed are entered into the "Input" worksheet in the STEPL model.
USLE land slope (LS) factors were obtained from a previous RUSLE assessment, and were area-weighted by land use within each STEPL subwatershed.

The STEPL model includes default curve numbers (CN) selected automatically based on HSG and land use inputs. The STEPL default CN was left in place for other land uses.

Sediment Delivery Ratio.
The total sediment load to the lake is smaller than total sheet and rill erosion because some 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). The SDR in STEPL was calculated at 0.183.

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. For this TMDL manure was applied for two months (spring and fall).

Livestock Grazing.
There are some small grazing operations but contributions are relatively insignificant (in terms of nutrient loading to the lake) and do not increase STEPL nutrient runoff parameters.

Animal Feeding.
A hog animal feeding operation is located within subbasin one and is represented within the STEPL model. This operation falls under permitted levels and does not meet EPA's criteria for a medium or large CAFO.

Wildlife.
STEPL assumes that wildlife add to the manure deposited on the land surface. If animal densities are significant, nutrient concentration in runoff is increased. For Volga Lake, an estimate of 50 geese and 8 deer per square mile (Fayette County Conservation estimate) were used. Both of these numbers represent over estimates. Additionally, 30 beavers and 30 raccoons per square mile were added. Even with overestimates of geese and deer populations, wildlife contributions are relatively insignificant (in terms of nutrient loading to the lake) and do not increase STEPL nutrient runoff parameters.

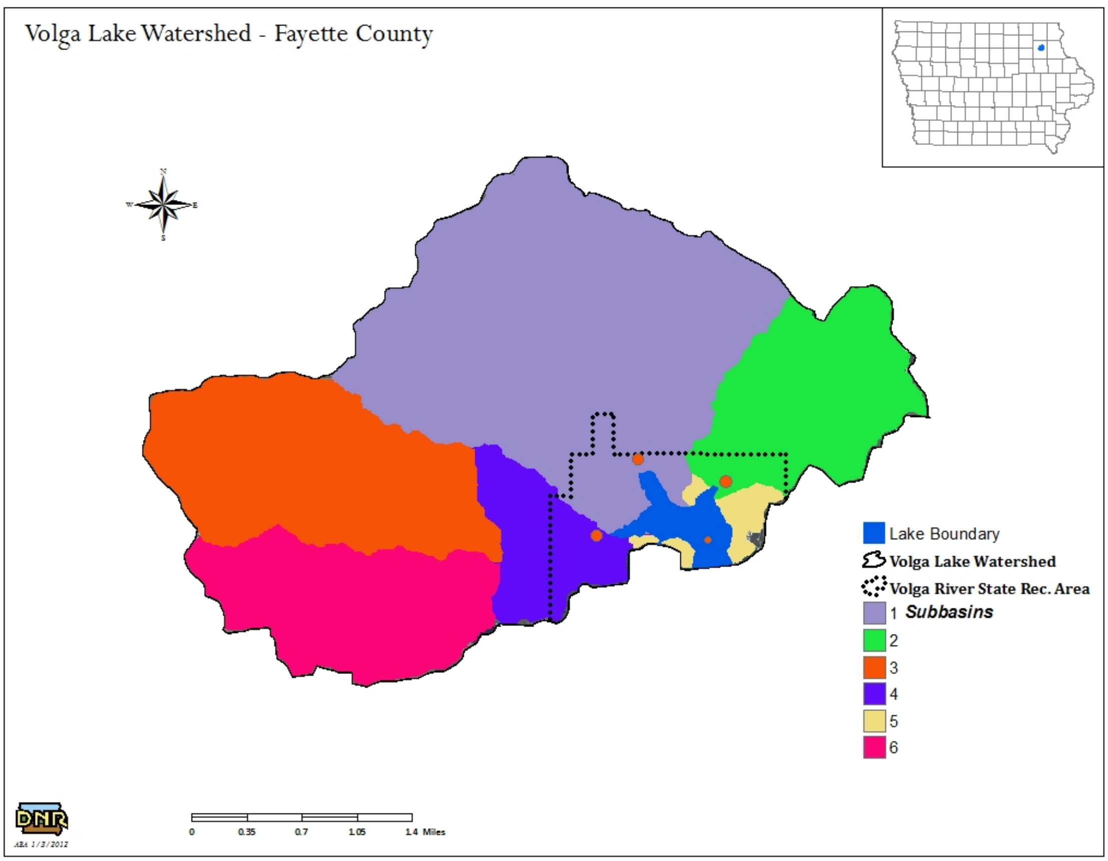

Figure D.1. Subbasins used in model development.

Table D.1 provides the acres of landuse per watershed used to develop the STEP-L model. The outputs of the model provided both a load to enter into BATHTUB and also provided a breakdown of the TP input from landuses (figure D.2). This output suggests slightly more than half the TP load comes from the row cropped regions. The row cropped lands in the HEL depicted in Section 4 should be of highest priority.

Table D.1. Subbasin landuse inputs for STEPL (acres).

Watershed	Urban	Cropland	Pasture	Forest	Grassland
W1	108	1058	693.9	332.6	279.7
W2	20	284	116	232	148
W3	79	890	99	82	51
W4	4.8	126.4	17.3	232.2	34.5
W5	0	12.4	0	72.7	8.9
W6	36.8	594	33.8	52.6	128.3

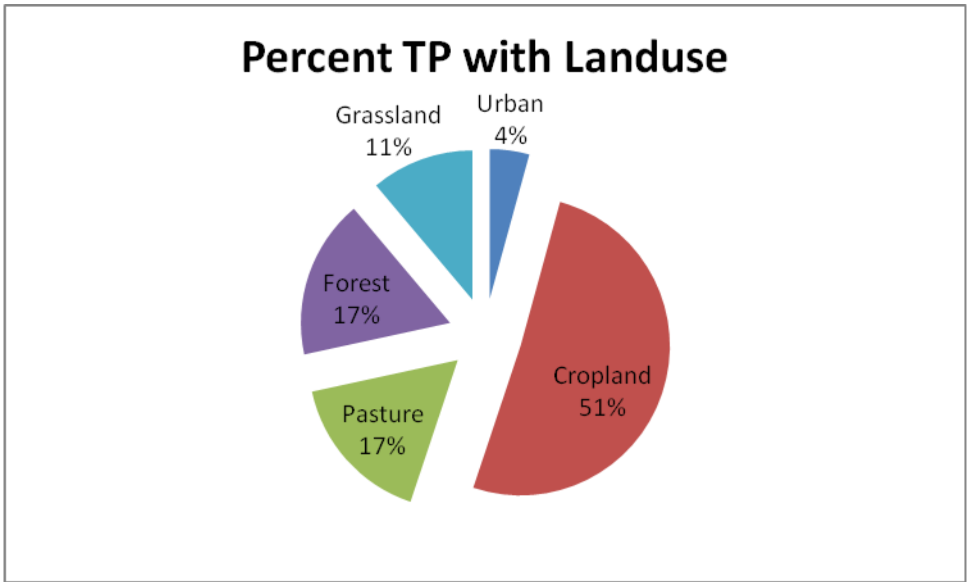

Figure D.2. Percent of Phosphorus load per landuse for Watershed.

The model was developed based on the average conditions observed from 2002 to 2011. No special consideration was given to wet or dry periods since relationships between precipitation and TSI values or chlorophyll-a concentrations could not be established.

Appendix E --- In-Lake Water Quality Model

A combination of modeling software packages were used to develop the Total Maximum Daily Load (TMDL) for Volga 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 6.14, 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 Volga Lake and its watershed.

E.1. 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).

E.2. 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 Volga 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 Volga Lake BATHTUB model and report input parameters for each menu.

Model Selections.
BATHTUB includes several models 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.

Table E.1 reports the models selected for each parameter used to simulate eutrophication response in Volga Lake. Preference was given to Models 1 and 2 during evaluation of model performance and calibration of the Volga Lake model. Final selection of model type was based on applicability to lake characteristics, availability of data, and agreement between predicted and observed data. However, during calibration, the Jones and Bachmann model routinely provided better calibration for chlorophyll.

Table E.1. Model selections for Volga Lake.

Parameter	Model No.	Model Description
Total Phosphorus	01	2^{nd} order*
Chlorophyll-a	05	Jones and Bachmann
Transparency	01	vs. Chl-a & Turbidity *
Longitudinal Dispersion	01	Fischer-Numeric *
Phosphorus Calibration	01	Decay rates *
Availability Factors	00	Ignore *

* Indicates BATHTUB default

Global Variables.
Global input data for Volga Lake are reported in Table E.2. 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 Volga Lake.

Table E.2. Global variables data for 2002-20011 simulation period.

Parameter	Observed Data	BATHTUB Input
Averaging Period	Annual	1.0 year
Precipitation	39.35 in	0.99m
Evaporation	43.3 in	1.10 m
[1]Increase in Storage	0	0
[2]Atmospheric Loads:		
TP	0.3 kg/ha-yr	30 mg/m^2-yr

[1]Change in lake volume from beginning to end of simulation period.
[2]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. Assessment and calibration of model performance for Volga Lake utilizes a three-segment model (Table E.3 and Figure E.1).

Table E.3. Conceptual BATHTUB model for Volga Lake.

	Segment and Tributaries		Length (km)	Segment Surface Area (km2)
Segment	1		0.3	0.22
	Tributary:	1		
	Tributary:	3		
	Tributary:	4		
	Tributary:	6		
Segment	2		0.46	0.23
	Tributary:	2		
Segment	3		0.32	0.14
	Tributary:	5		

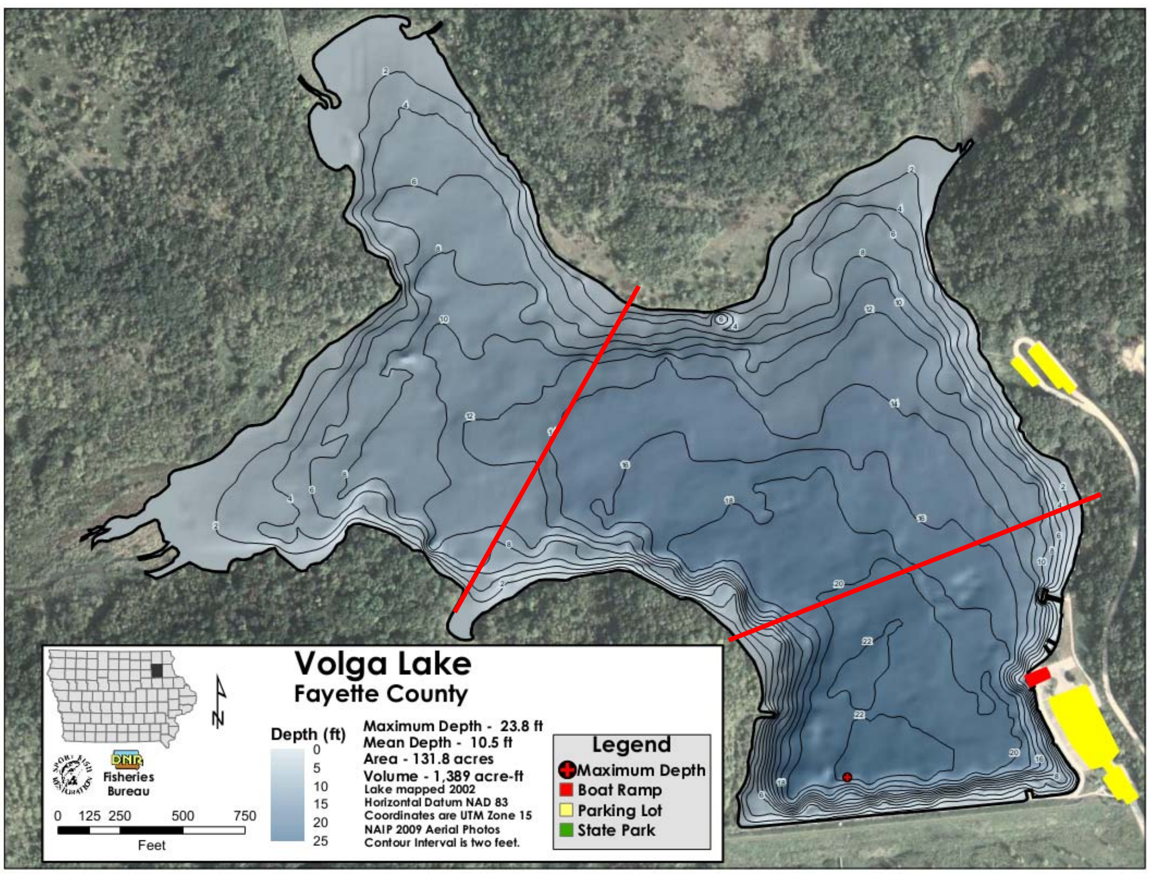

Figure E.1. Segmentation based on Bathymetry (note image lists lake at 131.9 acres but has since been assessed at 146 acres).

The BATHTUB model developed for Volga Lake does not simulate dynamic conditions associated with storm events or even between individual growing seasons. Rather, the model predicts the water quality period of 2002-2011. Observed water quality data for the lake is included in Appendix C – Water Quality Data. Table E.4 lists BATHTUB segment inputs for segments 1-3. Observable water quality data is only available for segment 3 through the monitoring program. Therefore water quality inputs are not listed for segments 1 and 2.

Table E.4. Segments 1-3 inputs.

Segment 1 Parameter	BATHTUB Input	Calibration Factor
Surface Area (km2)	0.22	N/A
Mean Depth (m)	2.13	N/A
Length (km)	0.3	N/A
Mixed layer Depth (m)	2.1	N/A
Non-Algal Turbidity (1/m)	0.08	1*
Total Phosphorus (ug/l)	0	1.2
Chlorophyll-a (ug/l)	0	.9
Secchi Depth (m)	0	1.2
Internal Load P (mg/mg2-day)	4	N/A

* Indicates Default

Segment 2 Parameter	BATHTUB Input	Calibration Factor
Surface Area (km2)	0.23	N/A
Mean Depth (m)	4.88	N/A
Length (km)	0.46	N/A
Mixed layer Depth (m)	4.5	N/A
Non-Algal Turbidity (1/m)	0.08	1*
Total Phosphorus (ug/l)	0	1.2
Chlorophyll-a (ug/l)	0	.9
Secchi Depth (m)	0	1.2
Internal Load P (mg/mg2-day)	4	N/A

* Indicates Default

Segment 3 Parameter	BATHTUB Input	Calibration Factor
Surface Area (km2)	0.14	N/A
Mean Depth (m)	6.71	N/A
Length (km)	0.32	N/A
Mixed layer Depth (m)	5.5	N/A

Non-Algal Turbidity (1/m)	0.08	1*
Total Phosphorus (ug/l)	100.4	1.2
Chlorophyll-a (ug/l)	60.5	.9
Secchi Depth (m)	0.8	1.2
Internal Load P (mg/mg2-day)	4	N/A

* Indicates Default

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. Flow and nutrient loads used in the development of the Volga 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 flows.

Because of the segmented nature of Volga Lake and the implementation of BMPs, six subbasins were included in the STEPL model to provide tributary inputs for BATHTUB. Tributary data are reported in Table E.5.

Table E.5. Tributary inputs for BATHTUB.

Watershed	Area (ac)	Flow (hm3)	TP (ppb)
W1	2,542.7	2.7	436
W2	800	0.9	215.7
W3	1,194.3	1.3	343.7
W4	400.5	0.4	146.6
W5	162.5	0.1	82.2
W6	839.8	0.9	342.4

E.3. Model Performance and Calibration

The Volga Lake water quality model was 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 2002 and 2011. Calibration was an iterative process that involved running both the watershed model (STEPL) and in-lake model (BATHTUB), and refining model parameters to (1) produce simulated values that were within reasonable ranges, and (2) provide good agreement with observed water quality in Volga Lake.

BATHTUB Calibration.
Performance of the BATHTUB model was assessed by comparing predicted water quality with observed data collected in Volga Lake from 2002 to 2011 in segment 3 of the BATHTUB model. Simulation of TP concentration was critical for TMDL development, as was chlorophyll-a and transparency predictions. Nitrogen constituents are less important because Volga Lake is not nitrogen limited. Therefore, nitrogen simulations were not calibrated. The observed data was obtained as part of the ambient lake monitoring program, and is based on data reported in Appendix C. Calibration consists of bringing in tributary loads and then adding internal load until predicted water quality matches observed water quality.

BATHTUB Target Assessment.
After calibration the bathtub model was used to determine the water quality target. This was done by incrementally reducing loads of TP in both tributaries and internal loading until the desired Chl-a concentration of 27 mg/l was achieved for a whole lake average. This was expressed as an annual load and then expressed as an average daily maximum via a statistical approach described in Appendix F.

The model assumes a uniform reduction in loads of all sources. In reality there would be many combinations of practices and pathways to achieve this goal and would most likely not be accomplished by trying to cut 68 percent of the load across all sources equally. In fact, that is most likely not possible. The best approach would be to target the highest contributing sources as discussed in Section 3 of this report and systematically treat watershed based sources and then follow up with treating in-lake sources.

Figures E.2 and E.3 below provide the load response curves for Chl-a and Secchi Depth with total Phosphorus loads. These curves predict reductions in TP will lead to a reduction in Chlorophyll-a and an increase in Secchi depth leading to an overall better water clarity for Volga Lake.

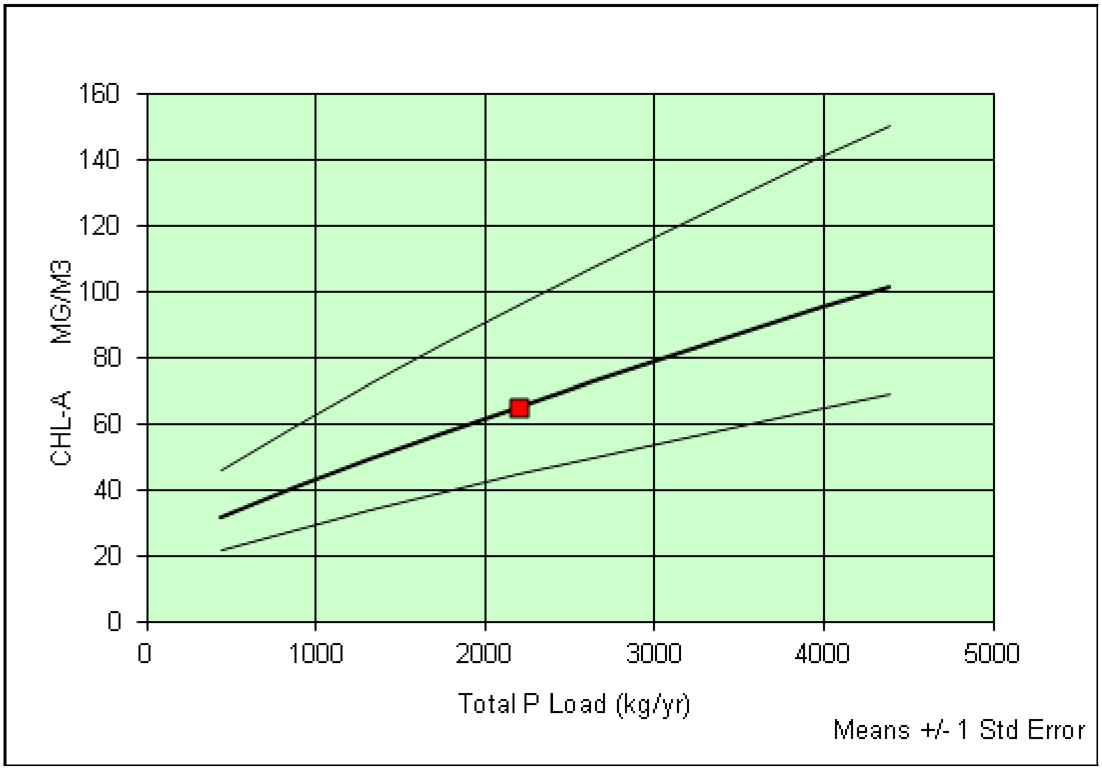

Figure E.2. The load response relationship between Chl-a and total P as predicted by BATHTUB. The red square represents current conditions.

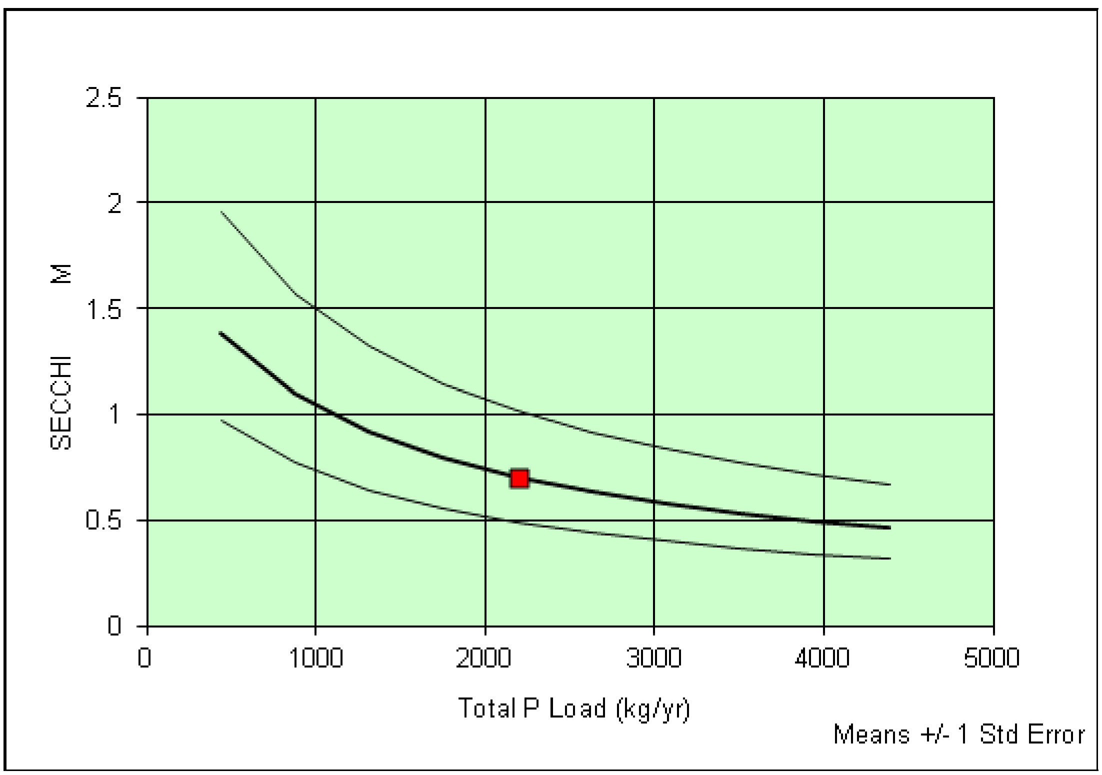

Figure E.3. The load response relationship between Secchi Depth and total P as predicted by BATHTUB. The red square represents current conditions.

Appendix F --- Establishing 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 Volga 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 E, and is 2,396.4 lbs/year.

The maximum daily load was estimated from the allowable growing season 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 an option for identifying a maximum daily load (MDL) that corresponds to the allowable annul 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 2,396.4 lbs/year is equivalent to a long-term average (LTA) daily of 6.57 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 F.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 26.40 lbs/day. This is without the applied MOS of 10 percent. The TMDL calculation is summarized in Table F.2.

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

TMDL = LC = Σ WLA (0 lbs-TP/day) + Σ LA (23.76 lbs-TP/day)
+ MOS (2.64, explicit 10 percent) = **26.40 lbs-TP/day**

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

Parameter	Value	Description
LTA	6.54 lbs/day	Annual Average
Z Statistic	2.778	Based on 365-day averaging period
CV	0.6	Used CV from annual TP loads
σ^2	0.31	ln (CV^2 + 1)
MDL	**26.40 lbs/day**	**TMDL expressed as daily load**

Appendix G --- Public Comments

One comment was received during the public comment period. The comment and Iowa DNR's response are included.

Berckes, Jeff [DNR]

From: John Hanson [johnlhanson@hotmail.com]
Sent: Wednesday, October 09, 2013 6:14 AM
To: Berckes, Jeff [DNR]
Subject: Enclosed are my public comments on the Volga Lake improvement plan

Categories: Public Comment

Enclosed are my public comments on the Volga Lake improvement plan.

I read the Water Quality Improvement Plan for Vogla Lake (2013) and I have two comments.
One, the plan for the highly erodible land in the watershed called for terrace construction as a method of reducing erosion and nutrient loss. Terraces are expensive to construct and require ongoing maintenance. Please review STRIPs (Science-based Trials of Rowcrops Integrated with Prairies) research from the Iowa State University "Leopold Center for Agricultural Sustainability" This field proven research seems to hold much more affordable and ecological valuable promise for the Volga watershed than terraces.
Two, once Volga Lake has nutrient issues accounted for I would like to see a scientifically-based response to the use/value of aeration to maintain water quality, fishery productivity, and aesthetics.
Sincerely,
-John

J. Lawrence Hanson, Ed.D.
2610 Northview Drive
Marion, IA 52302
STRIPs (Science-based Trials of Rowcrops Integrated with Prairies) - See more at:
http://www.leopold.iastate.edu/strips-research-team#sthash.q6mhzMV5.dpuf
STRIPs (Science-based Trials of Rowcrops Integrated with Prairies) - See more at:
http://www.leopold.iastate.edu/strips-research-team#sthash.q6mhzMV5.dpufT
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STRIPs (Science-based Trials of Rowcrops Integrated with Prairies) - See more at:
http://www.leopold.iastate.edu/strips-research-team#sthash.q6mhzMV5.dpuf

November 5, 2013

J. Lawrence Hanson
2610 Northview Drive
Marion, IA 52302

Subject: Volga Lake public comment response

Dear Mr. Hanson:

Thank you for your comments on the Volga Lake draft Water Quality Improvement Plan received during the public comment period.

The Iowa DNR's TMDL Program is well aware of the STRIPs research that Dr. Helmers and his associates at Iowa State University have conducted. Research from the STRIPs program has reported water quality benefits and is consistent with many of the recommendations found in the Implementation Section of the Water Quality Improvement Plan. It is not the intent of the Water Quality Improvement Plan to prescribe any specific best management practices but rather to provide a tool box full of practices that would potentially work to improve water quality. The ultimate choice for any land use changes in the watershed would be made by the landowners. If landowners are interested in implementing practices like those researched in the STRIPs research there are outlets to receive technical assistance.

To your second point regarding the valuation of aeration, we would encourage you to keep questions like this in mind as part of a watershed group. A locally-led watershed group is the most important entity in driving water quality improvement in and around a lake. As a waterbody moves from "impaired" to "restored," it is important for the watershed group to consider how it will maintain and manage the resource long-term.

Thank you again for your comment and let me know if you have further questions.

Sincerely,

Jeff Berckes, TMDL Program Coordinator
Watershed Improvement Section