Illinois
Environmental
Protection Agency

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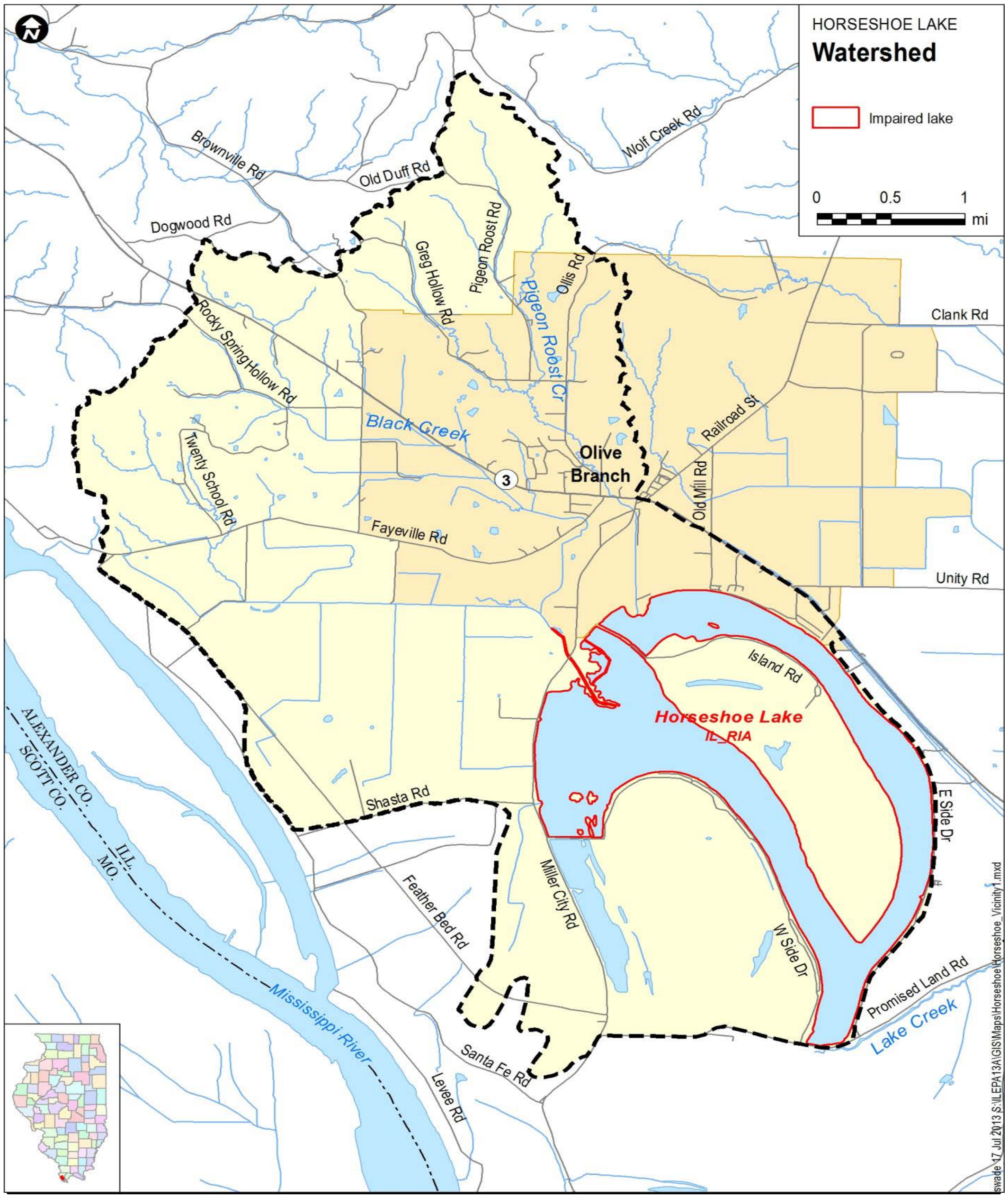
August 2016

IEPA/BOW/16-001

Horseshoe Lake (Alexander County) Watershed TMDL Report



TMDL Development for the Horseshoe Lake (Alexander County) Watershed, Illinois

This file contains the following documents:

1) U.S. EPA Approval letter and Decision Document for Stage Three TMDL Report

2) Stage One Report: Watershed Characterization, Data Analysis and Methodology Selection

3) Stage Three Report: TMDL Development

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF
WW-16J

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SWWS/IFAS

Sanjay Sofat, Chief
Bureau of Water
Illinois Environmental Protection Agency
P.O. Box 19276
Springfield, Illinois 62794-9276

Dear Mr. Sofat:

The U.S. Environmental Protection Agency has conducted a complete review of the final Total Maximum Daily Load (TMDL) for Horseshoe Lake, including supporting documentation and follow up information. The lake is located in southern Illinois. The TMDL for total phosphorus submitted by the Illinois Environmental Protection Agency addresses the impaired designated General Use for the lake.

The TMDL meets the requirements of Section 303(d) of the Clean Water Act and EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, EPA hereby approves Illinois's TMDL for total phosphorus in Horseshoe Lake. The statutory and regulatory requirements, and EPA's review of Illinois's compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois's effort in submitting this TMDL and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Mr. Peter Swenson, Chief of the Watersheds and Wetlands Branch, at 312-886-0236.

Sincerely,

Tinka G. Hyde

Tinka G. Hyde
Director, Water Division

Enclosure

cc: Abel Haile, IEPA

TMDL: Horseshoe Lake, Alexander County, Illinois
Date: August 22, 2016

DECISION DOCUMENT FOR THE APPROVAL OF THE HORSESHOE LAKE, IL TMDL

Section 303(d) of the Clean Water Act (CWA) and EPA's implementing regulations at 40 C.F.R. Part 130 describe the statutory and regulatory requirements for approvable TMDLs. Additional information is generally necessary for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations, and should be included in the submittal package. Use of the verb "must" below denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable. These TMDL review guidelines are not themselves regulations. They are an attempt to summarize and provide guidance regarding currently effective statutory and regulatory requirements relating to TMDLs. Any differences between these guidelines and EPA's TMDL regulations should be resolved in favor of the regulations themselves.

1. Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking

The TMDL submittal should identify the waterbody as it appears on the State's/Tribe's 303(d) list. The waterbody should be identified/georeferenced using the National Hydrography Dataset (NHD), and the TMDL should clearly identify the pollutant for which the TMDL is being established. In addition, the TMDL should identify the priority ranking of the waterbody and specify the link between the pollutant of concern and the water quality standard (see section 2 below).

The TMDL submittal should include an identification of the point and nonpoint sources of the pollutant of concern, including location of the source(s) and the quantity of the loading, e.g., lbs/per day. The TMDL should provide the identification numbers of the NPDES permits within the waterbody. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of the natural background. This information is necessary for EPA's review of the load and wasteload allocations, which are required by regulation.

The TMDL submittal should also contain a description of any important assumptions made in developing the TMDL, such as:

(1) the spatial extent of the watershed in which the impaired waterbody is located;
(2) the assumed distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources;
(4) present and future growth trends, if taken into consideration in preparing the TMDL (e.g., the TMDL could include the design capacity of a wastewater treatment facility); and
(5) an explanation and analytical basis for expressing the TMDL through *surrogate*

measures, if applicable. *Surrogate measures* are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

Comment:
Location Description: The Illinois Environmental Protection Agency (IEPA) developed a TMDL for total phosphorus for Horseshoe Lake (RIA) in southern Illinois. Horseshoe Lake is located in Alexander County, in the southernmost end of Illinois. The lake is a natural oxbow lake formed from the Mississippi River. The lake is situated in the Horseshoe Lake State Fish and Wildlife Area. The watershed for Horseshoe Lake is relatively small, approximately 15,000 acres and inflow to the lake is from two creeks, Black Creek and Pigeon Roost Creek. The lake is 1,890 acres in size, and averages three feet in depth, with a maximum of 6 feet in depth. The lake discharges through a spillway at the southern end of the lake (Figure 1 of the TMDL).

Distribution of land use: The land use for Horseshoe Lake is mainly forest and agricultural in nature, with most of the agricultural land use in row crop (corn/soybean). Grassland/pasture and open developed land (wildlife refuge and state forest) make up most of the remaining land use (Section 3.7 of Stage 1 of the TMDL). Table 2 of this Decision Document contains the land use for the waterbodies.

Table 1 Land use in acres in the Horseshoe Lake Watershed

Land Use	Acres	Watershed %
Developed, high intensity	0.7	0
Developed. Medium intensity	7.3	0
Developed, low intensity	119.4	1
Developed, open	910.7	6
Forest	5,488.3	37
Grassland/pasture/hay	1553.2	11
Water	1573.9	11
Wetlands	621.6	4
Corn	621	13
Soybeans	2487.7	17
Double crop Winter wheat/Soybeans	52.5	0
Total	14.697	100

Problem Identification:
Horseshoe Lake was added to the 2012 303(d) list for being impaired due to high levels of phosphorus. IEPA reviewed several years of data and determined that the lake had elevated total phosphorus (TP) average concentrations. Water quality sampling performed in 2009 documented exceedences of the water quality criteria at all three lake sample locations. (Section 5.1.3 of Stage 1 of the TMDL). The median whole lake TP concentration was 0.302 (WQS = 0.05), and all lake samples exceeded the WQS for TP. Additional sampling was performed in 2013 to confirm the impairment; the results continued to confirm that Horseshoe Lake was impaired due to excess phosphorus.

Pollutants of Concern:
The pollutant of concern is total phosphorus (TP).

Pollutant:
While TP is an essential nutrient for aquatic life, elevated concentrations of TP can lead to nuisance algal blooms that negatively impact aquatic life and recreation (swimming, boating, fishing, etc.). Algal decomposition depletes oxygen levels which stresses benthic macroinvertebrates and fish. Excess algae can shade the water column which limits the distribution of aquatic vegetation. Aquatic vegetation stabilizes bottom sediments, and also is an important habitat for macroinvertebrates and fish. Furthermore, depletion of oxygen can cause phosphorus release from bottom sediments (i.e. internal loading).

Degradations in aquatic habitats or water quality (ex. low dissolved oxygen) can negatively impact aquatic life use. Increased turbidity, brought on by elevated levels of nutrients within the water column, can reduce dissolved oxygen in the water column, and cause large shifts in dissolved oxygen and pH throughout the day. Shifting chemical conditions within the water column may stress aquatic biota (fish and macroinvertebrate species). In some instances, degradations in aquatic habitats or water quality have reduced fish populations or altered fish communities from those communities supporting sport fish species to communities which support more tolerant rough fish species.

Priority Ranking:
The watershed was given priority for TMDL development due to the impairment impacts on public health, the public value of the impaired water resource, the likelihood of completing the TMDL in an expedient manner, the inclusion of a strong base of existing data and the restorability of the water body, the technical capability and the willingness of local partners to assist with the TMDL, and the appropriate sequencing of TMDLs within a watershed or basin.

Source Identification (point and nonpoint sources):
Point Source Identification: No point sources in the watershed were identified by IEPA .

Nonpoint Source Identification: The potential nonpoint sources for the Horseshoe Lake phosphorus TMDL are:

Non-regulated stormwater runoff: Non-regulated stormwater runoff can add phosphorus to the lake. The sources of phosphorus in stormwater include organic material such as leaves, animal/pet wastes, fertilizers, etc. This runoff can erode streambanks, and carry phosphorus-rich sediment to the lake, where it contributes to the internal load of TP.

Failing septic systems: IEPA noted that failing septic systems, where waste material can pond at the surface and eventually flow into surface waters or be washed in during precipitation events, are potential sources of phosphorus. IEPA noted that little information is available on septic systems.

Internal loading: The release of phosphorus from lake sediments via physical disturbance from benthic fish (rough fish, ex. carp), from wind mixing the water column, and from decaying curly-leaf pondweed may all contribute internal phosphorus loading to Horseshoe Lake. Phosphorus may build up in the bottom waters of the lake and may be resuspended or mixed into the water column. IEPA noted that the lake serves as a wildlife refuge, and large numbers of ducks and other waterfowl visit the lake.

Population and future growth trends: The population for the watershed is fairly small, less than 1,000 people. The unincorporated community of Olive Branch is partially located in the watershed (population 864). As much of the land use in the watershed is part of the Horseshoe Lake State Fish and Wildlife Area or the Shawnee National Forest, IEPA does not expect any future growth in the watershed.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this first element.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

The TMDL submittal must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the antidegradation policy. (40 C.F.R. §130.7(c)(1)). EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

The TMDL submittal must identify a numeric water quality target(s) - a quantitative value used to measure whether or not the applicable water quality standard is attained. Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. The TMDL expresses the relationship between any necessary reduction of the pollutant of concern and the attainment of the numeric water quality target. Occasionally, the pollutant of concern is different from the pollutant that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as Dissolved Oxygen (DO) criteria). In such cases, the TMDL submittal should explain the linkage between the pollutant of concern and the chosen numeric water quality target.

Comment:
Designated Use/Standards: Section 5 of the TMDL states that Horseshoe Lake is not meeting the General Use designation. The applicable water quality standards (WQS) for these waterbodies are established in Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards, Subpart B for General Use Water Quality Standards.

Criteria: IEPA has a lake criterion for phosphorus of 0.05 mg/L (Title 35, Section 302.205).

Target: The water quality target for this TMDL is the water quality criterion of 0.050 mg/L TP.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this second element.

3. Loading Capacity - Linking Water Quality and Pollutant Sources

A TMDL must identify the loading capacity of a waterbody for the applicable pollutant. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

The pollutant loadings may be expressed as either mass-per-time, toxicity or other appropriate measure (40 C.F.R. §130.2(i)). If the TMDL is expressed in terms other than a daily load, e.g., an annual load, the submittal should explain why it is appropriate to express the TMDL in the unit of measurement chosen. The TMDL submittal should describe the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

The TMDL submittal should contain documentation supporting the TMDL analysis, including the basis for any assumptions; a discussion of strengths and weaknesses in the analytical process; and results from any water quality modeling. EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

TMDLs must take into account *critical conditions* for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable *critical conditions* and describe their approach to estimating both point and nonpoint source loadings under such *critical conditions*. In particular, the TMDL should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

Comment:
The approach utilized by the IEPA to calculate the loading capacity for Horseshoe Lake for phosphorus is described in Section 6 of the final TMDL.

IEPA used BATHTUB to determine the water quality based upon the TP loading. The BATHTUB model applies a series of empirical equations derived from assessments of lake data and performs steady state water and nutrient calculations based on lake morphometry and tributary inputs. The BATHTUB model requires fairly simple inputs to predict phosphorus loading. The model accounts for pollutant transport, sedimentation, and nutrient cycling. The model was used to determine the load needed to meet or maintain water quality standards for the lake (Section 6.1 of the TMDL).

For purposes of modeling, the lake was divided into three segments. IEPA determined that a separate watershed model was not needed to determine watershed pollutant loading, due to the small size of the watershed. To calculated tributary loads, IEPA used flows from a nearby United States Geological Survey flow gage (Massac Creek, Kentucky , #05140206) and the sampling results from the 2013 lake/tributary sampling (Section 6.1.3.d of the TMDL). The model parameters were adjusted until the model predictions fit the sample data. Once the data were calibrated, the source loads were reduced until the in-lake concentration met the appropriate water quality standard (WQS) (Section 7.1.1 of the TMDL). To account for internal loading of TP, IEPA added additional internal loading into the model. Internal loading was determined to be 23, 725 kg/yr.

IEPA subdivided the loading capacity among the WLA, LA and MOS components of the TMDL (Table 2 of this Decision Document). These calculations were based on the critical condition, the spring/early summer time, which is typically when loading is the highest. Modeling results showed that the current load of TP is well-above the WQS. Table 2 of this Decision Document shows the TMDL summary for Horseshoe Lake. The allocations result in an approximate 88% reduction in watershed loading (98% with the elimination of internal loading).

Table 2 TP TMDL summary for Horseshoe Lake

Load Capacity	Wasteload Allocation	Load Allocation	Margin of Safety
4.2 kg/day	0	3.78 kg/day	0.42 kg/day

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this third element.

4. Load Allocations (LAs)

EPA regulations require that a TMDL include LAs, which identify the portion of the loading capacity attributed to existing and future nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Where possible, load allocations should be described separately for natural background and nonpoint sources.

Comment:

The LA for the waterbodies are found in Table 2 of this Decision Document. Since IEPA determined there are no point sources of TP in the watershed, all the loading capacity was allocated to the load allocation. The sources of TP in the watershed are nonpoint source runoff from row crop agricultural fields, failing septics, streambank erosion, and wildlife.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this fourth element.

5. Wasteload Allocations (WLAs)

EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to individual existing and future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit.

The individual WLAs may take the form of uniform percentage reductions or individual mass based limitations for dischargers where it can be shown that this solution meets WQSs and does not result in localized impairments. These individual WLAs may be adjusted during the NPDES permitting process. If the WLAs are adjusted, the individual effluent limits for each permit issued to a discharger on the impaired water must be consistent with the assumptions and requirements of the adjusted WLAs in the TMDL. If the WLAs are not adjusted, effluent limits contained in the permit must be consistent with the individual WLAs specified in the TMDL. If a draft permit provides for a higher load for a discharger than the corresponding individual WLA in the TMDL, the State/Tribe must demonstrate that the total WLA in the TMDL will be achieved through reductions in the remaining individual WLAs and that localized impairments will not result. All permittees should be notified of any deviations from the initial individual WLAs contained in the TMDL. EPA does not require the establishment of a new TMDL to reflect these revised allocations as long as the total WLA, as expressed in the TMDL, remains the same or decreases, and there is no reallocation between the total WLA and the total LA.

Comment:
IEPA stated there are no known point sources of phosphorus in the watersheds. The WLA is 0 for the Horseshoe Lake phosphorus TMDL.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this fifth element.

6. Margin of Safety (MOS)

The statute and regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

Comment:
The Horseshoe Lake TMDL incorporated an explicit MOS of 10% of the TMDL (Table 2 of this Decision Document). IEPA noted that the 10% is reasonable due to the results of the generally good agreement between the BATHTUB water quality model and observed sampling results. (Section 7.5 of the TMDL). The results indicate the model adequately characterizes the lake and surrounding watershed, and therefore additional MOS is not needed.

EPA finds that the TMDL document submitted by IEPA has an appropriate implicit MOS satisfying all requirements concerning this sixth element.

7. Seasonal Variation

The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variations. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Comment:
IEPA accounted for seasonal variation via the modeling process. As noted in Section 6.1.3.b of the TMDL, the residence time of TP in the lake is between one and three months. In order to address the nutrient impacts on the lake, the model was adjusted to calculate loadings for the spring-summer (April-July), when the TP loads are the greatest.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this seventh element.

8. Reasonable Assurances

When a TMDL is developed for waters impaired by point sources only, the issuance of a National Pollutant Discharge Elimination System (NPDES) permit(s) provides the reasonable assurance that the wasteload allocations contained in the TMDL will be achieved. This is because 40 C.F.R. 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with "the assumptions and requirements of any available wasteload allocation" in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement water quality standards.

EPA's August 1997 TMDL Guidance also directs Regions to work with States to achieve TMDL load allocations in waters impaired only by nonpoint sources. However, EPA cannot disapprove a TMDL for nonpoint source-only impaired waters, which do not have a demonstration of reasonable assurance that LAs will be achieved, because such a showing is not required by current regulations.

Comment:
Section 9.4 of the TMDL documents discusses the reasonable assurance. Reasonable assurance does not strictly apply to the Horseshoe Lake TMDL, as there are no point sources contributing to the impairment. However, IEPA provided limited information on potential controls of TP that will be targeted to the watershed.

Section 9.2.1 of the TMDL explains that the Long Term Hydrologic Impact Analysis (L-THIA) model was used to estimate loads by land use type. IEPA noted that the L-THIA model offers better analysis of land use loads but is less able to account for absolute loads as compared to the unit area loads developed for the TMDL. L-THIA results showed that 96% of the TP watershed load to Horseshoe Lake is from general agriculture, while only comprising approximately 30% of the watershed area.

Tributary monitoring shows Black Creek being one of the significant contributors of TP in the watershed. Based upon this information and the results of the L-THIA modeling, IEPA determined that the Black Creek subwatershed should be prioritized for implementation actions.

EPA finds that this criterion has been adequately addressed.

9. Monitoring Plan to Track TMDL Effectiveness

EPA's 1991 document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA 440/4-91-001), recommends a monitoring plan to track the effectiveness of a TMDL, particularly when a TMDL involves both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur. Such a TMDL should provide assurances that nonpoint source controls will achieve expected load reductions and, such TMDL should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring and leading to attainment of water quality standards.

Comment:
The TMDL submittals contain discussion on future monitoring (Section 9.5 of the TMDL). Monitoring will occur as part of the Ambient Lake Monitoring Program. The TMDL also recommends monitoring of the tributaries to track implementation results. Table 7 of the TMDL lists the recommendations for monitoring actions in the watershed.

EPA finds that this criterion has been adequately addressed.

10. Implementation

EPA policy encourages Regions to work in partnership with States/Tribes to achieve nonpoint source load allocations established for 303(d)-listed waters impaired by nonpoint sources. Regions may assist States/Tribes in developing implementation plans that include reasonable assurances that nonpoint source LAs established in TMDLs for waters impaired solely or primarily by nonpoint sources will in fact be achieved. In addition, EPA policy recognizes that other relevant watershed management processes may be used in the TMDL process. EPA is not required to and does not approve TMDL implementation plans.

Comment:
A summary of potential implementation activities are in the TMDL. IEPA provided a number of programs that could be used to address the reductions needed, primarily through support of BMPs to control TP and TSS. These include the Clean Water Act Section 319 grants. Numerous programs administered by the US Department of Agriculture are also available, including the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), and Environmental Quality Incentive Program (EQIP). IEPA provided the contacts for various local offices that administer the programs.

EPA reviews, but does not approve, implementation plans. EPA also notes that the approval of the TMDL is not approval of any Section 319 plan or grant. EPA finds that this criterion has been adequately addressed.

11. Public Participation

EPA policy is that there should be full and meaningful public participation in the TMDL development process. The TMDL regulations require that each State/Tribe must subject calculations to establish TMDLs to public review consistent with its own continuing planning process (40 C.F.R. §130.7(c)(1)(ii)). In guidance, EPA has explained that final TMDLs submitted to EPA for review and approval should describe the State's/Tribe's public participation process, including a summary of significant comments and the State's/Tribe's responses to those comments. When EPA establishes a TMDL, EPA regulations require EPA to publish a notice seeking public comment (40 C.F.R. §130.7(d)(2)).

Provision of inadequate public participation may be a basis for disapproving a TMDL. If EPA determines that a State/Tribe has not provided adequate public participation, EPA may defer its approval action until adequate public participation has been provided for, either by the State/Tribe or by EPA.

Comment:

An initial public notice was released on November 16, 2013, notifying interested stakeholders of a public meeting on December 16, 2013. This preliminary meeting was held to discuss the proposed TMDL plan, and gather any additional data and information. The public comment period for the draft TMDL opened on October 22, 2015 and closed on December 21, 2015. A public meeting was held on November 19, 2015, in Tamms, Illinois.

The public notices were published in the local newspaper (The Cairo Citizen) and interested individuals and organizations received copies of the public notice. A hard copy of the TMDL was made available upon request. The draft TMDL was also made available at the website http://www.epa.state.il.us/water/tmdl/.

Comments were submitted by the Illinois Farm Bureau (IFB) on the TMDL. The comments focused on additional sources of TP into Horseshoe Lake. The IFB questioned whether or not TP loads from other sources had been considered, specifically failing septics, flooding from the Mississippi, geese wintering in the lake, and the levee break and resulting flood from the Mississippi River in 1993. The IFB also had a question about a sampling site location.

IEPA responded that the sources raised by IFB were accounted for in the TMDL indirectly. The effects from the various flooding events, as well as geese impacts, were addressed when the BATHTUB model was adjusted for internal loading. IEPA noted that there was no specific data to determine the amount or impact of any particular event; they were inherently accounted for in the tributary or lake loading. IEPA noted no data was available for septic systems failures, and their impacts would be noted indirectly in the modeling results. IEPA also provided a photo showing the site of the sample location in question, and confirmed that it is located adjacent to Horseshoe Lake.

EPA carefully reviewed the comments and IEPA's responses, and finds that IEPA appropriately addressed the submitted comments. EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this eleventh element.

12. Submittal Letter

A submittal letter should be included with the TMDL submittal, and should specify whether the TMDL is being submitted for a *technical review* or *final review and approval*. Each final TMDL submitted to EPA should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute. The submittal letter, whether for technical review or final review and approval, should contain such identifying information as the name and location of the waterbody, and the pollutant(s) of concern.

Comment:
On April 25, 2016, EPA received the Horseshoe Lake, Illinois TMDL, and a submittal letter. In the submittal letter, IEPA stated it was submitting the TMDL report for EPA's final approval. The submittal letter included the name and location of the waterbody and the pollutant of concern.

EPA finds that the TMDL document submitted by IEPA satisfies all requirements concerning this twelfth element.

Conclusion
After a full and complete review, EPA finds that the TMDL for Horseshoe Lake satisfies all of the elements of an approvable TMDL. This approval is for one TMDL for phosphorus for one waterbody.

EPA's approval of this TMDL does not extend to those waters that are within Indian Country, as defined in 18 U.S.C. Section 1151. EPA is taking no action to approve or disapprove TMDLs for those waters at this time. EPA, or eligible Indian Tribes, as appropriate, will retain responsibilities under the CWA Section 303(d) for those waters.

TMDL Report
Horseshoe Lake Watershed

Prepared for:
Illinois EPA

Final

August 26, 2016

LimnoTech
Water Environment | Scientists Engineers

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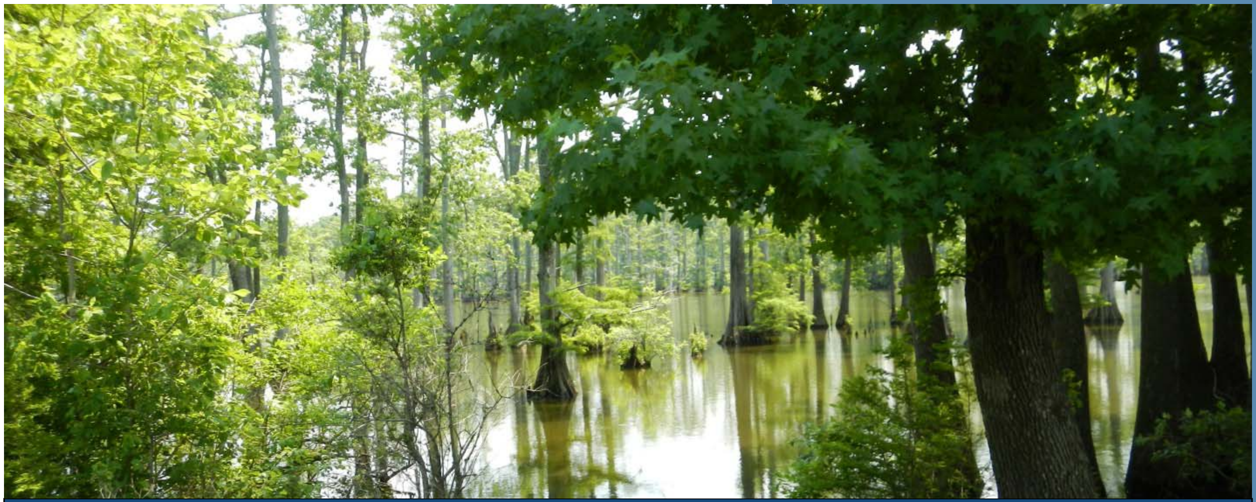
Final Stage 3 Report Horseshoe Lake





Stage 1 Report

Horseshoe Lake

Prepared for:
Illinois EPA

January 28, 2014

LimnoTech
Water Environment | Scientists Engineers

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Water | Scientists
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Horseshoe Lake Watershed
Total Maximum Daily Load
Stage One Report

Prepared for:
Illinois EPA

January 28, 2014

Prepared by:
LimnoTech

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ACRONYMS & ABREVIATIONS

ALMP	Ambient Lake Monitoring Program
BMP	Best Management Practices
CDL	Cropland data layer
CFR	Code of Federal Regulations
CLP	Clean Lakes Program
DO	Dissolved Oxygen
GIS	Geographic Information System
IDOA	Illinois Department of Agriculture
IEPA	Illinois Environmental Protection Agency
LRS	Load Reduction Strategy
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NVSS	Non-Volatile Suspended Solids
TMDL	Total Maximum Daily Load
TSI	Trophic State Index
TSS	Total Suspended Solids
UAL	Unit Area Load
USEPA	United States Environmental Protection Agency
USLE	Universal Soil Loss Equation
VRT	Variable Rate Technology
mg/L	milligrams per liter
µg/L	micrograms per liter

Executive Summary

This Stage 1 report was developed for the impaired waterbody segment located within the Horseshoe Lake watershed. It provides a characterization of watershed conditions, an analysis of water quality, an analysis of available data to confirm the sufficiency of the data to support both the listing decision and the sources of impairment that are included on the 2012 303(d) list, a review and recommendation of approaches for developing Total Maximum Daily Loads (TMDLs) and Load Reduction Strategies (LRSs). This report also provides a plan for collecting additional field data, and summarizes public participation in this Stage 1 process.

1.1 Confirmation of Impairments

The Horseshoe Lake watershed was indicated in the 2012 303(d) list as having 1 waterbody with impaired use support. For impaired waterbodies caused by pollutants that have numeric water quality standards, TMDLs are to be developed; other causes of impairment are to be addressed in LRSs. Based on a review of available water quality data and current state water quality standards, it is recommended that 1 TMDL and 1 LRS be completed for Horseshoe Lake.

TMDL and LRS recommendations

Waterbody	Pollutant	Recommendation
Horseshoe Lake (IL_RIA)	Total phosphorus	Prepare TMDL
	Total suspended solids	Prepare LRS

1.2 Recommendations for TMDL Development

A simple approach is recommended for the TMDL and LRS. The total phosphorus TMDL for Horseshoe Lake will be developed using the BATHTUB model, and measured or modeled tributary phosphorus loads. This approach has been used for previous lake phosphorus TMDLs and approved by EPA Region 5. The TSS load reduction strategy will be prepared using USLE-based methods, or, alternatively, a combination of the Simple Method and unit areal loading rates.

1.3 Recommendations for Field Data Collection

The available data are sufficient to support the recommended methods and development of the total phosphorus TMDL and TSS LRS. Therefore, no additional data collection is recommended if the recommended methods are selected.

1.4 Public Participation

On December 16, 2013, the Illinois EPA Planning Unit TMDL project managers, along with their consultant presented the results of the Stage One Draft report for the Horseshoe Lake watershed. The meeting was held in Tamms, Illinois and in addition to the meeting sponsors, six individuals attended this meeting.

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2

Introduction

Illinois EPA has developed a three-stage approach to Total Maximum Daily Load (TMDL) and Load Reduction Strategy (LRS) development. This Stage 1 report describes initial activities related to the development of TMDLs and LRSs for the Horseshoe Lake watershed, including: watershed characterization, data analysis to confirm the causes and sources of impairment, and methodology selection. Subsequent stages will include Stage 2 data collection (as needed) and Stage 3 model calibration, TMDL development and implementation plan development.

This section provides background information on the TMDL process, and Illinois assessment and listing procedures. The specific impairments of Horseshoe Lake are also described.

2.1 TMDL Process

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is called the 303(d) list. The State of Illinois' 2012 303(d) list (IEPA 2012) is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Load Reduction Strategies (LRSs) are being completed for causes that do not have numeric standards. LRSs for causes of impairment with target criteria will consist of loading capacity, percentage reduction for nonpoint sources, margin of safety and reserve capacity, if applicable.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and a consultant team have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. Additionally, this report recommends TMDL and LRS approaches, including an assessment of whether additional data are needed to develop a defensible TMDL.

In a subsequent stage of work the TMDLs and LRSs will be developed and IEPA will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

2.2 Illinois Assessment and Listing Procedures

Surface water assessments in the 2012 Integrated Report are based primarily on biological, water, physical habitat, and fish-tissue information collected through 2010 from various monitoring programs (IEPA, 2007). These programs include: the Ambient Water Quality Monitoring Network, Intensive Basin Surveys, Facility-Related Stream Surveys, the Fish Contaminant Monitoring Program, the Ambient Lake Monitoring Program, the Illinois Clean Lakes Monitoring Program, the Volunteer Lake Monitoring Program, the Lake Michigan Monitoring Program, TMDL monitoring and other outside sources (IEPA, 2012).

Illinois EPA conducts its assessment of water bodies using seven designated use categories: 1) public and food processing water supplies, 2) aquatic life, 3) fish consumption, 4) primary contact, 5) secondary contact, 6) indigenous aquatic life, and 7) aesthetic quality (IEPA, 2012). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of two possible "use-support" levels:

- Fully supporting (the water body attains the designated use); or
- Not supporting (the water body does not attain the designated use).

When sufficient data are available, each applicable designated use in each segment is assessed as Fully Supporting (good), Not Supporting (fair), or Not Supporting (poor). Waters in which at least one applicable use is not fully supported are called "impaired." Waters identified as impaired based on biological, physicochemical, physical habitat, and toxicity data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters.

2.3 Identified Watershed Impairment

The impaired water body segment included in the project watershed is listed in Table 1, along with the parameters it is listed for, and the use impairments as identified in the 2012 303(d) list (IEPA, 2012). TMDLs are currently only being developed for pollutants that have numerical water quality criteria. Load Reduction Strategies are being developed for those pollutants that do not have numerical water quality criteria. The pollutants that are the focus of this study are indicated in Table 1 in boldface type. Table 1 provides information on the targeted water body, including size, causes of impairment, and use support. Those impairments that are the focus of this report are shown in bold font.

The remaining sections of this report include:

- Watershed characterization: description of watershed features
- Water quality standards and impairment summary: discussion of relevant water quality standards, database development and summary of data for impaired segments
- Confirmation of causes and sources of impairment: assessment of sufficiency of data to support the listing and identification of potential sources contributing to the impairment
- Methodology: identification and recommendation of watershed and water quality models
- Data collection to support modeling: a general description of data needed to support modeling
- Public participation: description of the public meeting related to this project
- References

Table 1. Impaired waterbody summary

Waterbody/ Segment Name	Use Support [2]	Size (acres)	Impairment Cause	Potential Sources
Horseshoe Lake (Alexander County) IL_RIA	Aesthetic Quality (N), Aquatic Life (F), Fish Consumption (X), Primary Contact (X), Secondary Contact (X)	1,890	**Phosphorus (Total), TSS**, Aquatic Algae	Crop Production (crop land or dry land), Runoff from Forest/Grassland/Parkland

[1] Bold font indicates cause will be addressed in this report by a TMDL or LRS. Other potential causes of impairment listed for these water bodies are not subject to TMDL or LRS development at this time.

[2] F = Fully supporting, N = Not supporting, X = Not assessed

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3

Watershed Characterization

3.1 Methods

The project watershed was characterized by compiling and analyzing data and information from various sources. Where available, data were obtained in electronic or Geographic Information System (GIS) format to facilitate mapping and analysis. To develop a better understanding of land management practices in the watershed, local agencies were contacted to obtain information on crops, fertilizer application practices, tillage practices and best management practices employed. Additionally, a site visit was conducted on June 24 and meetings were held with IEPA and Horseshoe Lake State Fish & Wildlife Area staff. Appendix A lists the information obtained and consultations with state or local agencies. Appendix B provides photos of the lake, tributaries and watershed.

The watershed boundary for Horseshoe Lake was delineated in GIS using topographic and stream network (hydrography) information. Other relevant watershed characterization information was obtained and compiled. This included land use and land cover, soils, point source dischargers, state, county and municipal boundaries, coal mines, oil and gas wells, data collection locations and the location of the 2012 303(d) waterbodies. Additionally, several studies have been completed for Horseshoe Lake, and the results of these are described in this section, where applicable.

3.2 Watershed Location

Horseshoe Lake is a 1,890 acre lake created from a natural oxbow of the Mississippi River. The lake and its watershed are located entirely within Alexander County in southwestern Illinois, near the confluence of the Ohio River and Mississippi River and the community of Olive Branch (Figure 1). The lake supports a flooded forest of bald cyprus and water tupelo and is situated within the 10,200-acre Horseshoe Lake State Fish and Wildlife Area.

In the past, up to a million Canadian geese are reported to have visited this lake during winter migration, making it a popular hunting destination. In recent years, however, the number of geese visiting the lake has fallen significantly. The reason for the decline is unknown. Although very few geese have visited the lake in recent years, the population of ducks visiting the lake is still large.

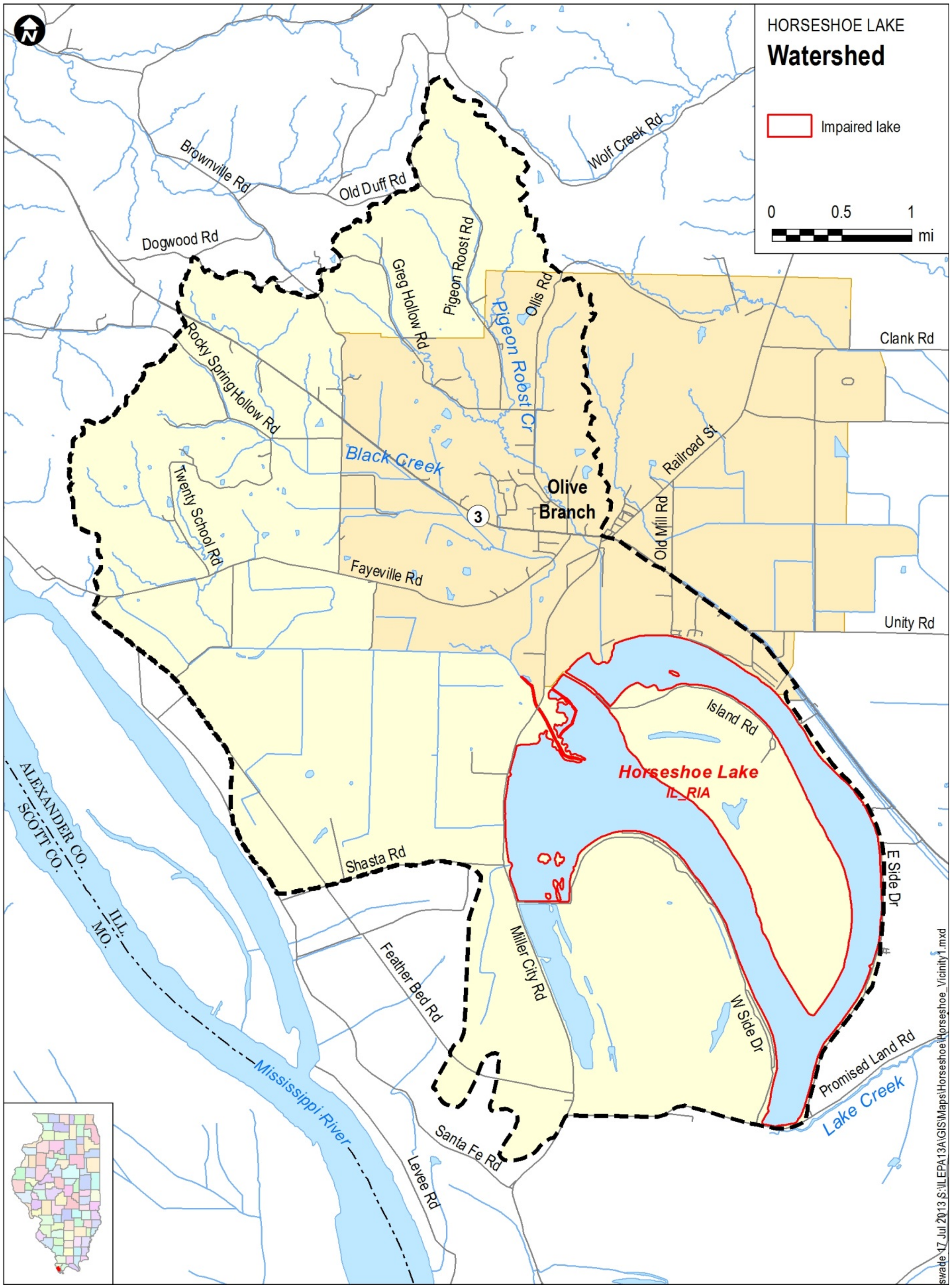

Figure 1. Study area map

3.3 Climate and Hydrology

The Horseshoe Lake watershed has hot and humid summers and winters that are generally cool. Climate data from 1895 – 2011 were obtained from the State Climatologist website http://mrcc.isws.illinois.edu/state_climatologists/illinois/clidiv/il_cli_div2.jsp . The average annual precipitation for Climate Division 8 (Southwest Illinois) over 117 years was 45.6 inches. The monthly average precipitation over this period is 3.63 inches, and ranges from 2.74 in February to 4.57 inches in May.

Average annual temperatures for the 1895-2011 period are 55.8 degrees Fahrenheit, and range from 55.7 in 1957 to 56.6 in 1998. The warmest average annual temperatures have been recorded in more recent years (Figure 2).

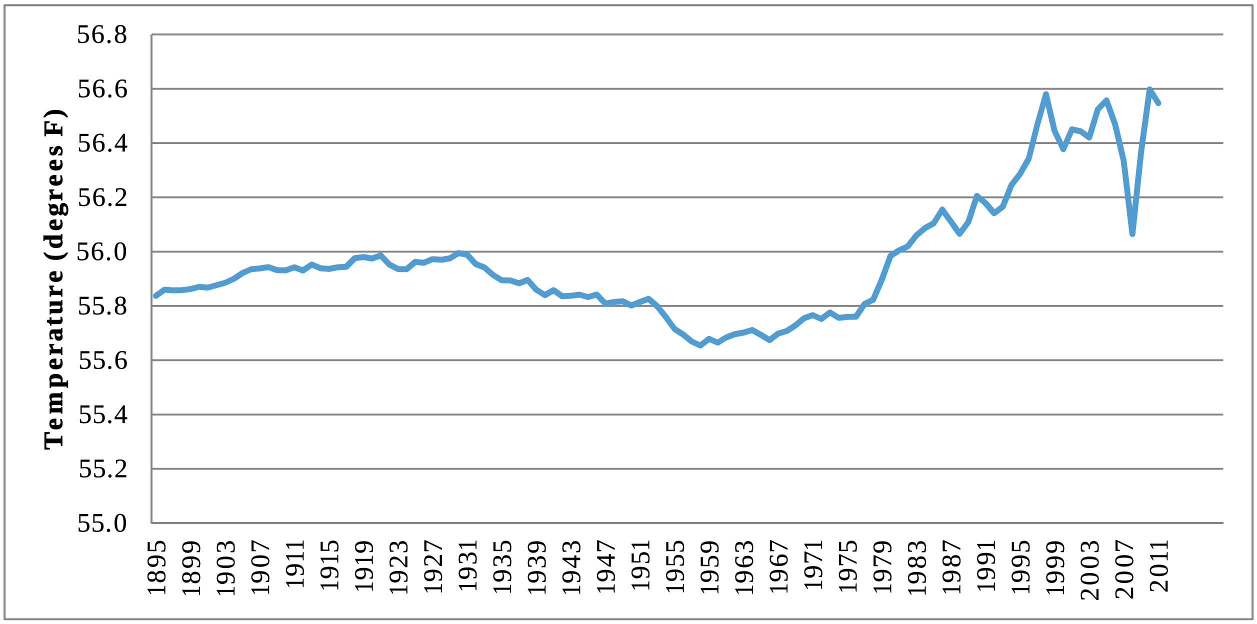

Figure 2. Annual average temperature in climate division 8 (1895-2011)

The primary tributaries to the lake are Black Creek and Pigeon Roost Creek. Pigeon Roost Creek was diverted to the lake sometime prior to 1927. These streams are subject to flash flooding during heavy rains and are the primary sources of water and sediment to the lake.

In the early 1930s, the state built a dam to stabilize the lake pool, raising the water level of the lake and flooding some of the surrounding land. Since this time, Horseshoe Lake has been maintained at a constant depth. Currently, the average depth of the lake is approximately three feet, but parts may reach depths up to six feet. Horseshoe Lake discharges to Lake Creek.

Prior to the construction of the Mississippi River levee system, the Mississippi and Ohio Rivers flooded the lake two out of three years, thereby creating a periodic, secondary source of water and sediment to the lake. The flooding event lasted an average of 30 days. The high floods occurred predominantly during March and April; however they may have begun in early February and ended in late June (Butts and Singh, 1997). When the combined stage of the Ohio and Mississippi Rivers reaches 85 feet, water begins backing up into Horseshoe Lake at the spillway, resulting in flooding of the lake. This flooding can be caused by either the Mississippi River or the Ohio River, although flooding will usually be more extensive when caused by elevated Ohio River flows. The lake periodically floods in this manner, at a frequency of roughly one out of every three years (Personal communication Horseshoe Lake Fish and Wildlife Area Site Superintendent, 2013).

The lake and surrounding area have also been inundated by several other severe floods. In 1993, flooding of the Mississippi River caused Horseshoe Lake to become submerged under 10 feet of water for several weeks. In 2011, the lake and surrounding areas including Olive Branch, were inundated after the US Army Corps of Engineers blasted a two-mile hole in a Mississippi River levee to relieve water pressure that was endangering Cairo, Illinois.

3.4 Topography

Topography in the Horseshoe Lake watershed is varied. The highest elevation in the watershed (626 feet) is found in the uplands in the far north end of the watershed. The lower elevations are in the flatlands around the lake. The lowest elevation in the watershed (313 ft) occurs at the outlet of the lake in the southeastern corner of the watershed.

3.5 Soils

Together with topography, the nature of soils in a watershed play an important role in the amount of runoff generated and soil erosion. The Natural Resources Conservation Service's Soil Survey Geographic (SSURGO) database was reviewed to characterize study area soils. The NRCS places soils into erodibility classes based upon slope and other factors. The erodibility potential of soils in the study area was assessed by classifying the numeric Kw factors for the surface soil horizon (SSURGO soil data) into erodibility categories. Nearly two-thirds of the watershed soils were characterized as being highly erodible and the remainder are moderately erodible (Figure 3). The most common soil types in the watershed are silt loam (62%), fine sandy loam (16%), silty clay (11%), and silty clay loam (5%).

The Alexander County NRCS indicated that the majority of farmers do a good job at implementing best management practices to prevent soil erosion in the watershed, but there are many more projects to implement BMPs that could be completed. The NRCS also indicated that some stream bank stabilization projects have been completed. At the public meeting (see Section 8) it was noted that streambank erosion, particularly in the northern third of the watershed is a real problem. In addition ponds were constructed to promote sedimentation of farm runoff in the late 1990s and early 2000s. At the public meeting (see Section 8) it was noted that conservation practices in the Horseshoe Lake watershed in the early 2000's also included structures and pasture seeding, in addition to ponds. A Cache River watershed plan may also be useful.

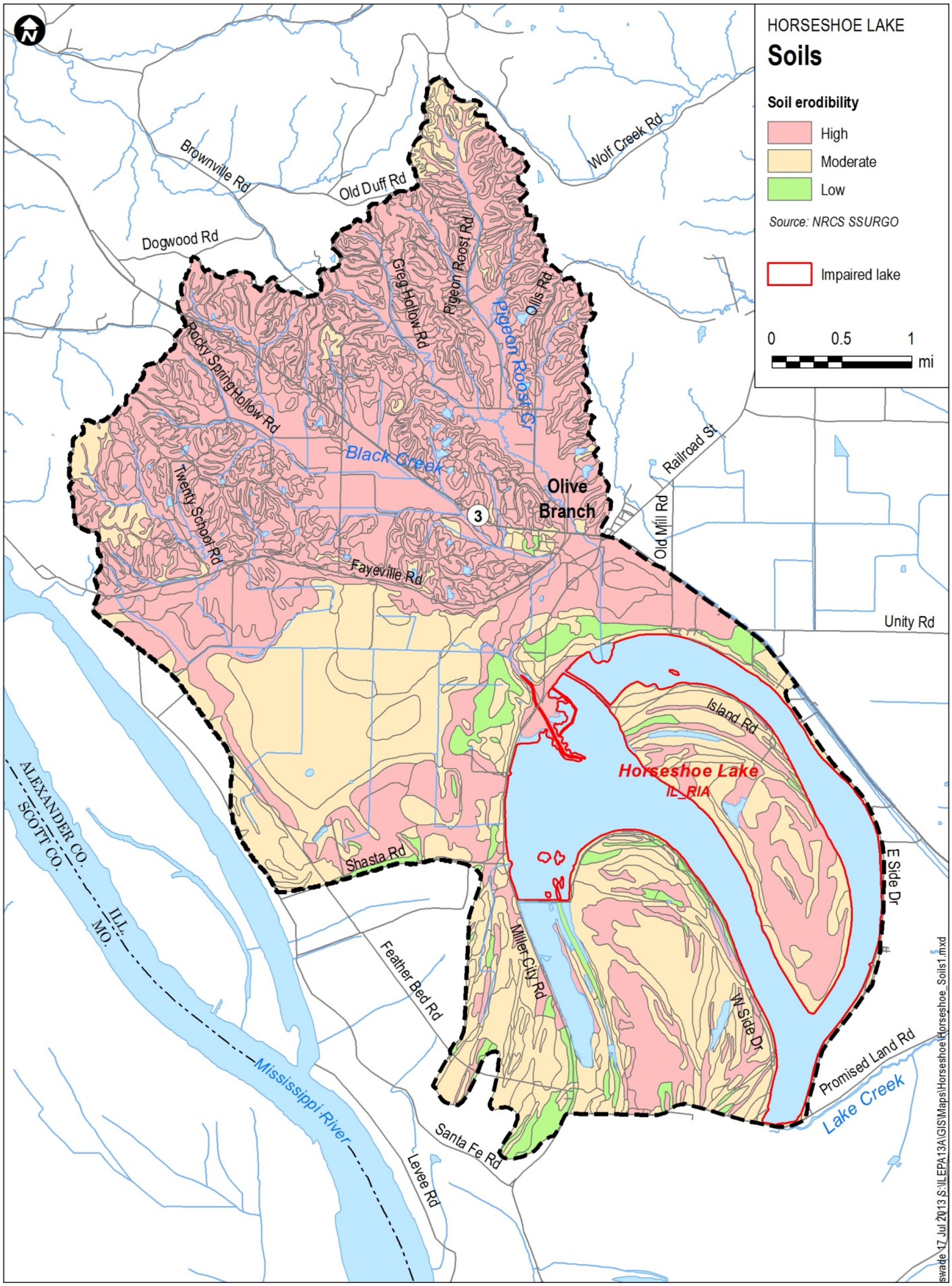

Figure 3. Soil map

The Illinois Soil Conservation Transect Survey program provides a general overview of the current status of soil conservation efforts on agriculture land in the state. Survey results provide data on the presence of conservation practices in each county (IDOA 2011). The 2011 survey provided information on tillage systems used in planting corn and soybean crops in the spring and small grain crops in the fall. And, the surveyors also collect data on ephemeral or gully erosion in surveyed fields. Data are available by county rather than by watershed (Tables 2 through 5). At the public meeting (Section 8), it was noted that tillage practices in the Horseshoe Lake watershed are probably similar to the county-wide statistics.

Table 2. Percent of corn fields in each tillage system in Illinois and in target watershed counties

County	Conventional	Reduced	Mulch-Till	No-Till
Illinois	46%	25%	19%	11%
Alexander County	93%	0%	0%	7%

Table 3. Percent of soybean fields in each tillage system in Illinois and in target watershed counties

County	Conventional	Reduced	Mulch-Till	No-Till
Illinois	14%	20%	25%	41%
Alexander County	45%	6%	4%	45%

Table 4. Percent of small grain fields in each tillage system in Illinois and in target watershed counties

County	Conventional	Reduced	Mulch-Till	No-Till
Illinois	24%	19%	17%	39%
Alexander County	100%	0%	0%	0%

Table 5. Percent of fields indicating ephemeral erosion in Illinois and in target watershed counties

County	Yes	No
Illinois	20%	80%
Alexander County	1%	99%

3.6 Urbanization and Growth

The Horseshoe Lake watershed is overwhelmingly rural in nature, but does contain the small unincorporated community of Olive Branch, located north of the lake (Figure 1). In 2010, Olive Branch had a population of 864 (http://censusviewer.com/city/IL/Olive%20Branch/2010). The land cover data indicates that the watershed is approximately 1% urbanized; however little of the land is considered heavily developed.

Population statistics and projections are available on a county basis. This watershed is located entirely within Alexander County. Alexander County's population decreased slightly between 2000 and 2010. In 2000, Alexander County had a population of 9,590 and in 2010, 9,501 people were counted by the U.S. Census Bureau. The population within the watershed is very small, due to the small size of the watershed, the location of the Horseshoe Lake State Fish and Wildlife Area and the predominantly agricultural land use. The majority of the people reside to the north of the lake.

It is anticipated that the population in Alexander County will increase through 2020, when 9,933 residents are projected for this county (Illinois Department of Commerce and Economic Activity http://www.ildceo.net/dceo/Bureaus/Facts_Figures/Population_Projections/).

3.7 Land Cover

Runoff from the land surface can contribute pollutants to nearby receiving waters, including sediment and phosphorus, which are impairments in Horseshoe Lake. Land cover in the watershed was examined to better understand runoff sources contributing to waterbody impairments.

Land cover is tabulated in Table 6 and shown in Figure 4. These data are derived from 2011 Cropland Data Layer (CDL) for Illinois from the Natural Resources Conservation Service (NRCS). CDL is a variation on the National Land Cover Database (NLCD).

The majority of the watershed consists of forests, wetlands and open water including the lake. Approximately 7% of the watershed is characterized as developed, and of that 6% is developed open space. Roughly 30% of the watershed supports cultivated crops (primarily soybeans 56% and corn 43% with less than 1% winter wheat and rice) and 11% pasture/hay. Some of the agricultural land cover is in the wildlife refuge surrounding Horseshoe Lake, where green pasture and grain crops are produced for the migrating ducks and geese.

According the local Natural Resources Conservation Service (NRCS) Tamms Service Center, the crops in the watershed consist of corn, soybeans, and wheat. Tillage practices are reported to vary by year, with the stage of the Mississippi River affecting decisions to till or not (i.e., if it floods farmers might not till in a certain year if they are behind schedule planting crops). The NRCS estimates that in a typical year, tillage practices in the watershed are roughly 50% no till and 50% conventional tillage, although there are a few farmers who practice minimal till techniques.

The NRCS notes that water control structures (i.e., dry dams) and ponds have been implemented in the upper watershed. Additionally, in the late 1990s and early 2000s, ponds were built in the Black Creek watershed to control runoff. Furthermore, some stream bed stabilization has been conducted in the watershed. Most farmers are reported to be doing a good job implementing and maintaining best management practices (BMPs). The NRCS is hoping to implement more BMPs in the watershed if funding becomes available, noting that there is a lot more work that could be done in the watershed.

According to the NRCS, most farmers use Variable Rate Technology (VRT, soil tests), and do targeted chemical fertilizer application in the locations that are nutrient deficient according to the tests. Only chemical fertilizers are applied in the watershed; manure and other soil amendments are not used. The majority of the farmers use pesticides. Scouts determine the amount and location where pesticides are needed and then conduct a cost-benefit analysis to determine whether to apply the pesticide based on the condition of the crops and the projected yield. The use of the scouts helps farmers apply as little pesticide as possible.

Table 6. Land cover in the project watershed

Land Cover	Area (acres)	% of watershed
Barren	0.2	0%
Developed, high intensity	0.7	0%
Developed, low intensity	119.4	1%
Developed, medium intensity	7.3	0%
Developed, open	910.7	6%
Forest	5,488.3	37%
Grassland/pasture/hay	1,553.2	11%
Water	1,573.9	11%
Wetlands	621.6	4%
Corn	1,881.5	13%
Rice	0.7	0%
Soybeans	2,487.7	17%
Double Crop Winter Wheat/Soybeans	52.5	0%
Grand Total	**14,697.6**	**100%**

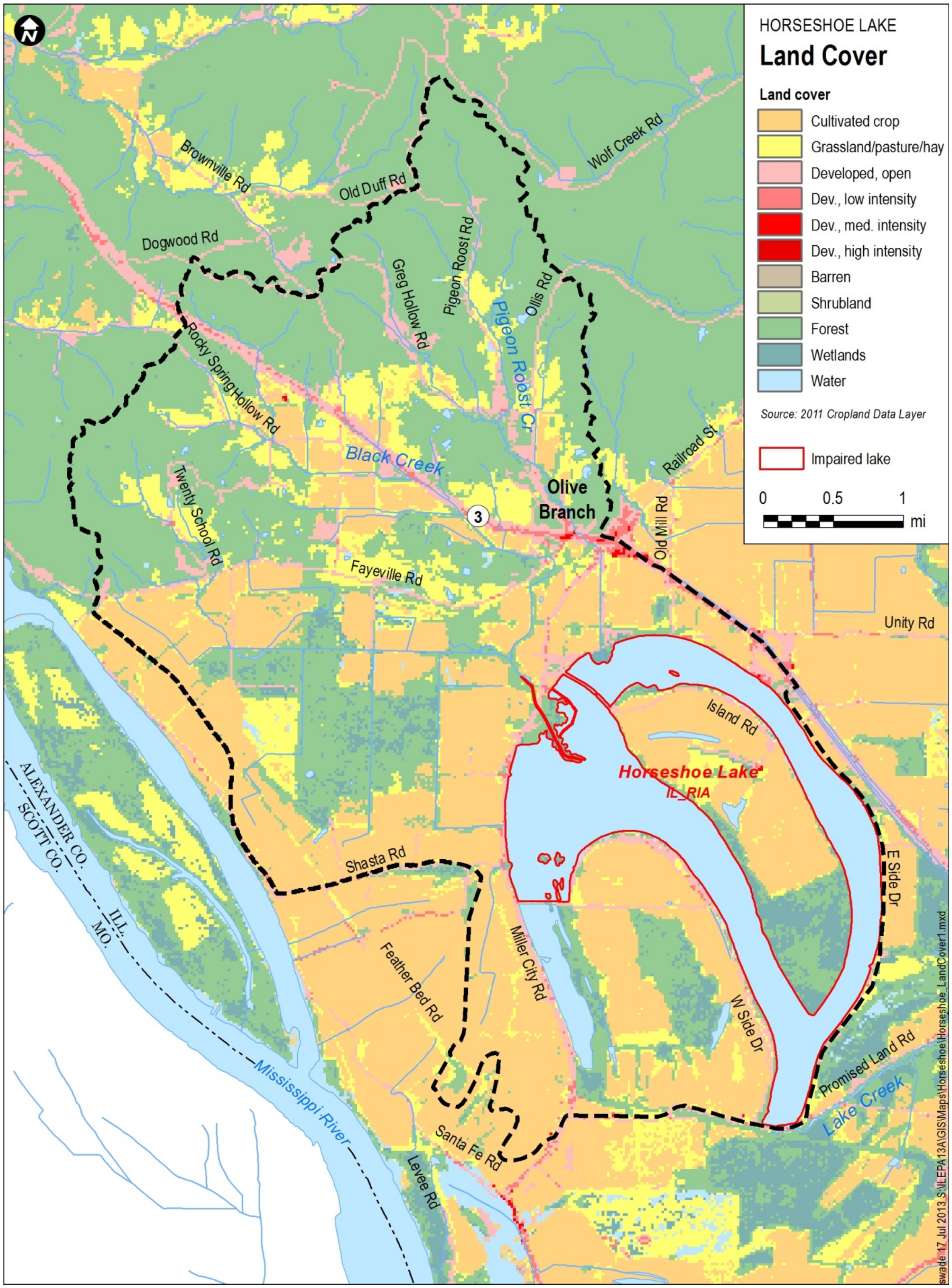

Figure 4. Land cover in the project watershed

3.8 Public and on-site wastewater treatment

The Southern 7 Health Department was contacted regarding sanitation services in the watershed. Based on the call, it was determined that the community of Olive Branch is served by public sewer, although the wastewater treatment plant serving this population is located outside the watershed. Areas located outside the town are served primarily by private septic and aeration systems. The septic tanks discharge into leach fields and aeration systems are designed for surface discharge. Citizens of Olive Branch had the option of staying off the public sewer system if their on-site system was in good working order. As soon as their private system fails they are required to hook up to the public sewer. The health department said that most people are probably hooked up to the sewer in Olive Branch, but some homes still might not be. The official contacted estimated that most systems are probably up to code and not many on-site treatment systems are failing; however they pointed out that they do not inspect the systems after they are installed unless a neighbor complains about a treatment system that is suspected to be inadequate. At the public meeting (Section 8), it was noted that new on-site systems require permits, and that usually includes an inspection, but like other counties, there is no inspection unless there is a specific complaint received by the county health department.

3.9 Livestock and poultry

The National Agricultural Statistics Service performs a census of livestock and poultry production every five years. The most recent census is from 2007. The data are not collected on a watershed basis, but are available by county (Table 7). Tables from the census are relevant as these operations are a potential source of pollutants to area waterbodies. Livestock are a source of nutrients while their grazing can increase erosion introducing sediments to area waterways; however, IEPA is not aware of any large livestock operations in the watershed.

Table 7. Livestock and poultry census data (2007)

County	Census Item	Number
Alexander County	Cattle, including calves - inventory	1,850
	Hogs - inventory	29
	Sheep, including lambs - inventory	(D)
	Poultry totals - hatched, measured in head	33

(D) Withheld to avoid disclosing data for individual operations.

3.10 Previous Studies

Several studies of Horseshoe Lake were reviewed to gain a historical perspective of the lake and issues related to nutrients and sediments. Highlights from the two most recent reports are summarized below.

A 1992 study by Lee (1992) describes a sediment detention basin feasibility study, evaluating different alternatives. Lee found that a single detention basin would reduce sediment loads the most, likely more than land treatment.

A 1997 Butts and Singh study describes benthic sediment conditions and remediation alternatives for Horseshoe Lake. This study describes an average sediment inflow to the lake of 80 acre-feet per year, with smaller sedimentation rates being found than in 1984. It was noted that the 1993 flood possibly scoured some sediments from the lake. This study also found that the lake "has not lost volume during the past 11 years." In terms of remediation, sediment venting (flushing sediments out through the undersluice gates) was determined not to work, but it was noted that "increasing the hydraulic conveyance of Lake Creek, using mechanisms to deliver more sediments for venting, and increasing flow releases could increase sediment evacuation to about 40 acre-feet per year." Dredging was described as being a questionable means for rehabilitating the lake. Finally, eutrophic conditions due to nutrient inputs are identified as a bigger problem than sedimentation, and it is observed that, "due to the loss of periodic flow-through flooding because of levee construction and improvements, accelerated algal fallout and bottom degradation will continue."

Information from these reports will be considered when developing the Stage 3 implementation plan.

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Water Quality Standards and Impairment Summary

Water quality standards are developed and enforced by the state to protect the "designated uses" of waterways. In the state of Illinois, the Illinois Pollution Control Board (IPCB) is responsible for setting water quality standards. The state is required to update water quality standards every three years in accordance with the Clean Water Act. The standards requiring modifications are identified and prioritized by Illinois EPA, in conjunction with USEPA. New standards are then developed or revised during the three-year period.

Illinois EPA is also responsible for developing scientifically based water quality criteria and proposing them to the IPCB for adoption into state rules and regulations. The Illinois water quality standards are established in the Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards.

4.1 Designated Uses

The waters of Illinois are classified by designated uses, which include: public and food processing water supplies, aquatic life, fish consumption, primary contact, secondary contact, indigenous aquatic life, and aesthetic quality (IEPA, 2012). The designated use applicable to the project watershed is aesthetic quality, which is not supporting. IEPA also assesses use support for aquatic life, and determined that the aquatic life use was being fully supported.

4.1.1 General Use

General Use Standards (35 Ill. Adm. Code Part 302, Subpart B) apply to almost all waters of the state and are intended to protect aquatic life, wildlife, agricultural, primary contact, secondary contact, and most industrial uses. These General Use Standards are also designed to ensure the aesthetic quality of the state's aquatic environment and to protect human health from disease or other harmful effects that could occur from ingesting aquatic organisms taken from surface waters of the state (IEPA, 2012).

4.1.2 Aesthetic Quality

The Aesthetic Quality Index (AQI) is the primary tool used to assess aesthetic quality for inland lakes. The AQI represents the extent to which pleasure boating, canoeing and aesthetic enjoyment are attained at a lake. The AQI is calculated from the Trophic State Index, the percent surface area macrophyte coverage during the peak growing season (June through August) and the median concentration of nonvolatile suspended solids.

4.2 Database Development

All relevant data were compiled into a project database to facilitate data analysis to support characterization of waterbody conditions, confirm the waterbody listings, and support identification of potential sources contributing to waterbody impairment.

All readily available water quality data were obtained from Illinois EPA and analyzed in Microsoft Excel. Information regarding water quality criteria and use assessment was also obtained for comparison to the recent data.

Data were subsequently analyzed by computing summary statistics, developing profiles and comparing data to water quality criteria.

4.2.1 Data Sources

Data used for this analysis were collected by the Illinois EPA in the summer of 2009 as part of their regular lake water quality sampling program. Older data are also available for this lake for 2000, 2001 and 2003, and these data are presented in Appendix C.

4.3 Summary of Impairment

Horseshoe Lake is identified as nonsuporting of the aesthetic quality use for the lake. Causes of impairments identified by IEPA are phosphorus and total suspended solids.

Table 8 summarizes relevant water quality data collected from Horseshoe Lake within the past five years. Sampling station locations for the data analyzed for this report are shown in Figure 5.

Table 8. Water quality data summary for Horseshoe Lake

Parameter	Sampling Station	Period of Record (# samples)	Minimum	Maximum	Average
Secchi (inches)	RIA-1	April 23- October 6, 2009 (N=5)	9	15	11.2
	RIA-2	April 23- October 6, 2009 (N=5)	9	15	11.4
	RIA-3	April 23- October 6, 2009 (N=5)	8	15	11.4
Turbidity (NTU)	RIA-1	April 23- October 6, 2009 (N=5)	19	38	28.6
	RIA-2	April 23- October 6, 2009 (N=5)	20	136	47.4
	RIA-3	April 23- October 6, 2009 (N=5)	18	34	27.4
Percent-surface-area macrophyte coverage	Whole lake	April 23- October 6, 2009 (N=5)	Less Than 5%	Less Than 5%	Less Than 5%
Total phosphorus (mg/l)	RIA-1	April 23- October 6, 2009 (N=10)	0.187	0.452	0.320
	RIA-2	April 23- October 6, 2009 (N=5)	0.199	0.448	0.331
	RIA-3	April 23- October 6, 2009 (N=5)	0.178	0.33	0.244
Total phosphorus (mg/kg in sediment)	RIA-1	August 5, 2009 (N=1)	1030	1030	N/A*
	RIA-3	August 5, 2009 (N=1)	1850	1850	N/A*

Parameter	Sampling Station	Period of Record (# samples)	Minimum	Maximum	Average
Chlorophyll a, corrected for pheophytin (ug/l)	RIA-1	April 23- October 6, 2009 (N=5)	53.8	184	135
	RIA-2	April 23- October 6, 2009 (N=5)	82	222	162
	RIA-3	April 23- October 6, 2009 (N=5)	53.4	155	103
Nonvolatile suspended solids (NVSS) (mg/l)	RIA-1	April 23- October 6, 2009 (N=10)	4	9	7
	RIA-2	April 23- October 6, 2009 (N=5)	0	7	4
	RIA-3	April 23- October 6, 2009 (N=6)	5	11	8
Dissolved Oxygen (mg/l)	RIA-1	April 23- October 6, 2009 (N=17)	1.66	9.63	6
	RIA-2	April 23- October 6, 2009 (N=15)	1.74	12.45	8
	RIA-3	April 23- October 6, 2009 (N=10)	7.64	12.46	10
Temperature (°C)	RIA-1	April 23- October 6, 2009 (N=17)	17.13	28.04	24
	RIA-2	April 23- October 6, 2009 (N=12)	17.37	28.76	25
	RIA-3	April 23- October 6, 2009 (N=10)	18.03	29.69	24

*N/A because only one sample.

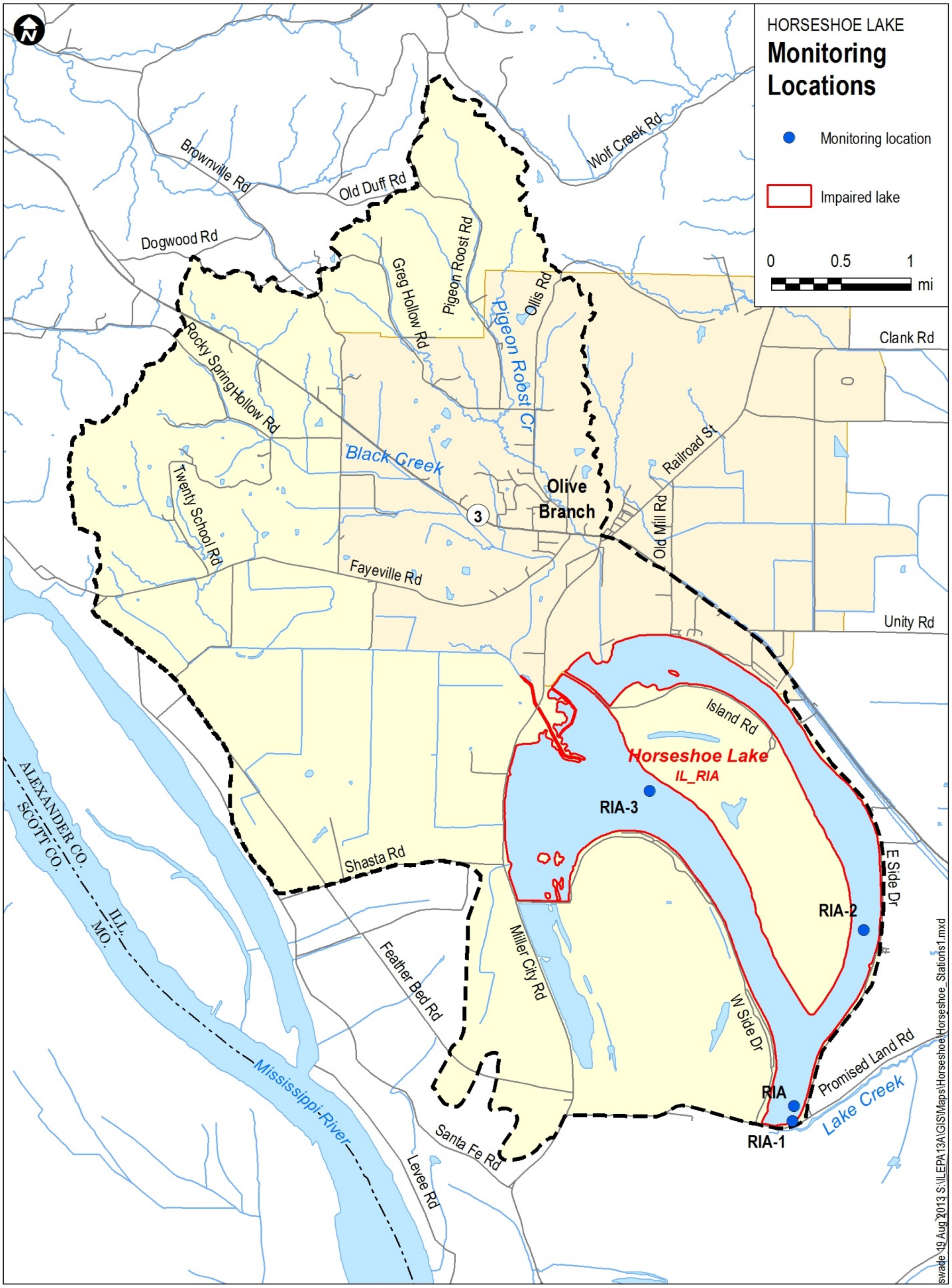


Figure 5. Sampling locations

5

Confirmation of Causes and Sources of Impairment

This section provides an analysis of available water quality data to verify the impairments identified in Section 1, Table 1, and identifies impairment causes and potential pollutant sources in the project watershed.

5.1 Sufficiency of data to support listing

Horseshoe Lake appears on the 2012 303(d) list due to nonsupport of the aesthetic quality use. 2009 water quality data have been reviewed to determine if they are suitable for use support assessments and whether the data are sufficient to confirm the use impairment and the causes of impairment.

5.1.1 Suitability of data to support use support assessment

The physical and chemical data used for aesthetic quality use assessments include: Secchi disk transparency, chlorophyll a, total phosphorus (epilimnetic samples only), nonvolatile suspended solids (NVSS, epilimnetic samples only), and percent surface area macrophyte coverage. Data are collected a minimum of five times per year (April through October) from one or more established lake sites. IEPA (2012) considers data to be usable for use support assessments if they meet the following minimum requirements: 1) At least four out of seven months (April through October) of data are available, 2) At least two of these months occurs during the peak growing season of June through August (this requirement does not apply to non-volatile suspended solids (NVSS) and 3) Usable data are available from at least half of all lakes sites within any given lake each month. Additionally, there are minimum parameter requirements (2 out of 3 parameters required for aesthetic use support assessment). The parameters are total phosphorus, secchi depth and chlorophyll a.

The data summary shown in Table 8 confirms that the 2009 dataset for Horseshoe Lake meets the minimum site and parameter requirements and is usable for use support assessments.

5.1.2 Assessment of Aesthetic Use Impairment

The State of Illinois uses the Aesthetic Quality Index (AQI) to assess if a lake is supporting the aesthetic quality use. The AQI is the sum of the median Trophic State Index (TSI) (Carlson, 1977), and scores based on percent macrophyte coverage and NVSS concentration.

AQI evaluation factors and scoring for Horseshoe Lake are shown in Table 9. The 2009 data support the listing of Horseshoe Lake due to non-support (fair) of the aesthetic quality use.

Table 9. Aesthetic Quality Index (AQI) calculations

Evaluation Factor	Parameter	Weighting Criteria	Points	Horseshoe Lake Score
1. Median Trophic State Index (TSI)	For data collected May-October: Median lake TSI value calculated from total phosphorus (samples collected at one foot depth), chlorophyll a and Secchi disk transparency.	Actual Median TSI Value		79.35
2. Macrophyte Coverage	Average percentage of lake surface area covered by macrophytes during peak growing season (June through August). Determined by: a. Macrophyte survey conducted during same water year as the chemical data used in the assessment; or b. Average value reported on the VLMP Secchi Monitoring Data form.	a. <5 b. >5<15 c. >15<25 d. >25	a. 0 b. 5 c. 10 d. 15	0.00
3. Nonvolatile Suspended Solids (NVSS) Concentration	Median lake surface NVSS concentration for samples collected at one foot depth (reported in mg/l)	a. <3 b. >3<7 c. >7<15 d. >15	a. 0 b. 5 c. 10 d. 15	5.00
			Total AQI Score >>	**84.35**

The degree of use support is evaluated based on the guidelines in Table 10 and is assessed as Not Supporting (Fair), consistent with IEPA's assessment of use support for Horseshoe Lake.

Table 10. Guidelines for assessing aesthetic quality use support in Illinois inland lakes

Degree of Use Support	Guidelines
Fully Supporting (Good)	Total AQI points are < 60
Not Supporting (Fair)	Total AQI points are ≥ 60 <90
Not Supporting (Poor)	Total AQI points are ≥ 90

Source: IEPA, 2012

5.1.3 Assessment of Causes of Impairment

Based on a review of previous 303(d) lists, it appears that Horseshoe Lake was first identified as impaired due to total phosphorus and total suspended solids on the 2006 303(d) list. In the 2012 assessments, IEPA implemented changes in their assessment methodology, removing total suspended solids as a possible cause of aesthetic quality use impairment; however, Horseshoe Lake is still identified as impaired due to total suspended solids (as well as total phosphorus) based on past assessments. The total suspended solids cause was therefore confirmed using the methodology shown in Table 11, which is the methodology used to put Horseshoe Lake on the 303(d) list.

Table 11. Guidelines for identifying potential causes of impairment of aesthetic quality use in Illinois inland lakes

	Basis for Identifying Causes (1)		
Potential			
Aquatic Algae		Unnatural Algal Growth	Median chlorophyll a (corrected) data >20 mg/L
Aquatic Plants (Macrophytes)		Unnatural Plant Growth	≥5% of lake surface area covered by macrophytes
Phosphorus (Total)	0.05 mg/L (2)		0.05 mg/L(3)
Total Suspended Solids			Median surface nonvolatile suspended solids ≥3 mg/L

1. In general, a single exceedance of the criteria results in listing the parameter as a potential cause of impairment.
   Determination of causes is normally based on the most recent year of data from the Ambient Lake Monitoring Program (ALMP) or Illinois Clean Lakes Program (CLP).
2. From Illinois General Use Water Quality Standards 35 Illinois Administrative Code, Part 302, Subpart B.
3. The total phosphorus standard applies to lakes of 20 acres or larger. However, an observation of total phosphorus greater than 0.05 mg/L in lakes under 20 acres in size is also used to indicate a cause of impairment.

5.1.3.a Total Phosphorus

The identification of phosphorus as a cause in lakes over 20 acres, is based on the total phosphorus numeric criteria of 0.05 mg/l (IEPA, 2012). Phosphorus is confirmed as a cause, based on the fact that all of the 2009 total phosphorus measurements are greater than 0.05 mg/l.

In 2009, total phosphorus was measured at 3 locations in the lake (RIA-1, RIA-2, RIA-3). These were collected at depths of 1, 2 and 4 feet at location RIA-1 and at a depth of 1 foot at the other locations. The median whole lake phosphorus concentration was 0.302 $mg \cdot L^{-1}$, and all 15 epilimnetic samples were greater than 0.05 $mg \cdot L^{-1}$.

Total phosphorus concentrations have exceeded the lake total phosphorus criteria of 0.05 mg/l for many years, as shown in Figure 6. Figure 7 shows phosphorus concentrations at different depths. This figure shows that phosphorus concentrations were also observed to be higher in the summer with depth at RIA-1.

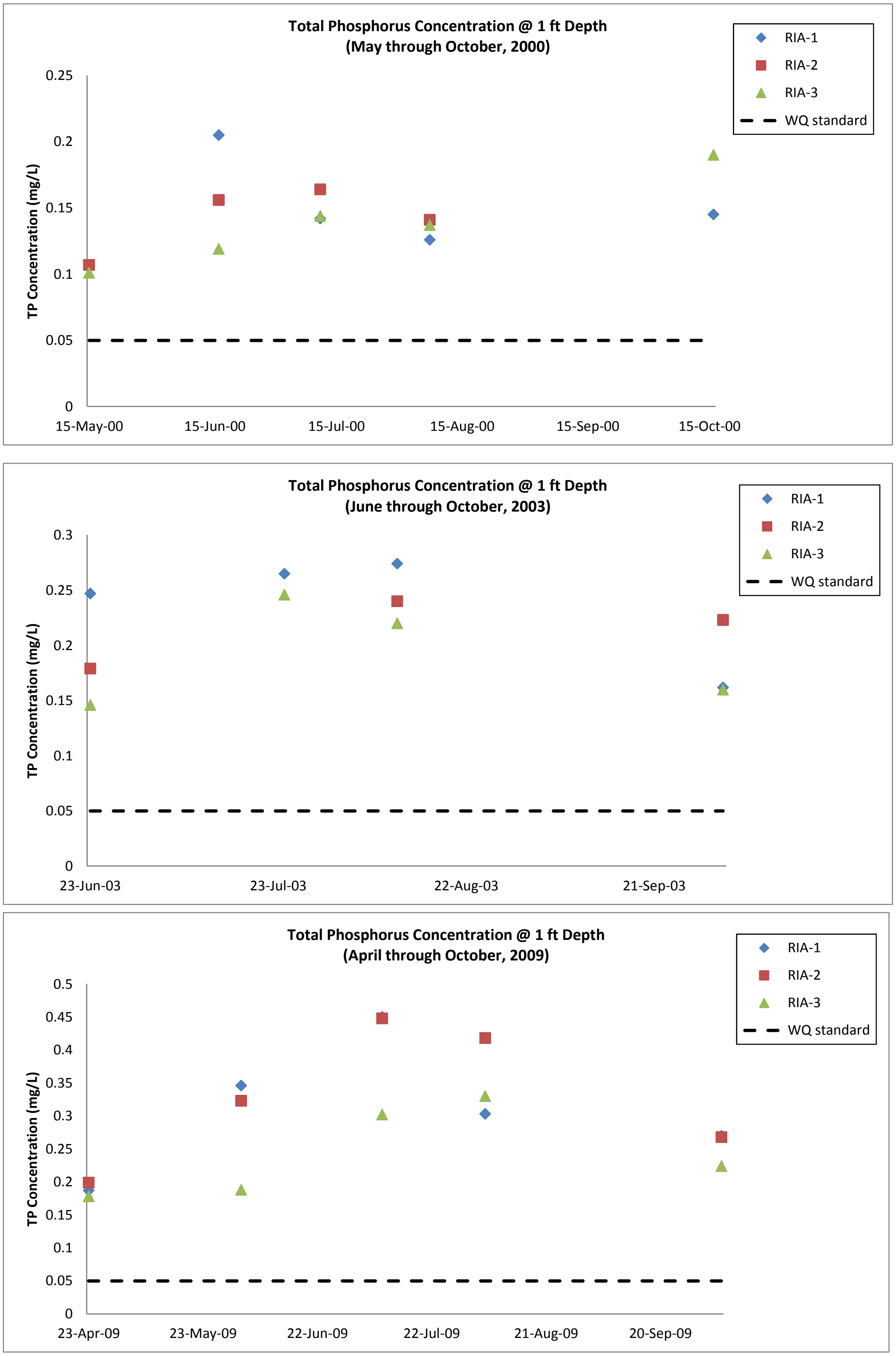


Figure 6. Epilimnetic total phosphorus concentrations in 2000, 2003 and 2009 at the three monitoring locations.

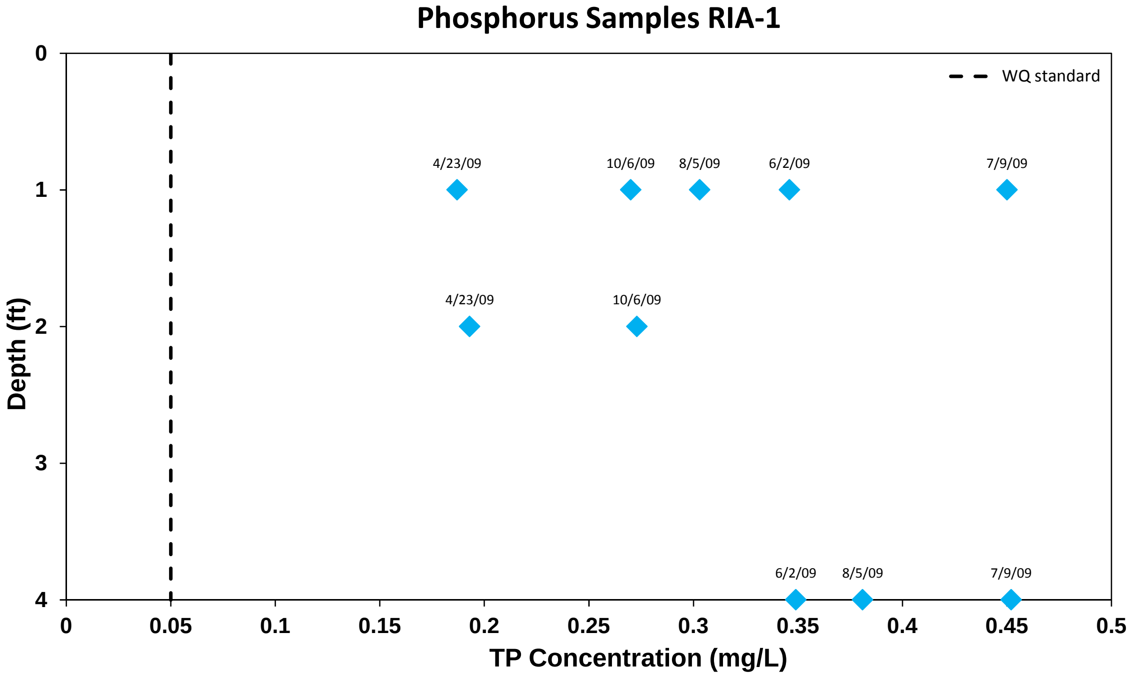


Figure 7. Concentrations of total phosphorus in the water column versus depth at RIA-1.

Note: Dates are shown on data labels.

The identification of TSS as a cause of impairment is based on a median surface nonvolatile suspended solids concentration greater than 3 mg/l. The median surface nonvolatile suspended solids concentration in Horseshoe Lake was 7 mg/l in 2009. This is based on an analysis of 2009 data from the three lake stations, confirming TSS as a cause of impairment. Nonvolatile suspended solids concentrations in Horseshoe Lake in 2003 were also examined. In 2003, the median surface nonvolatile suspended solids concentration in Horseshoe Lake equaled 9 mg/l, based on 15 samples collected between April and October, 2003 at the three sampling locations.

5.2 Source Assessment

IEPA (IEPA, 2012) defines potential sources as Waterfowl, Crop Production (crop land or dry land), Runoff from Forest/Grassland/Parkland. The potential sources identified for Horseshoe Lake (IEPA, 2012) are presented in Table 12. Additional sources identified through Stage 1 work include stream bank erosion, erosion of highly erodible soils, and possibly failing septic systems (Table 13).

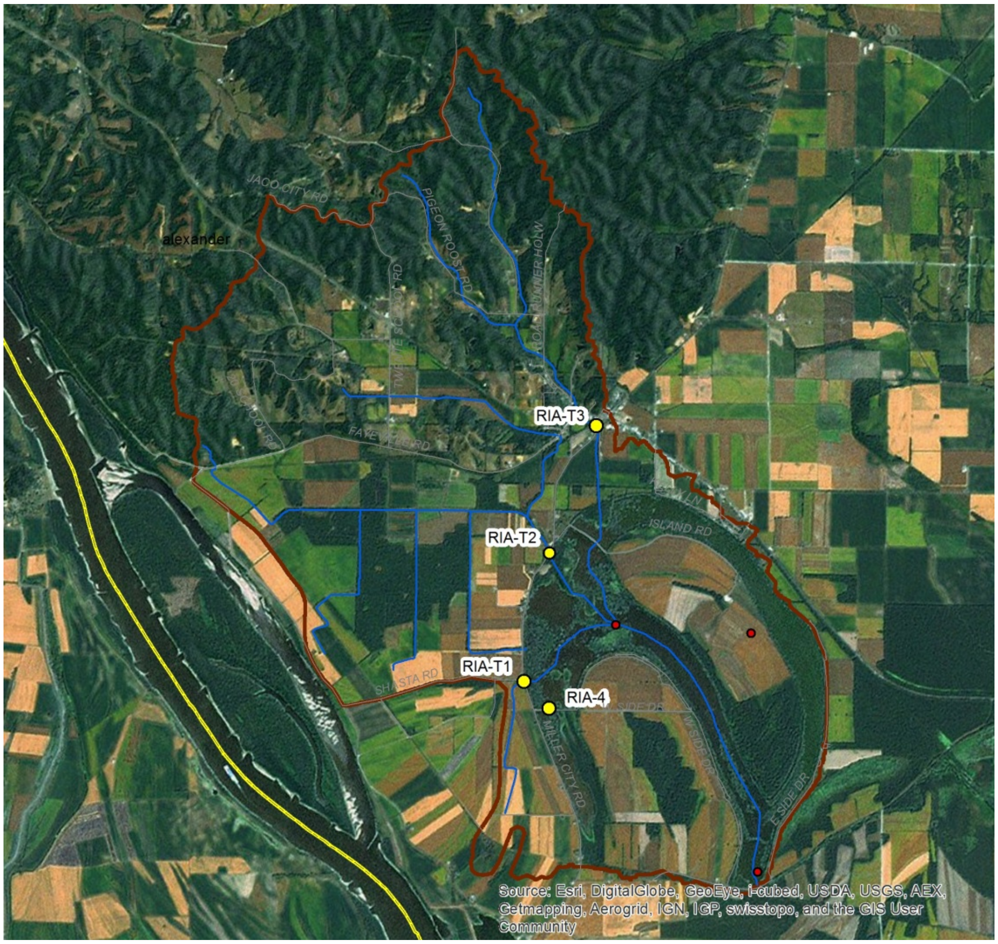
Table 12. Waterbody impairment causes and sources (IEPA, 2012)

Cause of impairment	Potential Sources (IEPA, 2012)
Phosphorus (Total)	Waterfowl, Crop Production (crop land or dry land), Runoff from Forest/Grassland/Parkland
Total suspended solids	

Table 13. Sources of impairment determined through this study

Cause of impairment	Potential Sources
Phosphorus (Total)	Waterfowl, Runoff from cropland or Forest/Grassland/Parkland, stream bank erosion, erosion of highly erodible soils, failing septic systems, resuspension of bottom sediments.
Total suspended solids	

During 2013, IEPA conducted sampling at three tributary and two lake locations. The three tributary locations, and one of the lake locations (RIA-4) have not been previously sampled. These are shown in Figure 8. Figure 5 shows the location of lake sampling station RIA-1, which was sampled previously.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 8. 2013 tributary sampling locations and one lake sampling location (RIA-4) that was not sampled prior to 2013

A summary of the data collected by IEPA at the tributary locations is presented in Table 14, confirming that elevated phosphorus and sediment concentrations are entering the lake from the tributaries. Note that the NVSS concentrations are calculated as the difference in total suspended solids and volatile suspended solids measurements. The highest phosphorus concentrations were observed in an unnamed tributary (RIA-T1) and Black Creek (RIA-T2). Much lower phosphorus concentrations were measured in Pigeon Roost Creek at RIA-T3, although the Pigeon Roost Creek levels are still above the phosphorus water quality standard of 0.05 mg/l for Horseshoe Lake. Tributary NVSS concentrations above the 3 mg/l target for the lake, were observed at all three tributary sampling locations, on at least one occasion during the sampling period. Tributary nitrate concentrations are also presented, although nitrate is not the focus of this TMDL. Nitrate concentrations were less than the detection level in many of the samples.

Table 14. Tributary and lake concentrations measured by IEPA, April through June, 2013

Nonvolatile Suspended Solids (mg/l), Calculated			
Location	**4/3/2013**	**5/16/2013**	**6/12/2013**
RIA-1	9	6	4
RIA-4		6	0
RIA-T1		9	15
RIA-T2	10	10	12
RIA-T3	3	1	Not detected
Nitrate (mg/l)			
Location	**4/3/2013**	**5/16/2013**	**6/12/2013**
RIA-1	Not detected	Not detected	Not detected
RIA-4		Not detected	
RIA-T1		Not detected	Not detected
RIA-T2	0.124	Not detected	Not detected
RIA-T3	0.059	0.106	0.153
Total phosphorus (mg/l)			
Location	**4/3/2013**	**5/16/2013**	**6/12/2013**
RIA-1	0.15	0.16	0.256
RIA-4		0.211	
RIA-T1		0.344	0.723
RIA-T2	0.363	0.649	0.526
RIA-T3	0.073	0.072	0.08

Note: RIA-1 and RIA-4 are lake sampling locations (See Figure 5 and Figure 8, respectively for locations). RIA-T1, RIA-T2 and RIA-T3 are tributary sampling locations (See Figure 8).

Historically, Horseshoe Lake was a destination for goose hunting with hundreds of thousands of geese wintering on the lake. During the site visit Illinois Department of Natural Resources officials stated that very few geese now winter at Horseshoe Lake, but many ducks still do. This would indicate that waterfowl continue to be a source of nutrients to the lake.

The majority of the soils in the Horseshoe Lake watershed are highly erodible (Figure 3), and runoff from these areas is a potential source of TSS and phosphorus. During a June site visit, mud-colored tributaries were observed flowing into the lake following a storm the prior evening. Crop production occurs in the watershed with 30% of the watershed in cultivated crops (Table 6). The county NRCS indicated that more needs to be done to control runoff from farms. Due to the erodible nature of the soils, runoff from other land uses (forest, grassland and parkland) is also identified as a potential source.

Streambank erosion, observed during the June site visit, is identified as a potential source of nutrients and TSS to the lake. Another potential source of nutrient is failing septic systems. Because these are not inspected, a failure rate is not known.

Finally, Horseshoe Lake is very shallow and well mixed. Resuspension of TSS and phosphorus from bottom sediments may be caused by wind, boats or waterfowl, and is identified as a potential source.

All sources contributing nutrients to the lake are identified as contributing to aquatic algae growth in Horseshoe Lake, which is not the focus of this study, but which is also an identified cause of impairment of Horseshoe Lake. Controls and activities focused on phosphorus reduction can also reduce algal growth in the lake, and the implementation of a TMDL for phosphorus is expected to decrease both phosphorus and algae concentrations.

6

Methodology

This section identifies potentially applicable methodologies to be used in TMDL development, describes the model selection process, and finally, provides specific recommendations for TMDL and LRS for the project watershed.

6.1 Identification of potentially applicable models and procedures to be used in TMDL and LRS development

Development of TMDLs and LRSs requires: 1) a method to estimate the amount of pollutant load being delivered to the water body of interest from all contributing sources, and 2) a method to convert these pollutant loads into an in-stream (or, in this case in-lake) concentration for comparison to water quality targets. Both of these steps can be accomplished using a wide range of methodologies, ranging from simple calculations to complex computer models. This section describes the approach for identifying methodologies that are potentially applicable for the Horseshoe Lake. It is divided into separate discussions of:

- Identifying candidate watershed model frameworks
- Identifying candidate water quality model frameworks
- Selection of a final approach

6.1.1 Identify Candidate Watershed Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize watershed loads for TMDL and LRS development. Table 15 summarizes some important characteristics of each of the models relative to TMDL and LRS application, and Appendix D describes each of these modeling frameworks in more detail.

Table 15. Summary of potentially applicable models for estimating watershed loads

Model	Data Needs	Output Timescale	Potential Accuracy	Calibration	Applicability for TMDL or LRS
Empirical Approach	High	Any	High	N/A	Good for defining existing total load; less applicable for defining individual contributions or future loads
Simple Method/Unit Area Loads	Low	Annual average	Low	None	Acceptable when limited resources prevent development of more detailed model
USLE	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
AVGWLF/ MapShed	Moderate	Monthly average	Moderate	Requires data describing flow and concentration	Good for mixed use watersheds; compromise between simple and more complex models
L-THIA	Moderate	Annual Average	Low	None	Good for screening-level assessments. Model focuses on the average impact, rather than an extreme year or storm.
STEPL	Moderate	Annual Total	Moderate	none	Suited for urban and rural watersheds. A simple model designed for TMDL support.
SWMM	Moderate	Continuous	Moderate	Requires data describing flow and concentration	Primarily suited for urban watersheds
AnnAGNPS	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available
HSPF	High	Continuous	High	Requires data describing flow and concentration	Good for mixed use watersheds; highly applicable if sufficient resources are available
SWAT	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available

6.1.2 Identify Candidate Water Quality Methodologies and Modeling Frameworks

Once pollutant loads are predicted by a watershed methodology or model, this information will be used by a water quality methodology or model to predict the system response to loading. Numerous methodologies exist to characterize the relationship between watershed loads and water quality for TMDL or LRS development. These are presented in Table 16, along with some important characteristics of each of the models relative to TMDL and LRS application. Additional information regarding these methodologies and their suitability for defining water quality for TMDL or LRS development is presented in Appendix E.

Table 16. Summary of potentially applicable models for estimating water quality

Model	Time scale	Water body type	Spatial scale	Data Needs	Pollutants Simulated	Applicability for TMDL or LRS
Spreadsheet approaches/ Load duration curve	Steady State	River or lake	0- or 1-D	Low	DO, nutrients, algae, metals	Good for screening-level assessments
EUTROMOD	Steady State	Lake	0-D	Low	DO, nutrients, algae	Good for screening-level assessments
BATHTUB	Steady State	Lake	1-D	Moderate	DO, nutrients, algae	Good for screening-level assessments; can provide more refined assessments if supporting data exist
QUAL2E/ QUAL2K	Steady State	River	1-D	Moderate/ High	DO, nutrients, algae, bacteria	Good for low-flow assessments of conventional pollutants in rivers
WASP7	Dynamic	River or lake	1-D to 3-D	High	DO, nutrients, metals, organics	Excellent water quality capability; simple hydraulics
CE-QUAL-RIV1	Dynamic	River	1-D	High	DO, nutrients, algae	Good for conventional pollutants in hydraulically complex rivers
HSPF	Dynamic	River or lake	1-D	High	DO, nutrients, metals, organics, bacteria	Wide range of water quality capabilities, directly linked to watershed model
CE-QUAL-W2	Dynamic	Lake	2-D vertical	High	DO, nutrients, algae, some metals	Good for conventional pollutants in stratified lakes or impoundments
EFDC	Dynamic	River or lake	3-D	High	DO, nutrients, metals, organics, bacteria	Potentially applicable to all sites, if sufficient data exist

6.2 Model Selection

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop the total phosphorus TMDL and total suspended solids LRS. This section describes the general guidelines that were applied to make specific model recommendations.

The following factors were considered when selecting an appropriate model for TMDL and LRS development:

- Management objectives: Management objectives define the specific purpose of the model, including the pollutant of concern, the water quality objective, the space and time scales of interest, and required level or precision/accuracy.
- Available resources: The resources available to support the modeling effort include data, time, and level of modeling effort.
- Site-specific characteristics: Site-specific characteristics include the land use activity in the watershed, type of water body (e.g. lake vs. river), important transport and transformation processes, and environmental conditions.

Model selection must be balanced between competing demands. Management objectives typically call for a high degree of model reliability, although available resources are generally insufficient to provide the degree of reliability desired. Decisions are often required regarding whether to proceed with a higher-than-desired level of uncertainty, or to postpone modeling until additional resources can be obtained.

The required level of reliability for this modeling effort is one able to “support development of a credible TMDL” and “support development of a reasonably assurable LRS.” The selected methods must be acceptable by IEPA and USEPA Region V. The amount of reliability required to develop a credible TMDL depends also on the degree of implementation to be included in the TMDL, which for this watershed, will be focused on nonpoint sources, as there are no point sources in the watershed. The approach to be taken here regarding model selection will also consider the models’ ability to provide recommendations which correspond to the level of detail required to be eligible for 319 funding. In terms of available resources, there are several years of lake water quality data available for three sampling locations. Tributary data are not available. Two models (QUAL-2K and CE-QUAL-RIV1) are designed for flowing systems, and were therefore eliminated from consideration for TMDL or LRS development.

6.3 Model Recommendations

Table 17 summarizes models recommended for development of a credible TMDL and LRS. Empirical estimates of watershed loads linked to the BATHTUB model is recommended as the model framework of choice for total phosphorus, as this approach has been successfully applied to support total phosphorus TMDLs for numerous similar lakes and impoundments throughout Illinois. An alternate approach would be to use a Unit Area Load approach to calculate watershed phosphorus loads to the lake.

It is recommended that the TSS load reduction strategy will be prepared using USLE-based methods, or, alternatively, a combination of the Simple Method and unit areal loading rates. The Simple Method/Unit Area Loads (UAL) techniques may be met with diminished stakeholder acceptance.

These models are on the simpler end of the complexity scale, but have been demonstrated to be capable of satisfying management objectives at a much lower level of resources than required by the other candidate models. Final model selection will occur with input from Illinois EPA.

Table 17. Initial model recommendations

Water body / Segment	Pollutants Considered	Watershed Model	Water Quality Model
Horseshoe Lake, Alexander County (IL_RIA)	Total phosphorus	Empirical Approach	BATHTUB
	TSS	Universal Soil Loss Equation or Simple Method/UAL	Spreadsheet Approach

7

Data Collection to Support Modeling

This section describes whether additional data are recommended to support development of the total phosphorus TMDL and TSS LRS for Horseshoe Lake.

7.1 Water Quality Data Collection

Both tributary and lake water quality data are necessary to apply the recommended approach for the total phosphorus TMDL and total suspended solids LRS. Tributary data are needed to estimate watershed loads to the lake, and lake concentration data are needed to support calibration of the BATHTUB water quality model.

The most comprehensive lake phosphorus and non-volatile suspended solids measurements were collected in 2009 from three in-lake locations (RIA-1, RIA-2 and RIA-3). Between April and June, 2013 three total phosphorus and three NVSS measurements were also collected at lake station RIA-1, confirming elevated concentrations of these parameters. Furthermore, the total phosphorus and NVSS concentrations measured at RIA-1 in 2013 are very similar to those measured at this location in 2009. Between April and June, 2013, tributary concentrations were collected at the mouth of three tributaries (unnamed tributary near Shasta Road, Pigeon Roost Creek and Black Creek) at the same time as the lake sampling at RIA-1. The tributary (and lake) sampling occurred during wet weather conditions, either during a rain event or within several days following a rain event, while the water levels were elevated.

BATHTUB could be applied for the total phosphorus TMDL, using the 2009 lake data, if it is assumed that the tributary concentrations measured in 2013 are reflective of concentrations during 2009. This is a reasonable assumption because lake concentrations in 2009 and 2013 are similar. Flows to the lake could be estimated using a simple empirical approach, and used in combination with the tributary concentration data to estimate watershed loads.

The TSS LRS could be completed using available tributary and lake concentrations, again based on the assumption that the tributary concentrations measured in 2013 are reflective of concentrations during 2009.

The final decision regarding additional monitoring will be made following discussions with Illinois EPA.

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8

Public Participation

This section summarizes the results of a December 16, 2013 public meeting, at which Illinois EPA Planning Unit TMDL project managers, along with their consultant presented the results of the Stage One Draft report for the Horseshoe Lake watershed.

On November 16, 2013, a public meeting was announced for presentation of the Stage One findings http://www.epa.state.il.us/public-notices/. The public meeting was held at 2:30 pm on Monday, December 16, 2013 in Tamms, Illinois at the Alexander/Pulaski NRCS Service Center.
This meeting provided an opportunity for local agencies and the general public to provide input on work completed to date. Prior to the meeting, Illinois EPA posted the draft Stage 1 Report for the Horseshoe Lake watershed to their website http://www.epa.state.il.us/water/tmdl/report/horseshoe-lake/stage-one-draft.pdf

In addition to the meeting's sponsors, six individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage One findings by Baetis Environmental Services, Inc. This was followed by a general question and answer session.

Additional information and opinions provided during the discussion that followed the presentation are described below, along with responses:

- In the early 2000's, Horseshoe Lake watershed was targeted for conservation practices including structures, ponds and pasture seeding, using C2000 funds. Additional funding is needed. The Cache River watershed plan was mentioned and may be revisited to include Horseshoe Lake.
    - *Response: This discussion has been included in this report.*
- Tillage practices in Horseshoe Lake watershed are probably similar to county-wide statistics
    - *Response: Section 3.5 has been updated to reflect this comment.*
- Streambank erosion, particularly in the northern 1/3 of watershed is real problem. There is currently no funding source available to the District for streambank stabilization.
    - *Response: This discussion has been added to section 3.5.*
- New on-site systems require permits, and that usually includes an inspection, but like other counties, there is no inspection unless there is a specific complaint received by the county health department.
    - *Response: This comment was added to section 3.8.*
- Oxbow lakes probably should not be classed together with natural lakes or reservoirs for use attainment status or even the phosphorus standard.
    - *Response: Horseshoe Lake is a 1,890-acre oxbow lake. The total phosphorus standard of 0.05 mg/l applies to lakes > 20 acres (302.205). If a lake has a hydraulic retention time of 0.05 years (18 days) or less (then the waterbody is more stream-like and the lake standard does not apply. Because Horseshoe Lake has a retention time greater than 18 days, the 0.05 mg/l total phosphorus standard applies. There are no other classifications for lakes.*
- The Mississippi River regularly floods Horseshoe Lake, either directly or as backwater when Ohio River is in flood stage (as in 2011). This should be recognized in formulating the TMDL.

  - *Response: This is discussed in Section 3.3 and will be considered in formulating the TMDL.*

The Agency entertained questions and concerns from the public through January 15, 2014. No additional questions or comments were received.

9
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Appendix A.
Data Sources and Local Contacts

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Table A-1. Data sources

Data description	**Agency**	**Source**
Climate summaries	Illinois State Water Survey	http://www.sws.uiuc.edu/atmos/statecli/index.htm
Cropland Data Layer (CDL)	Natural Resources Conservation Service	http://datagateway.nrcs.usda.gov/
NPDES Dischargers	Illinois EPA	Email from staff
Soils	Natural Resources Conservation Service	http://datagateway.nrcs.usda.gov/
Impaired segments	Illinois EPA	Email from staff
Sampling stations - statewide	Illinois EPA	Email from staff
Populated places	U.S. Census Bureau	Esri ArcGIS Online
Watershed Boundary Dataset	Natural Resources Conservation Service	http://datagateway.nrcs.usda.gov/
Elevation (used to help delineate watershed)	National Elevation Dataset via the U.S. Geological Survey's The National Map	http://nationalmap.gov/viewer.html
MS4 status list	Illinois Environmental Protection Agency	http://www.epa.state.il.us/water/permits/storm-water/urbanized-area-list.html
Railroads	U.S. Census Bureau	http://www.census.gov/cgi-bin/geo/shapefiles2012/main
Counties	U.S. Census Bureau	http://www.census.gov/cgi-bin/geo/shapefiles2012/main

Table A-2. State and Local Contacts

Contact	Agency/Organization	Phone/e-mail	Subject
Joe Thurston	Horseshoe Lake Fish and Wildlife Area Site Superintendent	In person visit Joe.Thurston@Illinois.gov	Horseshoe Lake hydrology, flooding, uses
Jeff Denny	Illinois DNR	In person visit	Horseshoe Lake hydrology, flooding, uses
Bev Welch/Danette Cross	NRCS Service Center Office / Tamms Service Center	618) 747-2305 ext 3 / danette.cross@il.usda.gov	Agricultural Practices
Brad Rendelman	Southern 7 Health Department	618-634-2297 ext 121 / brendelman@s7hd.org	Wastewater treatment

Appendix B.
Photos

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Horseshoe Lake from various locations around the lake, including the spillway

Pigeon Roost Creek (looking downstream) at Miller City Road

Black Creek upstream (left) and downstream (right) at Miller City Road

Unnamed tributary on southwest side of lake near Miller City and Shasta Road

Watershed near the lake

Upland areas along Cache River Road

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Appendix C.
Historical Sampling Data

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Horseshoe Lake Data - 2000

LakeDataversion1.IDENTIFICATION_CD	ID_CODE	Field0	START_DATE	MEDIUM_TYPE_NAME	PARAMETER_NAME	ResultValue	RemarkCode	Sample Depth
RIA-1	B00733000	RIA-1	5/15/2000	Water	DEPTH ft	1		3
RIA-1	B00733000	RIA-1	5/15/2000	Water	DEPTH, BOTTOM ft	5		3
RIA-1	B00733000	RIA-1	5/15/2000	Water	DEPTH, SECCHI DISK DEPTH in	10		3
RIA-1	B00733000	RIA-1	5/15/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.013		3
RIA-1	B00733000	RIA-1	5/15/2000	Water	PHOSPHORUS AS P,Total mg/l	0.088		3
RIA-1	B00733000	RIA-1	5/15/2000	Water	SOLIDS, FIXED,Total mg/l	84		3
RIA-1	B00733000	RIA-1	5/15/2000	Water	SOLIDS, FIXED,Volatile mg/l	24		3
RIA-1	B00733000	RIA-1	5/15/2000	Water	TURBIDITY FTU	50		3
RIA-1	B00733300	RIA-1	5/15/2000	Water	DEPTH ft	3		3
RIA-1	B00733300	RIA-1	5/15/2000	Water	DEPTH, BOTTOM ft	5		3
RIA-1	B00733300	RIA-1	5/15/2000	Water	DEPTH, SECCHI DISK DEPTH in	10		3
RIA-1	B00733300	RIA-1	5/15/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.012		3
RIA-1	B00733300	RIA-1	5/15/2000	Water	PHOSPHORUS AS P,Total mg/l	0.091		3
RIA-1	B00733300	RIA-1	5/15/2000	Water	SOLIDS, FIXED,Total mg/l	92		3
RIA-1	B00733300	RIA-1	5/15/2000	Water	SOLIDS, FIXED,Volatile mg/l	26		3
RIA-1	B00733300	RIA-1	5/15/2000	Water	TURBIDITY FTU	52		3
RIA-1	B00778800	RIA-1	5/15/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	192		2
RIA-1	B00778800	RIA-1	5/15/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Total	181		2
RIA-1	B00778800	RIA-1	5/15/2000	Water	DEPTH ft	2		2
RIA-1	B00959200	RIA-1	6/16/2000	Water	DEPTH ft	1		1
RIA-1	B00959200	RIA-1	6/16/2000	Water	DEPTH, BOTTOM ft	5		1
RIA-1	B00959200	RIA-1	6/16/2000	Water	DEPTH, SECCHI DISK DEPTH in	10		1
RIA-1	B00959200	RIA-1	6/16/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.025		1
RIA-1	B00959200	RIA-1	6/16/2000	Water	PHOSPHORUS AS P,Total mg/l	0.205		1
RIA-1	B00959200	RIA-1	6/16/2000	Water	SOLIDS, FIXED,Total mg/l	52		1
RIA-1	B00959200	RIA-1	6/16/2000	Water	SOLIDS, FIXED,Volatile mg/l	14		1
RIA-1	B00959500	RIA-1	6/16/2000	Water	DEPTH ft	3		3
RIA-1	B00959500	RIA-1	6/16/2000	Water	DEPTH, BOTTOM ft	5		
RIA-1	B00959500	RIA-1	6/16/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.026		3
RIA-1	B00959500	RIA-1	6/16/2000	Water	PHOSPHORUS AS P,Total mg/l	0.143		3
RIA-1	B00959500	RIA-1	6/16/2000	Water	SOLIDS, FIXED,Total mg/l	62		3
RIA-1	B00959500	RIA-1	6/16/2000	Water	SOLIDS, FIXED,Volatile mg/l	34		3
RIA-1	B01003200	RIA-1	6/16/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	219		2
RIA-1	B01003200	RIA-1	6/16/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Total	204		2
RIA-1	B01003200	RIA-1	6/16/2000	Water	DEPTH ft	2		2
RIA-1	P000616D0000	RIA-1	6/16/2000	Water	DEPTH ft	0		0
RIA-1	P000616D0000	RIA-1	6/16/2000	Water	DISSOLVED OXYGEN (DO) mg/l	4.5		0
RIA-1	P000616D0000	RIA-1	6/16/2000	Water	TEMPERATURE, WATER deg C	26.6		0
RIA-1	P000616D0001	RIA-1	6/16/2000	Water	DEPTH ft	1		1
RIA-1	P000616D0001	RIA-1	6/16/2000	Water	DISSOLVED OXYGEN (DO) mg/l	4.1		1
RIA-1	P000616D0001	RIA-1	6/16/2000	Water	TEMPERATURE, WATER deg C	26.6		1
RIA-1	P000616D0003	RIA-1	6/16/2000	Water	DEPTH ft	3		3
RIA-1	P000616D0003	RIA-1	6/16/2000	Water	DISSOLVED OXYGEN (DO) mg/l	2.8		3
RIA-1	P000616D0003	RIA-1	6/16/2000	Water	TEMPERATURE, WATER deg C	26.5		3
RIA-1	B01123000	RIA-1	7/11/2000	Water	DEPTH ft	1		1
RIA-1	B01123000	RIA-1	7/11/2000	Water	DEPTH, BOTTOM ft	5		1
RIA-1	B01123000	RIA-1	7/11/2000	Water	DEPTH, SECCHI DISK DEPTH in	8		1
RIA-1	B01123000	RIA-1	7/11/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.026		1
RIA-1	B01123000	RIA-1	7/11/2000	Water	PHOSPHORUS AS P,Total mg/l	0.142		1
RIA-1	B01123000	RIA-1	7/11/2000	Water	SOLIDS, FIXED,Total mg/l	50		1
RIA-1	B01123000	RIA-1	7/11/2000	Water	SOLIDS, FIXED,Volatile mg/l	38		1
RIA-1	B01123300	RIA-1	7/11/2000	Water	DEPTH ft	3		3
RIA-1	B01123300	RIA-1	7/11/2000	Water	DEPTH, BOTTOM ft	5		3
RIA-1	B01123300	RIA-1	7/11/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.022		3
RIA-1	B01123300	RIA-1	7/11/2000	Water	PHOSPHORUS AS P,Total mg/l	0.14		3
RIA-1	B01123300	RIA-1	7/11/2000	Water	SOLIDS, FIXED,Total mg/l	34		3
RIA-1	B01123300	RIA-1	7/11/2000	Water	SOLIDS, FIXED,Volatile mg/l	22		3
RIA-1	B01304400	RIA-1	7/11/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	157		1
RIA-1	B01304400	RIA-1	7/11/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Total	162		1
RIA-1	B01304400	RIA-1	7/11/2000	Water	DEPTH ft	1		1
RIA-1	P000711D0000	RIA-1	7/11/2000	Water	DEPTH ft	0		0
RIA-1	P000711D0000	RIA-1	7/11/2000	Water	DISSOLVED OXYGEN (DO) mg/l	13.4		0
RIA-1	P000711D0000	RIA-1	7/11/2000	Water	TEMPERATURE, WATER deg C	33.4		0
RIA-1	P000711D0001	RIA-1	7/11/2000	Water	DEPTH ft	1		1
RIA-1	P000711D0001	RIA-1	7/11/2000	Water	DISSOLVED OXYGEN (DO) mg/l	9.6		1
RIA-1	P000711D0001	RIA-1	7/11/2000	Water	TEMPERATURE, WATER deg C	31.6		1
RIA-1	P000711D0003	RIA-1	7/11/2000	Water	DEPTH ft	3		3
RIA-1	P000711D0003	RIA-1	7/11/2000	Water	DISSOLVED OXYGEN (DO) mg/l	2.9		3
RIA-1	P000711D0003	RIA-1	7/11/2000	Water	TEMPERATURE, WATER deg C	30.2		3
RIA-1	B01361700	RIA-1	8/7/2000	Water	DEPTH ft	1		1
RIA-1	B01361700	RIA-1	8/7/2000	Water	DEPTH, BOTTOM ft	4		1
RIA-1	B01361700	RIA-1	8/7/2000	Water	DEPTH, SECCHI DISK DEPTH in	9		1
RIA-1	B01361700	RIA-1	8/7/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.018		1
RIA-1	B01361700	RIA-1	8/7/2000	Water	PHOSPHORUS AS P,Total mg/l	0.126		1
RIA-1	B01361700	RIA-1	8/7/2000	Water	SOLIDS, FIXED,Total mg/l	53		1
RIA-1	B01361700	RIA-1	8/7/2000	Water	SOLIDS, FIXED,Volatile mg/l	32		1
RIA-1	B01361700	RIA-1	8/7/2000	Water	TURBIDITY FTU	52		1

LakeDataversion1.IDENTIFICATION_CD	ID_CODE	Field0	START_DATE	MEDIUM_TYPE_NAME	PARAMETER_NAME	ResultValue	RemarkCode	Sample Depth
RIA-1	B01477800	RIA-1	8/7/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	146		2
RIA-1	B01477800	RIA-1	8/7/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	186		2
RIA-1	B01477800	RIA-1	8/7/2000	Water	DEPTH ft	2		2
RIA-1	B01675800	RIA-1	8/7/2000	Sediment	DEPTH ft	4		4
RIA-1	B01675800	RIA-1	8/7/2000	Sediment	PHOSPHORUS AS P	791		4
RIA-1	B01675800	RIA-1	8/7/2000	Sediment	SOLIDS, TOTAL SUSPENDED,Non-volatile %	40.6		4
RIA-1	B01675800	RIA-1	8/7/2000	Sediment	SOLIDS, TOTAL SUSPENDED,Volatile %	9.9		4
RIA-1	D01115600	RIA-1	8/7/2000	Sediment	DEPTH ft	4		4
RIA-1	P000807D0000	RIA-1	8/7/2000	Water	DEPTH ft	0		0
RIA-1	P000807D0000	RIA-1	8/7/2000	Water	DISSOLVED OXYGEN (DO) mg/l	6.9		0
RIA-1	P000807D0000	RIA-1	8/7/2000	Water	TEMPERATURE, WATER deg C	29.1		0
RIA-1	P000807D0001	RIA-1	8/7/2000	Water	DEPTH ft	1		1
RIA-1	P000807D0001	RIA-1	8/7/2000	Water	DISSOLVED OXYGEN (DO) mg/l	4.8		1
RIA-1	P000807D0001	RIA-1	8/7/2000	Water	TEMPERATURE, WATER deg C	29		1
RIA-1	P000807D0002	RIA-1	8/7/2000	Water	DEPTH ft	2		2
RIA-1	P000807D0002	RIA-1	8/7/2000	Water	DISSOLVED OXYGEN (DO) mg/l	5.1		2
RIA-1	P000807D0002	RIA-1	8/7/2000	Water	TEMPERATURE, WATER deg C	29.1		2
RIA-1	B01857500	RIA-1	10/16/2000	Water	DEPTH ft	1		1
RIA-1	B01857500	RIA-1	10/16/2000	Water	DEPTH, BOTTOM ft	4		1
RIA-1	B01857500	RIA-1	10/16/2000	Water	DEPTH, SECCHI DISK DEPTH in	10		1
RIA-1	B01857500	RIA-1	10/16/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.017		1
RIA-1	B01857500	RIA-1	10/16/2000	Water	PHOSPHORUS AS P,Total mg/l	0.145		1
RIA-1	B01857500	RIA-1	10/16/2000	Water	SOLIDS, FIXED,Total mg/l	43		1
RIA-1	B01857500	RIA-1	10/16/2000	Water	SOLIDS, FIXED,Volatile mg/l	29		1
RIA-1	B01857500	RIA-1	10/16/2000	Water	TURBIDITY FTU	36.1		1
RIA-1	B01983000	RIA-1	10/16/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	91.8		2
RIA-1	B01983000	RIA-1	10/16/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	89.9		2
RIA-1	B01983000	RIA-1	10/16/2000	Water	DEPTH ft	2		2
RIA-2	B00733100	RIA-2	5/15/2000	Water	DEPTH ft	1		1
RIA-2	B00733100	RIA-2	5/15/2000	Water	DEPTH, BOTTOM ft	4		1
RIA-2	B00733100	RIA-2	5/15/2000	Water	DEPTH, SECCHI DISK DEPTH in	11		1
RIA-2	B00733100	RIA-2	5/15/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.017		1
RIA-2	B00733100	RIA-2	5/15/2000	Water	PHOSPHORUS AS P,Total mg/l	0.107		1
RIA-2	B00733100	RIA-2	5/15/2000	Water	SOLIDS, FIXED,Total mg/l	60		1
RIA-2	B00733100	RIA-2	5/15/2000	Water	SOLIDS, FIXED,Volatile mg/l	14		1
RIA-2	B00733100	RIA-2	5/15/2000	Water	TURBIDITY FTU	39		1
RIA-2	B00778900	RIA-2	5/15/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	248		2
RIA-2	B00778900	RIA-2	5/15/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Total	237		2
RIA-2	B00778900	RIA-2	5/15/2000	Water	DEPTH ft	2		2
RIA-2	B00959300	RIA-2	6/16/2000	Water	DEPTH ft	1		1
RIA-2	B00959300	RIA-2	6/16/2000	Water	DEPTH, BOTTOM ft	4		1
RIA-2	B00959300	RIA-2	6/16/2000	Water	DEPTH, SECCHI DISK DEPTH in	6		1
RIA-2	B00959300	RIA-2	6/16/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.021		1
RIA-2	B00959300	RIA-2	6/16/2000	Water	PHOSPHORUS AS P,Total mg/l	0.156		1
RIA-2	B00959300	RIA-2	6/16/2000	Water	SOLIDS, FIXED,Total mg/l	66		1
RIA-2	B00959300	RIA-2	6/16/2000	Water	SOLIDS, FIXED,Volatile mg/l	44		1
RIA-2	B01003300	RIA-2	6/16/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	371		1
RIA-2	B01003300	RIA-2	6/16/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Total	351		1
RIA-2	B01003300	RIA-2	6/16/2000	Water	DEPTH ft	1		1
RIA-2	P000616D0000	RIA-2	6/16/2000	Water	DEPTH ft	0		0
RIA-2	P000616D0000	RIA-2	6/16/2000	Water	DISSOLVED OXYGEN (DO) mg/l	6.2		0
RIA-2	P000616D0000	RIA-2	6/16/2000	Water	TEMPERATURE, WATER deg C	27		0
RIA-2	P000616D0001	RIA-2	6/16/2000	Water	DEPTH ft	1		1
RIA-2	P000616D0001	RIA-2	6/16/2000	Water	DISSOLVED OXYGEN (DO) mg/l	6.1		1
RIA-2	P000616D0001	RIA-2	6/16/2000	Water	TEMPERATURE, WATER deg C	26.9		1
RIA-2	P000616D0002	RIA-2	6/16/2000	Water	DEPTH ft	2		2
RIA-2	P000616D0002	RIA-2	6/16/2000	Water	DISSOLVED OXYGEN (DO) mg/l	6.1		2
RIA-2	P000616D0002	RIA-2	6/16/2000	Water	TEMPERATURE, WATER deg C	26.9		2
RIA-2	B01123100	RIA-2	7/11/2000	Water	DEPTH ft	1		1
RIA-2	B01123100	RIA-2	7/11/2000	Water	DEPTH, BOTTOM ft	4		1
RIA-2	B01123100	RIA-2	7/11/2000	Water	DEPTH, SECCHI DISK DEPTH in	8		1
RIA-2	B01123100	RIA-2	7/11/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.029		1
RIA-2	B01123100	RIA-2	7/11/2000	Water	PHOSPHORUS AS P,Total mg/l	0.164		1
RIA-2	B01123100	RIA-2	7/11/2000	Water	SOLIDS, FIXED,Total mg/l	30		1
RIA-2	B01123100	RIA-2	7/11/2000	Water	SOLIDS, FIXED,Volatile mg/l	24		1
RIA-2	B01304500	RIA-2	7/11/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	217		1
RIA-2	B01304500	RIA-2	7/11/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Total	210		1
RIA-2	B01304500	RIA-2	7/11/2000	Water	DEPTH ft	1		1
RIA-2	P000711D0000	RIA-2	7/11/2000	Water	DEPTH ft	0		0
RIA-2	P000711D0000	RIA-2	7/11/2000	Water	DISSOLVED OXYGEN (DO) mg/l	6.5		0
RIA-2	P000711D0000	RIA-2	7/11/2000	Water	TEMPERATURE, WATER deg C	30.6		0
RIA-2	P000711D0001	RIA-2	7/11/2000	Water	DEPTH ft	1		1
RIA-2	P000711D0001	RIA-2	7/11/2000	Water	DISSOLVED OXYGEN (DO) mg/l	6.3		1
RIA-2	P000711D0001	RIA-2	7/11/2000	Water	TEMPERATURE, WATER deg C	30.5		1
RIA-2	P000711D0002	RIA-2	7/11/2000	Water	DEPTH ft	2		2
RIA-2	P000711D0002	RIA-2	7/11/2000	Water	DISSOLVED OXYGEN (DO) mg/l	0.3		2
RIA-2	P000711D0002	RIA-2	7/11/2000	Water	TEMPERATURE, WATER deg C	29.4		2
RIA-2	B01361800	RIA-2	8/7/2000	Water	DEPTH ft	1		1
RIA-2	B01361800	RIA-2	8/7/2000	Water	DEPTH, BOTTOM ft	3		1

LakeDataversion1.IDENTIFICATION_CD	ID_CODE	Field0	START_DATE	MEDIUM_TYPE_NAME	PARAMETER_NAME	ResultValue	RemarkCode	Sample Depth
RIA-2	B01361800	RIA-2	8/7/2000	Water	DEPTH, SECCHI DISK DEPTH in	9		1
RIA-2	B01361800	RIA-2	8/7/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.028		1
RIA-2	B01361800	RIA-2	8/7/2000	Water	PHOSPHORUS AS P,Total mg/l	0.141		1
RIA-2	B01361800	RIA-2	8/7/2000	Water	SOLIDS, FIXED,Total mg/l	51		1
RIA-2	B01361800	RIA-2	8/7/2000	Water	SOLIDS, FIXED,Volatile mg/l	43		1
RIA-2	B01361800	RIA-2	8/7/2000	Water	TURBIDITY FTU	76		1
RIA-2	B01477900	RIA-2	8/7/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	311		1
RIA-2	B01477900	RIA-2	8/7/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	332		1
RIA-2	B01477900	RIA-2	8/7/2000	Water	DEPTH ft	1		1
RIA-2	P000807D0000	RIA-2	8/7/2000	Water	DEPTH ft	0		0
RIA-2	P000807D0000	RIA-2	8/7/2000	Water	DISSOLVED OXYGEN (DO) mg/l	8.5		0
RIA-2	P000807D0000	RIA-2	8/7/2000	Water	TEMPERATURE, WATER deg C	29		0
RIA-2	P000807D0001	RIA-2	8/7/2000	Water	DEPTH ft	1		1
RIA-2	P000807D0001	RIA-2	8/7/2000	Water	DISSOLVED OXYGEN (DO) mg/l	7.9		1
RIA-2	P000807D0001	RIA-2	8/7/2000	Water	TEMPERATURE, WATER deg C	29		1
RIA-2	B018576	RIA-2	8/7/2000	Water	DEPTH ft	1		3
RIA-2	B018576	RIA-2	8/7/2000	Water	DEPTH, BOTTOM ft	3		3
RIA-2	B018576	RIA-2	8/7/2000	Water	DEPTH, SECCHI DISK DEPTH in	8		3
RIA-2	B018576	RIA-2	8/7/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.027		3
RIA-2	B018576	RIA-2	8/7/2000	Water	PHOSPHORUS AS P,Total mg/l	0.149		3
RIA-2	B018576	RIA-2	8/7/2000	Water	SOLIDS, FIXED,Total mg/l	53		3
RIA-2	B018576	RIA-2	8/7/2000	Water	SOLIDS, FIXED,Volatile mg/l	42		3
RIA-2	B018576	RIA-2	8/7/2000	Water	TURBIDITY FTU	68		3
RIA-2	B01983100	RIA-2	10/16/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	355		1
RIA-2	B01983100	RIA-2	10/16/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	360		1
RIA-2	B01983100	RIA-2	10/16/2000	Water	DEPTH ft	1		1
RIA-3	B00733200	RIA-3	5/15/2000	Water	DEPTH ft	1		1
RIA-3	B00733200	RIA-3	5/15/2000	Water	DEPTH, BOTTOM ft	4		1
RIA-3	B00733200	RIA-3	5/15/2000	Water	DEPTH, SECCHI DISK DEPTH in	12		1
RIA-3	B00733200	RIA-3	5/15/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.014		1
RIA-3	B00733200	RIA-3	5/15/2000	Water	PHOSPHORUS AS P,Total mg/l	0.101		1
RIA-3	B00733200	RIA-3	5/15/2000	Water	SOLIDS, FIXED,Total mg/l	100		1
RIA-3	B00733200	RIA-3	5/15/2000	Water	SOLIDS, FIXED,Volatile mg/l	30		1
RIA-3	B00733200	RIA-3	5/15/2000	Water	TURBIDITY FTU	55		1
RIA-3	B00779000	RIA-3	5/15/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	241		2
RIA-3	B00779000	RIA-3	5/15/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Total	233		2
RIA-3	B00779000	RIA-3	5/15/2000	Water	DEPTH ft	2		2
RIA-3	B00959400	RIA-3	6/16/2000	Water	DEPTH ft	1		1
RIA-3	B00959400	RIA-3	6/16/2000	Water	DEPTH, BOTTOM ft	3		1
RIA-3	B00959400	RIA-3	6/16/2000	Water	DEPTH, SECCHI DISK DEPTH in	8		1
RIA-3	B00959400	RIA-3	6/16/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.028		1
RIA-3	B00959400	RIA-3	6/16/2000	Water	PHOSPHORUS AS P,Total mg/l	0.119		1
RIA-3	B00959400	RIA-3	6/16/2000	Water	SOLIDS, FIXED,Total mg/l	60		1
RIA-3	B00959400	RIA-3	6/16/2000	Water	SOLIDS, FIXED,Volatile mg/l	30		1
RIA-3	B01003400	RIA-3	6/16/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	198		1
RIA-3	B01003400	RIA-3	6/16/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Total	196		1
RIA-3	B01003400	RIA-3	6/16/2000	Water	DEPTH ft	1		1
RIA-3	P000616D0000	RIA-3	6/16/2000	Water	DEPTH ft	0		0
RIA-3	P000616D0000	RIA-3	6/16/2000	Water	DISSOLVED OXYGEN (DO) mg/l	8.3		0
RIA-3	P000616D0000	RIA-3	6/16/2000	Water	TEMPERATURE, WATER deg C	27.3		0
RIA-3	P000616D0001	RIA-3	6/16/2000	Water	DEPTH ft	1		1
RIA-3	P000616D0001	RIA-3	6/16/2000	Water	DISSOLVED OXYGEN (DO) mg/l	8.1		1
RIA-3	P000616D0001	RIA-3	6/16/2000	Water	TEMPERATURE, WATER deg C	27.3		1
RIA-3	B01123200	RIA-3	7/11/2000	Water	DEPTH ft	1		1
RIA-3	B01123200	RIA-3	7/11/2000	Water	DEPTH, BOTTOM ft	3		1
RIA-3	B01123200	RIA-3	7/11/2000	Water	DEPTH, SECCHI DISK DEPTH in	8		1
RIA-3	B01123200	RIA-3	7/11/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.031		1
RIA-3	B01123200	RIA-3	7/11/2000	Water	PHOSPHORUS AS P,Total mg/l	0.144		1
RIA-3	B01123200	RIA-3	7/11/2000	Water	SOLIDS, FIXED,Total mg/l	34		1
RIA-3	B01123200	RIA-3	7/11/2000	Water	SOLIDS, FIXED,Volatile mg/l	8		1
RIA-3	B01304600	RIA-3	7/11/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	146		1
RIA-3	B01304600	RIA-3	7/11/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Total	144		1
RIA-3	B01304600	RIA-3	7/11/2000	Water	DEPTH ft	1		1
RIA-3	P000711D0000	RIA-3	7/11/2000	Water	DEPTH ft	0		0
RIA-3	P000711D0000	RIA-3	7/11/2000	Water	DISSOLVED OXYGEN (DO) mg/l	10.3		0
RIA-3	P000711D0000	RIA-3	7/11/2000	Water	TEMPERATURE, WATER deg C	32.5		0
RIA-3	P000711D0001	RIA-3	7/11/2000	Water	DEPTH ft	1		1
RIA-3	P000711D0001	RIA-3	7/11/2000	Water	DISSOLVED OXYGEN (DO) mg/l	8.6		1
RIA-3	P000711D0001	RIA-3	7/11/2000	Water	TEMPERATURE, WATER deg C	31.9		1
RIA-3	B01361900	RIA-3	8/7/2000	Water	DEPTH ft	1		1
RIA-3	B01361900	RIA-3	8/7/2000	Water	DEPTH, BOTTOM ft	3		1
RIA-3	B01361900	RIA-3	8/7/2000	Water	DEPTH, SECCHI DISK DEPTH in	9		1
RIA-3	B01361900	RIA-3	8/7/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.028		1
RIA-3	B01361900	RIA-3	8/7/2000	Water	PHOSPHORUS AS P,Total mg/l	0.137		1
RIA-3	B01361900	RIA-3	8/7/2000	Water	SOLIDS, FIXED,Total mg/l	55		1
RIA-3	B01361900	RIA-3	8/7/2000	Water	SOLIDS, FIXED,Volatile mg/l	30		1
RIA-3	B01361900	RIA-3	8/7/2000	Water	TURBIDITY FTU	54		1
RIA-3	B01478000	RIA-3	8/7/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	148		1
RIA-3	B01478000	RIA-3	8/7/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	169		1

LakeDataversion1.IDENTIFICATION_CD	ID_CODE	Field0	START_DATE	MEDIUM_TYPE_NAME	PARAMETER_NAME	ResultValue	RemarkCode	Sample Depth
RIA-3	B01478000	RIA-3	8/7/2000	Water	DEPTH ft	1		1
RIA-3	D01115700	RIA-3	8/7/2000	Sediment	DEPTH ft	3		3
RIA-3	P000807D0000	RIA-3	8/7/2000	Water	DEPTH ft	0		0
RIA-3	P000807D0000	RIA-3	8/7/2000	Water	DISSOLVED OXYGEN (DO) mg/l	7.2		0
RIA-3	P000807D0000	RIA-3	8/7/2000	Water	TEMPERATURE, WATER deg C	29.5		0
RIA-3	P000807D0001	RIA-3	8/7/2000	Water	DEPTH ft	1		1
RIA-3	P000807D0001	RIA-3	8/7/2000	Water	DISSOLVED OXYGEN (DO) mg/l	6.9		1
RIA-3	P000807D0001	RIA-3	8/7/2000	Water	TEMPERATURE, WATER deg C	29.5		1
RIA-3	B01983200	RIA-3	10/16/2000	Water	CHLOROPHYLL A, CORRECTED FOR PHEOPHYTIN ug/l	206		1
RIA-3	B01983200	RIA-3	10/16/2000	Water	CHLOROPHYLL A, UNCORRECTED FOR PHEOPHYTIN,Fixed	207		1
RIA-3	B01983200	RIA-3	10/16/2000	Water	DEPTH ft	1		1
RIA-3	B018577	RIA-3	10/16/2000	Water	DEPTH ft	1		1
RIA-3	B018577	RIA-3	10/16/2000	Water	DEPTH, BOTTOM ft	3		1
RIA-3	B018577	RIA-3	10/16/2000	Water	DEPTH, SECCHI DISK DEPTH in	7		1
RIA-3	B018577	RIA-3	10/16/2000	Water	PHOSPHORUS AS P,Dissolved mg/l	0.021		1
RIA-3	B018577	RIA-3	10/16/2000	Water	PHOSPHORUS AS P,Total mg/l	0.19		1
RIA-3	B018577	RIA-3	10/16/2000	Water	SOLIDS, FIXED,Total mg/l	61		1
RIA-3	B018577	RIA-3	10/16/2000	Water	SOLIDS, FIXED,Volatile mg/l	33		1

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STATION_ID		STATION_NAME	ACTIVITY_START_DATE	CHARACTERISTIC_NAME	RESULT_VALUE	RESULT_UNIT	ACTIVITY_MEDIUM	ACTIVITY_DEPTH	ACTIVITY_DEPTH_UNIT
RIA-1	B306717	HORSESHOE LK-ALEXDR	04/22/2003	Chlorophyll a, corrected for pheophytin	73.5	ug/l	Water	2	ft
RIA-1	B306717	HORSESHOE LK-ALEXDR	04/22/2003	Chlorophyll a, uncorrected for pheophytin	79.9	ug/l	Water	2	ft
RIA-1	B306132	HORSESHOE LK-ALEXDR	04/22/2003	Depth, bottom	4	ft	Water	1	ft
RIA-1	B306132	HORSESHOE LK-ALEXDR	04/22/2003	Depth, Secchi Disk Depth	11	in	Water	1	ft
RIA-1	B306132	HORSESHOE LK-ALEXDR	04/22/2003	pH	7.5	None	Water	1	ft
RIA-1	B306132	HORSESHOE LK-ALEXDR	04/22/2003	Solids, Total Suspended (TSS)	44	mg/l	Water	1	ft
RIA-1	B306132	HORSESHOE LK-ALEXDR	04/22/2003	Solids, Volatile	22	mg/l	Water	1	ft
RIA-1	B306132	HORSESHOE LK-ALEXDR	04/22/2003	Temperature, sample	2	deg C	Water	1	ft
RIA-1	B306132	HORSESHOE LK-ALEXDR	04/22/2003	Turbidity	30	NTU	Water	1	ft
RIA-1	B311426	HORSESHOE LK-ALEXDR	06/23/2003	Chlorophyll a, corrected for pheophytin	87.8	ug/l	Water	1	ft
RIA-1	B311426	HORSESHOE LK-ALEXDR	06/23/2003	Chlorophyll a, uncorrected for pheophytin	91.3	ug/l	Water	1	ft
RIA-1	B310143	HORSESHOE LK-ALEXDR	06/23/2003	Depth, bottom	5	ft	Water	1	ft
RIA-1	B310143	HORSESHOE LK-ALEXDR	06/23/2003	Depth, Secchi Disk Depth	7	in	Water	1	ft
RIA-1	B310143	HORSESHOE LK-ALEXDR	06/23/2003	pH	8.7	None	Water	1	ft
RIA-1	B310143	HORSESHOE LK-ALEXDR	06/23/2003	Phosphorus as P, Dissolved	0.029	mg/l	Water	1	ft
RIA-1	B310143	HORSESHOE LK-ALEXDR	06/23/2003	Phosphorus as P, Total	0.247	mg/l	Water	1	ft
RIA-1	B310143	HORSESHOE LK-ALEXDR	06/23/2003	Solids, Total Suspended (TSS)	46	mg/l	Water	1	ft
RIA-1	B310143	HORSESHOE LK-ALEXDR	06/23/2003	Solids, Volatile	32	mg/l	Water	1	ft
RIA-1	B310143	HORSESHOE LK-ALEXDR	06/23/2003	Temperature, sample	3	deg C	Water	1	ft
RIA-1	B310143	HORSESHOE LK-ALEXDR	06/23/2003	Turbidity	31.3	NTU	Water	1	ft
RIA-1	B313950	HORSESHOE LK-ALEXDR	07/24/2003	Chlorophyll a, corrected for pheophytin	168	ug/l	Water	2	ft
RIA-1	B313950	HORSESHOE LK-ALEXDR	07/24/2003	Chlorophyll a, uncorrected for pheophytin	173	ug/l	Water	2	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	Depth- Chlorophyll samples	2	ft	Water	2	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	Depth, bottom	5	ft	Water	1	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	Depth, Secchi Disk Depth	9	in	Water	1	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	pH	7.1	None	Water	1	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	Phosphorus as P, Dissolved	0.009	mg/l	Water	1	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	Phosphorus as P, Total	0.265	mg/l	Water	1	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	Solids, Total Suspended (TSS)	41	mg/l	Water	1	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	Solids, Volatile	30	mg/l	Water	1	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	Temperature, sample	2	deg C	Water	1	ft
RIA-1	B312115	HORSESHOE LK-ALEXDR	07/24/2003	Turbidity	25.6	NTU	Water	1	ft
RIA-1	B313969	HORSESHOE LK-ALEXDR	08/11/2003	Chlorophyll a, corrected for pheophytin	121	ug/l	Water	1	ft
RIA-1	B313969	HORSESHOE LK-ALEXDR	08/11/2003	Chlorophyll a, uncorrected for pheophytin	135	ug/l	Water	1	ft
RIA-1	B313347	HORSESHOE LK-ALEXDR	08/11/2003	Depth, bottom	4.5	ft	Water	1	ft
RIA-1	B313347	HORSESHOE LK-ALEXDR	08/11/2003	Depth, Secchi Disk Depth	3	in	Water	1	ft
RIA-1	B313347	HORSESHOE LK-ALEXDR	08/11/2003	pH	6.7	None	Water	1	ft
RIA-1	B313347	HORSESHOE LK-ALEXDR	08/11/2003	Phosphorus as P, Dissolved	0.062	mg/l	Water	1	ft
RIA-1	B313347	HORSESHOE LK-ALEXDR	08/11/2003	Phosphorus as P, Total	0.274	mg/l	Water	1	ft
RIA-1	B315776	HORSESHOE LK-ALEXDR	08/11/2003	Phosphorus as P	371	mg/kg	Sediment	4.5	ft
RIA-1	B315776	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Fixed	11.9	%	Sediment	4.5	ft
RIA-1	B315776	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Fixed	20.4	%	Sediment	4.5	ft
RIA-1	B313347	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Total Suspended (TSS)	34	mg/l	Water	1	ft
RIA-1	B313347	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Volatile	29	mg/l	Water	1	ft
RIA-1	B313347	HORSESHOE LK-ALEXDR	08/11/2003	Temperature, sample	0	deg C	Water	1	ft
RIA-1	B313347	HORSESHOE LK-ALEXDR	08/11/2003	Turbidity	21	NTU	Water	1	ft
RIA-1	B318310	HORSESHOE LK-ALEXDR	10/02/2003	Chlorophyll a, corrected for pheophytin	125	ug/l	Water	2	ft
RIA-1	B318310	HORSESHOE LK-ALEXDR	10/02/2003	Chlorophyll a, uncorrected for pheophytin	138	ug/l	Water	2	ft
RIA-1	B318310	HORSESHOE LK-ALEXDR	10/02/2003	Depth, chlorophyll only	2	ft	Water	1	ft
RIA-1	B317018	HORSESHOE LK-ALEXDR	10/02/2003	Depth, bottom	5	ft	Water	1	ft
RIA-1	B317018	HORSESHOE LK-ALEXDR	10/02/2003	Depth, Secchi Disk Depth	10	in	Water	1	ft
RIA-1	B317018	HORSESHOE LK-ALEXDR	10/02/2003	pH	6.7	None	Water	1	ft
RIA-1	B317018	HORSESHOE LK-ALEXDR	10/02/2003	Phosphorus as P, Dissolved	0.013	mg/l	Water	1	ft
RIA-1	B317018	HORSESHOE LK-ALEXDR	10/02/2003	Phosphorus as P, Total	0.162	mg/l	Water	1	ft
RIA-1	B317018	HORSESHOE LK-ALEXDR	10/02/2003	Solids, Total Suspended (TSS)	30	mg/l	Water	1	ft

STATION_ID		STATION_NAME	ACTIVITY_START_DATE	CHARACTERISTIC_NAME	RESULT_VALUE	RESULT_UNIT	ACTIVITY_MEDIUM	ACTIVITY_DEPTH	ACTIVITY_DEPTH_UNIT
RIA-1	B317018	HORSESHOE LK-ALEXDR	10/02/2003	Solids, Volatile	20	mg/l	Water	1	ft
RIA-1	B317018	HORSESHOE LK-ALEXDR	10/02/2003	Temperature, sample	3	deg C	Water	1	ft
RIA-1	B317018	HORSESHOE LK-ALEXDR	10/02/2003	Turbidity	18.4	NTU	Water	1	ft
RIA-2	B306718	HORSESHOE LK-ALEXDR	04/22/2003	Chlorophyll a, corrected for pheophytin	124	ug/l	Water	2	ft
RIA-2	B306718	HORSESHOE LK-ALEXDR	04/22/2003	Chlorophyll a, uncorrected for pheophytin	141	ug/l	Water	2	ft
RIA-2	B306133	HORSESHOE LK-ALEXDR	04/22/2003	Depth, bottom	4	ft	Water	1	ft
RIA-2	B306133	HORSESHOE LK-ALEXDR	04/22/2003	Depth, Secchi Disk Depth	11	in	Water	1	ft
RIA-2	B306133	HORSESHOE LK-ALEXDR	04/22/2003	pH	8.8	None	Water	1	ft
RIA-2	B306133	HORSESHOE LK-ALEXDR	04/22/2003	Solids, Total Suspended (TSS)	49	mg/l	Water	1	ft
RIA-2	B306133	HORSESHOE LK-ALEXDR	04/22/2003	Solids, Volatile	36	mg/l	Water	1	ft
RIA-2	B306133	HORSESHOE LK-ALEXDR	04/22/2003	Temperature, sample	2	deg C	Water	1	ft
RIA-2	B306133	HORSESHOE LK-ALEXDR	04/22/2003	Turbidity	28	NTU	Water	1	ft
RIA-2	B311427	HORSESHOE LK-ALEXDR	06/23/2003	Chlorophyll a, corrected for pheophytin	170	ug/l	Water	2	ft
RIA-2	B311427	HORSESHOE LK-ALEXDR	06/23/2003	Chlorophyll a, uncorrected for pheophytin	173	ug/l	Water	2	ft
RIA-2	B310144	HORSESHOE LK-ALEXDR	06/23/2003	Depth, bottom	4	ft	Water	1	ft
RIA-2	B310144	HORSESHOE LK-ALEXDR	06/23/2003	Depth, Secchi Disk Depth	10	in	Water	1	ft
RIA-2	B310144	HORSESHOE LK-ALEXDR	06/23/2003	pH	8.9	None	Water	1	ft
RIA-2	B310144	HORSESHOE LK-ALEXDR	06/23/2003	Phosphorus as P, Dissolved	0.015	mg/l	Water	1	ft
RIA-2	B310144	HORSESHOE LK-ALEXDR	06/23/2003	Phosphorus as P, Total	0.179	mg/l	Water	1	ft
RIA-2	B310144	HORSESHOE LK-ALEXDR	06/23/2003	Solids, Total Suspended (TSS)	33	mg/l	Water	1	ft
RIA-2	B310144	HORSESHOE LK-ALEXDR	06/23/2003	Solids, Volatile	29	mg/l	Water	1	ft
RIA-2	B310144	HORSESHOE LK-ALEXDR	06/23/2003	Temperature, sample	3	deg C	Water	1	ft
RIA-2	B310144	HORSESHOE LK-ALEXDR	06/23/2003	Turbidity	26.6	NTU	Water	1	ft
RIA-2	B313951	HORSESHOE LK-ALEXDR	07/24/2003	Chlorophyll a, corrected for pheophytin	280	ug/l	Water	2	ft
RIA-2	B313951	HORSESHOE LK-ALEXDR	07/24/2003	Chlorophyll a, uncorrected for pheophytin	282	ug/l	Water	2	ft
RIA-2	B313951	HORSESHOE LK-ALEXDR	07/24/2003	Depth- Chlorophyll samples	2	ft	Water	2	ft
RIA-2	B312116	HORSESHOE LK-ALEXDR	07/24/2003	Depth, bottom	4	ft	Water	1	ft
RIA-2	B312116	HORSESHOE LK-ALEXDR	07/24/2003	Depth, Secchi Disk Depth	9	in	Water	1	ft
RIA-2	B312116	HORSESHOE LK-ALEXDR	07/24/2003	pH	8.8	None	Water	1	ft
RIA-2	B312116	HORSESHOE LK-ALEXDR	07/24/2003	Phosphorus as P	0.008	mg/l	Water	1	ft
RIA-2	B312116	HORSESHOE LK-ALEXDR	07/24/2003	Phosphorus as P	0.307	mg/l	Water	1	ft
RIA-2	B312116	HORSESHOE LK-ALEXDR	07/24/2003	Solids, Total Suspended (TSS)	44	mg/l	Water	1	ft
RIA-2	B312116	HORSESHOE LK-ALEXDR	07/24/2003	Solids, Volatile	39	mg/l	Water	1	ft
RIA-2	B312116	HORSESHOE LK-ALEXDR	07/24/2003	Temperature, sample	2	deg C	Water	1	ft
RIA-2	B312116	HORSESHOE LK-ALEXDR	07/24/2003	Turbidity	33	NTU	Water	1	ft
RIA-2	B313970	HORSESHOE LK-ALEXDR	08/11/2003	Chlorophyll a, corrected for pheophytin	158	ug/l	Water	1	ft
RIA-2	B313970	HORSESHOE LK-ALEXDR	08/11/2003	Chlorophyll a, uncorrected for pheophytin	163	ug/l	Water	1	ft
RIA-2	B313970	HORSESHOE LK-ALEXDR	08/11/2003	Depth- Chlorophyll samples	1	ft	Water	1	ft
RIA-2	B313348	HORSESHOE LK-ALEXDR	08/11/2003	Depth, bottom	4	ft	Water	1	ft
RIA-2	B313348	HORSESHOE LK-ALEXDR	08/11/2003	Depth, Secchi Disk Depth	7	in	Water	1	ft
RIA-2	B313348	HORSESHOE LK-ALEXDR	08/11/2003	pH	8.9	None	Water	1	ft
RIA-2	B313348	HORSESHOE LK-ALEXDR	08/11/2003	Phosphorus as P, Dissolved	0.017	mg/l	Water	1	ft
RIA-2	B313348	HORSESHOE LK-ALEXDR	08/11/2003	Phosphorus as P, Total	0.24	mg/l	Water	1	ft
RIA-2	B313348	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Total Suspended (TSS)	48	mg/l	Water	1	ft
RIA-2	B313348	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Volatile	44	mg/l	Water	1	ft
RIA-2	B313348	HORSESHOE LK-ALEXDR	08/11/2003	Temperature, sample	0	deg C	Water	1	ft
RIA-2	B313348	HORSESHOE LK-ALEXDR	08/11/2003	Turbidity	24.2	NTU	Water	1	ft
RIA-2	B318311	HORSESHOE LK-ALEXDR	10/02/2003	Chlorophyll a, corrected for pheophytin	168	ug/l	Water	1	ft
RIA-2	B318311	HORSESHOE LK-ALEXDR	10/02/2003	Chlorophyll a, uncorrected for pheophytin	171	ug/l	Water	1	ft
RIA-2	B317019	HORSESHOE LK-ALEXDR	10/02/2003	Depth, bottom	4	ft	Water	1	ft
RIA-2	B317019	HORSESHOE LK-ALEXDR	10/02/2003	Depth, Secchi Disk Depth	10	in	Water	1	ft
RIA-2	B317019	HORSESHOE LK-ALEXDR	10/02/2003	pH	9.2	None	Water	1	ft
RIA-2	B317019	HORSESHOE LK-ALEXDR	10/02/2003	Phosphorus as P, Dissolved	0.013	mg/l	Water	1	ft
RIA-2	B317019	HORSESHOE LK-ALEXDR	10/02/2003	Phosphorus as P, Total	0.223	mg/l	Water	1	ft
RIA-2	B317019	HORSESHOE LK-ALEXDR	10/02/2003	Solids, Total Suspended (TSS)	33	mg/l	Water	1	ft
RIA-2	B317019	HORSESHOE LK-ALEXDR	10/02/2003	Solids, Volatile	33	mg/l	Water	1	ft
RIA-2	B317019	HORSESHOE LK-ALEXDR	10/02/2003	Temperature, sample	3	deg C	Water	1	ft

STATION_ID		STATION_NAME	ACTIVITY_START_DATE	CHARACTERISTIC_NAME	RESULT_VALUE	RESULT_UNIT	ACTIVITY_MEDIUM	ACTIVITY_DEPTH	ACTIVITY_DEPTH_UNIT
RIA-2	B317019	HORSESHOE LK-ALEXDR	10/02/2003	Turbidity	23	NTU	Water	1	ft
RIA-3	B306719	HORSESHOE LK-ALEXDR	04/22/2003	Chlorophyll a, corrected for pheophytin	54	ug/l	Water	2	ft
RIA-3	B306719	HORSESHOE LK-ALEXDR	04/22/2003	Chlorophyll a, uncorrected for pheophytin	59.6	ug/l	Water	2	ft
RIA-3	B306719	HORSESHOE LK-ALEXDR	04/22/2003	Depth- Chlorophyll samples	2	ft	Water	2	ft
RIA-3	B306134	HORSESHOE LK-ALEXDR	04/22/2003	Depth, bottom	4	ft	Water	1	ft
RIA-3	B306134	HORSESHOE LK-ALEXDR	04/22/2003	Depth, Secchi Disk Depth	11	in	Water	1	ft
RIA-3	B306134	HORSESHOE LK-ALEXDR	04/22/2003	pH	7.6	None	Water	1	ft
RIA-3	B306134	HORSESHOE LK-ALEXDR	04/22/2003	Solids, Total Suspended (TSS)	28	mg/l	Water	1	ft
RIA-3	B306134	HORSESHOE LK-ALEXDR	04/22/2003	Solids, Volatile	15	mg/l	Water	1	ft
RIA-3	B306134	HORSESHOE LK-ALEXDR	04/22/2003	Temperature, sample	2	deg C	Water	1	ft
RIA-3	B306134	HORSESHOE LK-ALEXDR	04/22/2003	Turbidity	25	NTU	Water	1	ft
RIA-3	B311428	HORSESHOE LK-ALEXDR	06/23/2003	Chlorophyll a, corrected for pheophytin	70.1	ug/l	Water	1	ft
RIA-3	B311428	HORSESHOE LK-ALEXDR	06/23/2003	Chlorophyll a, uncorrected for pheophytin	75	ug/l	Water	1	ft
RIA-3	B310145	HORSESHOE LK-ALEXDR	06/23/2003	Depth, bottom	4	ft	Water	1	ft
RIA-3	B310145	HORSESHOE LK-ALEXDR	06/23/2003	Depth, Secchi Disk Depth	7	in	Water	1	ft
RIA-3	B310145	HORSESHOE LK-ALEXDR	06/23/2003	pH	8.3	None	Water	1	ft
RIA-3	B310145	HORSESHOE LK-ALEXDR	06/23/2003	Phosphorus as P, Dissolved	0.027	mg/l	Water	1	ft
RIA-3	B310145	HORSESHOE LK-ALEXDR	06/23/2003	Phosphorus as P, Total	0.146	mg/l	Water	1	ft
RIA-3	B310145	HORSESHOE LK-ALEXDR	06/23/2003	Solids, Total Suspended (TSS)	25	mg/l	Water	1	ft
RIA-3	B310145	HORSESHOE LK-ALEXDR	06/23/2003	Solids, Volatile	18	mg/l	Water	1	ft
RIA-3	B310145	HORSESHOE LK-ALEXDR	06/23/2003	Temperature, sample	3	deg C	Water	1	ft
RIA-3	B310145	HORSESHOE LK-ALEXDR	06/23/2003	Turbidity	17.4	NTU	Water	1	ft
RIA-3	B313952	HORSESHOE LK-ALEXDR	07/24/2003	Chlorophyll a, corrected for pheophytin	123	ug/l	Water	2	ft
RIA-3	B313952	HORSESHOE LK-ALEXDR	07/24/2003	Chlorophyll a, uncorrected for pheophytin	127	ug/l	Water	2	ft
RIA-3	B313952	HORSESHOE LK-ALEXDR	07/24/2003	Depth, chlorophyll only	2	ft	Water	2	ft
RIA-3	B312117	HORSESHOE LK-ALEXDR	07/24/2003	Depth, bottom	4	ft	Water	1	ft
RIA-3	B312117	HORSESHOE LK-ALEXDR	07/24/2003	Depth, Secchi Disk Depth	12	in	Water	1	ft
RIA-3	B312117	HORSESHOE LK-ALEXDR	07/24/2003	pH	7	None	Water	1	ft
RIA-3	B312117	HORSESHOE LK-ALEXDR	07/24/2003	Phosphorus as P, Dissolved	0.008	mg/l	Water	1	ft
RIA-3	B312117	HORSESHOE LK-ALEXDR	07/24/2003	Phosphorus as P, Total	0.246	mg/l	Water	1	ft
RIA-3	B312117	HORSESHOE LK-ALEXDR	07/24/2003	Solids, Total Suspended (TSS)	32	mg/l	Water	1	ft
RIA-3	B312117	HORSESHOE LK-ALEXDR	07/24/2003	Solids, Volatile	23	mg/l	Water	1	ft
RIA-3	B312117	HORSESHOE LK-ALEXDR	07/24/2003	Temperature, sample	2	deg C	Water	1	ft
RIA-3	B312117	HORSESHOE LK-ALEXDR	07/24/2003	Turbidity	22.6	NTU	Water	1	ft
RIA-3	B313971	HORSESHOE LK-ALEXDR	08/11/2003	Chlorophyll a, corrected for pheophytin	144	ug/l	Water	1	ft
RIA-3	B313971	HORSESHOE LK-ALEXDR	08/11/2003	Chlorophyll a, uncorrected for pheophytin	147	ug/l	Water	1	ft
RIA-3	B313971	HORSESHOE LK-ALEXDR	08/11/2003	Depth, chlorophyll only	1	ft	Water	1	ft
RIA-3	B313349	HORSESHOE LK-ALEXDR	08/11/2003	Depth, bottom	4	ft	Water	1	ft
RIA-3	B313349	HORSESHOE LK-ALEXDR	08/11/2003	Depth, Secchi Disk Depth	6	in	Water	1	ft
RIA-3	B313349	HORSESHOE LK-ALEXDR	08/11/2003	pH	7.1	None	Water	1	ft
RIA-3	B313349	HORSESHOE LK-ALEXDR	08/11/2003	Phosphorus as P, Dissolved	0.01	mg/l	Water	1	ft
RIA-3	B313349	HORSESHOE LK-ALEXDR	08/11/2003	Phosphorus as P, Total	0.22	mg/l	Water	1	ft
RIA-3	B315777	HORSESHOE LK-ALEXDR	08/11/2003	Phosphorus as P	2020	mg/kg	Sediment	4	ft
RIA-3	B315777	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Fixed	2	%	Sediment	4	ft
RIA-3	B315777	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Fixed	18.9	%	Sediment	4	ft
RIA-3	B313349	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Total Suspended (TSS)	38	mg/l	Water	1	ft
RIA-3	B313349	HORSESHOE LK-ALEXDR	08/11/2003	Solids, Volatile	29	mg/l	Water	1	ft
RIA-3	B313349	HORSESHOE LK-ALEXDR	08/11/2003	Temperature, sample	0	deg C	Water	1	ft
RIA-3	B313349	HORSESHOE LK-ALEXDR	08/11/2003	Turbidity	21.4	NTU	Water	1	ft
RIA-3	B318312	HORSESHOE LK-ALEXDR	10/02/2003	Chlorophyll a, corrected for pheophytin	80.7	ug/l	Water	2	ft
RIA-3	B318312	HORSESHOE LK-ALEXDR	10/02/2003	Chlorophyll a, uncorrected for pheophytin	107	ug/l	Water	2	ft
RIA-3	B317020	HORSESHOE LK-ALEXDR	10/02/2003	Depth, bottom	4	ft	Water	1	ft
RIA-3	B317020	HORSESHOE LK-ALEXDR	10/02/2003	Depth, Secchi Disk Depth	12	in	Water	1	ft
RIA-3	B317020	HORSESHOE LK-ALEXDR	10/02/2003	pH	7.4	None	Water	1	ft
RIA-3	B317020	HORSESHOE LK-ALEXDR	10/02/2003	Phosphorus as P, Dissolved	0.012	mg/l	Water	1	ft
RIA-3	B317020	HORSESHOE LK-ALEXDR	10/02/2003	Phosphorus as P, Total	0.16	mg/l	Water	1	ft
RIA-3	B317020	HORSESHOE LK-ALEXDR	10/02/2003	Solids, Total Suspended (TSS)	29	mg/l	Water	1	ft

STATION_ID		STATION_NAME	ACTIVITY_START_DATE	CHARACTERISTIC_NAME	RESULT_VALUE	RESULT_UNIT	ACTIVITY_MEDIUM	ACTIVITY_DEPTH	ACTIVITY_DEPTH_UNIT
RIA-3	B317020	HORSESHOE LK-ALEXDR	10/02/2003	Solids, Volatile	18	mg/l	Water	1	ft
RIA-3	B317020	HORSESHOE LK-ALEXDR	10/02/2003	Temperature, sample	3	deg C	Water	1	ft
RIA-3	B317020	HORSESHOE LK-ALEXDR	10/02/2003	Turbidity	19	NTU	Water	1	ft

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StationCode	SampleDepth	CollectionDate	SampleMedium	Analyte	SampleFraction	Result_NUM	ResultUnits	Qualifier	Usability_IEPAOnly
RIA-1	3	23-Apr-09	Water	Chlorophyll a, corrected for pheophytin	Total	53.8	ug/l		Usable
RIA-1	3	23-Apr-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	58.4	ug/l		Usable
RIA-1	1	23-Apr-09	Water	Phosphorus as P	Dissolved	0.013	mg/l		Usable
RIA-1	2	23-Apr-09	Water	Phosphorus as P	Total	0.193	mg/l		Usable
RIA-1	2	23-Apr-09	Water	Phosphorus as P	Dissolved	0.011	mg/l		Usable
RIA-1	1	23-Apr-09	Water	Phosphorus as P	Total	0.187	mg/l		Usable
RIA-1	2	23-Apr-09	Water	Solids, suspended, volatile		15	mg/l		Usable
RIA-1	1	23-Apr-09	Water	Solids, suspended, volatile		16	mg/l		Usable
RIA-1	2	23-Apr-09	Water	Solids, Total Suspended (TSS)		21	mg/l		Usable
RIA-1	1	23-Apr-09	Water	Solids, Total Suspended (TSS)		22	mg/l		Usable
RIA-1	3	23-Apr-09	Water	Temperature, sample		0	deg C		Usable
RIA-1	2	23-Apr-09	Water	Temperature, sample		3	deg C		Usable
RIA-1	1	23-Apr-09	Water	Temperature, sample		3	deg C		Usable
RIA-1	2	02-Jun-09	Water	Chlorophyll a, corrected for pheophytin	Total	133	ug/l		Usable
RIA-1	2	02-Jun-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	140	ug/l		Usable
RIA-1	1	02-Jun-09	Water	Phosphorus as P	Dissolved	0.054	mg/l		Usable
RIA-1	1	02-Jun-09	Water	Phosphorus as P	Total	0.346	mg/l		Usable
RIA-1	4	02-Jun-09	Water	Phosphorus as P	Dissolved	0.063	mg/l		Usable
RIA-1	4	02-Jun-09	Water	Phosphorus as P	Total	0.349	mg/l		Usable
RIA-1	1	02-Jun-09	Water	Solids, suspended, volatile		23	mg/l		Usable
RIA-1	4	02-Jun-09	Water	Solids, suspended, volatile		23	mg/l		Usable
RIA-1	1	02-Jun-09	Water	Solids, Total Suspended (TSS)		30	mg/l		Usable
RIA-1	4	02-Jun-09	Water	Solids, Total Suspended (TSS)		30	mg/l		Usable
RIA-1	4	02-Jun-09	Water	Temperature, sample		2	deg C		Usable
RIA-1	2	02-Jun-09	Water	Temperature, sample		0	deg C		Usable
RIA-1	1	02-Jun-09	Water	Temperature, sample		2	deg C		Usable
RIA-1	2	09-Jul-09	Water	Chlorophyll a, corrected for pheophytin	Total	153	ug/l		Usable
RIA-1	2	09-Jul-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	168	ug/l		Usable
RIA-1	4	09-Jul-09	Water	Phosphorus as P	Total	0.452	mg/l		Usable
RIA-1	4	09-Jul-09	Water	Phosphorus as P	Dissolved	0.06	mg/l		Usable
RIA-1	1	09-Jul-09	Water	Phosphorus as P	Total	0.45	mg/l		Usable
RIA-1	1	09-Jul-09	Water	Phosphorus as P	Dissolved	0.042	mg/l		Usable
RIA-1	4	09-Jul-09	Water	Solids, suspended, volatile		28	mg/l		Usable
RIA-1	1	09-Jul-09	Water	Solids, suspended, volatile		30	mg/l		Usable
RIA-1	4	09-Jul-09	Water	Solids, Total Suspended (TSS)		37	mg/l		Usable
RIA-1	1	09-Jul-09	Water	Solids, Total Suspended (TSS)		39	mg/l		Usable
RIA-1	4	09-Jul-09	Water	Temperature, sample		4	deg C		Usable
RIA-1	1	09-Jul-09	Water	Temperature, sample		3	deg C		Usable
RIA-1	2	05-Aug-09	Water	Chlorophyll a, corrected for pheophytin	Total	184	ug/l		Usable
RIA-1	2	05-Aug-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	208	ug/l		Usable
RIA-1	1	05-Aug-09	Water	Phosphorus as P	Total	0.303	mg/l		Usable
RIA-1	1	05-Aug-09	Water	Phosphorus as P	Dissolved	0.025	mg/l		Usable
RIA-1	4	05-Aug-09	Water	Phosphorus as P	Total	0.381	mg/l		Usable
RIA-1	4	05-Aug-09	Water	Phosphorus as P	Dissolved	0.076	mg/l		Usable
RIA-1	6	05-Aug-09	Sediment	Phosphorus as P	Total	1030	mg/kg		Usable
RIA-1	6	05-Aug-09	Sediment	Solids, Dissolved	Dissolved	89.5	%		Usable
RIA-1	1	05-Aug-09	Water	Solids, suspended, volatile		29	mg/l		Usable
RIA-1	4	05-Aug-09	Water	Solids, suspended, volatile		28	mg/l		Usable
RIA-1	6	05-Aug-09	Sediment	Solids, suspended, volatile		10.5	%		Usable
RIA-1	1	05-Aug-09	Water	Solids, Total Suspended (TSS)		33	mg/l		Usable
RIA-1	4	05-Aug-09	Water	Solids, Total Suspended (TSS)		33	mg/l		Usable
RIA-1	6	05-Aug-09	Sediment	Solids, Total Suspended (TSS)		34.2	%		Usable
RIA-1	1	05-Aug-09	Water	Temperature, sample		4	deg C		Usable
RIA-1	4	05-Aug-09	Water	Temperature, sample		4	deg C		Usable
RIA-1	6	05-Aug-09	Sediment	Temperature, sample		0	deg C		Usable
RIA-1	2	06-Oct-09	Water	Chlorophyll a, corrected for pheophytin	Total	152	ug/l		Usable
RIA-1	2	06-Oct-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	169	ug/l		Usable
RIA-1	1	06-Oct-09	Water	Phosphorus as P	Total	0.27	mg/l		Usable
RIA-1	2	06-Oct-09	Water	Phosphorus as P	Total	0.273	mg/l		Usable
RIA-1	2	06-Oct-09	Water	Phosphorus as P	Dissolved	0.08	mg/l		Usable
RIA-1	1	06-Oct-09	Water	Phosphorus as P	Dissolved	0.176	mg/l		Usable
RIA-1	1	06-Oct-09	Water	Solids, suspended, volatile		26	mg/l		Usable
RIA-1	2	06-Oct-09	Water	Solids, suspended, volatile		25	mg/l		Usable
RIA-1	1	06-Oct-09	Water	Solids, Total Suspended (TSS)		34	mg/l		Usable
RIA-1	2	06-Oct-09	Water	Solids, Total Suspended (TSS)		33	mg/l		Usable

StationCode	SampleDepth	CollectionDate	SampleMedium	Analyte	SampleFraction	Result_NUM	ResultUnits	Qualifier	Usability_IEPAOnly
RIA-1	1	06-Oct-09	Water	Temperature, sample		4	deg C		Usable
RIA-1	2	06-Oct-09	Water	Temperature, sample		4	deg C		Usable
RIA-2	3	23-Apr-09	Water	Chlorophyll a, corrected for pheophytin	Total	82	ug/l		Usable
RIA-2	3	23-Apr-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	90.3	ug/l		Usable
RIA-2	1	23-Apr-09	Water	Phosphorus as P	Total	0.199	mg/l		Usable
RIA-2	1	23-Apr-09	Water	Phosphorus as P	Dissolved	0.011	mg/l		Usable
RIA-2	1	23-Apr-09	Water	Solids, suspended, volatile		23	mg/l		Usable
RIA-2	1	23-Apr-09	Water	Solids, Total Suspended (TSS)		27	mg/l		Usable
RIA-2	3	23-Apr-09	Water	Temperature, sample		0	deg C		Usable
RIA-2	1	23-Apr-09	Water	Temperature, sample		3	deg C		Usable
RIA-2	2	02-Jun-09	Water	Chlorophyll a, corrected for pheophytin	Total	147	ug/l		Usable
RIA-2	2	02-Jun-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	154	ug/l		Usable
RIA-2	1	02-Jun-09	Water	Phosphorus as P	Total	0.323	mg/l		Usable
RIA-2	1	02-Jun-09	Water	Phosphorus as P	Dissolved	0.046	mg/l		Usable
RIA-2	1	02-Jun-09	Water	Solids, suspended, volatile		25	mg/l		Usable
RIA-2	1	02-Jun-09	Water	Solids, Total Suspended (TSS)		29	mg/l		Usable
RIA-2	2	02-Jun-09	Water	Temperature, sample		0	deg C		Usable
RIA-2	1	02-Jun-09	Water	Temperature, sample		2	deg C		Usable
RIA-2	2	09-Jul-09	Water	Chlorophyll a, corrected for pheophytin	Total	222	ug/l		Usable
RIA-2	2	09-Jul-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	244	ug/l		Usable
RIA-2	1	09-Jul-09	Water	Phosphorus as P	Total	0.448	mg/l		Usable
RIA-2	1	09-Jul-09	Water	Phosphorus as P	Dissolved	0.094	mg/l		Usable
RIA-2	1	09-Jul-09	Water	Solids, suspended, volatile		26	mg/l		Usable
RIA-2	1	09-Jul-09	Water	Solids, Total Suspended (TSS)		32	mg/l		Usable
RIA-2	1	09-Jul-09	Water	Temperature, sample		4	deg C		Usable
RIA-2	2	05-Aug-09	Water	Chlorophyll a, corrected for pheophytin	Total	214	ug/l		Usable
RIA-2	2	05-Aug-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	243	ug/l		Usable
RIA-2	1	05-Aug-09	Water	Phosphorus as P	Total	0.418	mg/l		Usable
RIA-2	1	05-Aug-09	Water	Phosphorus as P	Dissolved	0.04	mg/l		Usable
RIA-2	1	05-Aug-09	Water	Solids, suspended, volatile		33	mg/l		Usable
RIA-2	1	05-Aug-09	Water	Solids, Total Suspended (TSS)		40	mg/l		Usable
RIA-2	1	05-Aug-09	Water	Temperature, sample		4	deg C		Usable
RIA-2	2	06-Oct-09	Water	Chlorophyll a, corrected for pheophytin	Total	144	ug/l		Usable
RIA-2	2	06-Oct-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	160	ug/l		Usable
RIA-2	1	06-Oct-09	Water	Phosphorus as P	Dissolved	0.034	mg/l		Usable
RIA-2	1	06-Oct-09	Water	Phosphorus as P	Total	0.268	mg/l		Usable
RIA-2	1	06-Oct-09	Water	Solids, suspended, volatile		24	mg/l		Usable
RIA-2	1	06-Oct-09	Water	Solids, Total Suspended (TSS)		24	mg/l		Usable
RIA-2	1	06-Oct-09	Water	Temperature, sample		4	deg C		Usable
RIA-3	3	23-Apr-09	Water	Chlorophyll a, corrected for pheophytin	Total	53.4	ug/l		Usable
RIA-3	3	23-Apr-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	57.2	ug/l		Usable
RIA-3	1	23-Apr-09	Water	Phosphorus as P	Dissolved	0.023	mg/l		Usable
RIA-3	1	23-Apr-09	Water	Phosphorus as P	Total	0.178	mg/l		Usable
RIA-3	1	23-Apr-09	Water	Solids, suspended, volatile		14	mg/l		Usable
RIA-3	1	23-Apr-09	Water	Solids, Total Suspended (TSS)		25	mg/l		Usable
RIA-3	3	23-Apr-09	Water	Temperature, sample		0	deg C		Usable
RIA-3	1	23-Apr-09	Water	Temperature, sample		3	deg C		Usable
RIA-3	2	02-Jun-09	Water	Chlorophyll a, corrected for pheophytin	Total	66.1	ug/l		Usable
RIA-3	2	02-Jun-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	68.7	ug/l		Usable
RIA-3	1	02-Jun-09	Water	Phosphorus as P	Dissolved	0.037	mg/l		Usable
RIA-3	1	02-Jun-09	Water	Phosphorus as P	Total	0.188	mg/l		Usable
RIA-3	1	02-Jun-09	Water	Solids, suspended, volatile		17	mg/l		Usable
RIA-3	1	02-Jun-09	Water	Solids, Total Suspended (TSS)		22	mg/l		Usable
RIA-3	1	02-Jun-09	Water	Temperature, sample		2	deg C		Usable
RIA-3	2	02-Jun-09	Water	Temperature, sample		0	deg C		Usable
RIA-3	1	09-Jul-09	Water	Chlorophyll a, corrected for pheophytin	Total	130	ug/l		Usable
RIA-3	1	09-Jul-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	141	ug/l		Usable
RIA-3	1	09-Jul-09	Water	Phosphorus as P	Total	0.302	mg/l		Usable
RIA-3	1	09-Jul-09	Water	Phosphorus as P	Dissolved	0.047	mg/l		Usable
RIA-3	1	09-Jul-09	Water	Solids, suspended, volatile		19	mg/l		Usable
RIA-3	1	09-Jul-09	Water	Solids, Total Suspended (TSS)		26	mg/l		Usable
RIA-3	1	09-Jul-09	Water	Temperature, sample		3	deg C		Usable
RIA-3	2	05-Aug-09	Water	Chlorophyll a, corrected for pheophytin	Total	155	ug/l		Usable
RIA-3	2	05-Aug-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	168	ug/l		Usable
RIA-3	1	05-Aug-09	Water	Phosphorus as P	Total	0.33	mg/l		Usable
RIA-3	1	05-Aug-09	Water	Phosphorus as P	Dissolved	0.046	mg/l		Usable
RIA-3	4	05-Aug-09	Sediment	Phosphorus as P	Total	1850	mg/kg		Usable

StationCode	SampleDepth	CollectionDate	SampleMedium	Analyte	SampleFraction	Result_NUM	ResultUnits	Qualifier	Usability_IEPAOnly
RIA-3	4	05-Aug-09	Sediment	Solids, Dissolved	Dissolved	79.1	%		Usable
RIA-3	4	05-Aug-09	Sediment	Solids, suspended, volatile		20.9	%		Usable
RIA-3	1	05-Aug-09	Water	Solids, suspended, volatile		27	mg/l		Usable
RIA-3	1	05-Aug-09	Water	Solids, Total Suspended (TSS)		37	mg/l		Usable
RIA-3	4	05-Aug-09	Sediment	Solids, Total Suspended (TSS)		27.4	%		Usable
RIA-3	4	05-Aug-09	Sediment	Temperature, sample		0	deg C		Usable
RIA-3	1	05-Aug-09	Water	Temperature, sample		4	deg C		Usable
RIA-3	2	06-Oct-09	Water	Chlorophyll a, corrected for pheophytin	Total	111	ug/l		Usable
RIA-3	2	06-Oct-09	Water	Chlorophyll a, uncorrected for pheophytin	Total	126	ug/l		Usable
RIA-3	1	06-Oct-09	Water	Phosphorus as P	Total	0.224	mg/l		Usable
RIA-3	1	06-Oct-09	Water	Phosphorus as P	Dissolved	0.192	mg/l		Usable
RIA-3	1	06-Oct-09	Water	Solids, suspended, volatile		21	mg/l		Usable
RIA-3	1	06-Oct-09	Water	Solids, Total Suspended (TSS)		30	mg/l		Usable
RIA-3	1	06-Oct-09	Water	Temperature, sample		4	deg C		Usable

Appendix D.
Candidate Watershed Methodologies and Modeling Frameworks

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Candidate watershed methodologies and modeling frameworks are described below.

Empirical Approaches:

Empirical approaches estimate pollutant loading rates based upon site-specific measurements, without the use of a model to describe specific cause-effect relationships. Time series information is required for both stream flow and pollutant concentration.

One advantage of empirical approaches is that direct measurement of pollutant loading will generally be far more accurate than any model-based estimate. The approach, however, has several disadvantages. The empirical approach provides information specific to the storms that are monitored, but does not provide direct information on conditions for events that were not monitored. To address this limitation, statistical methods (e.g., Preston et al., 1989) can be used to integrate discrete measurements of suspended solids concentrations with continuous flow records to provide estimates of solids loads over a range of conditions.

The primary limitation of empirical techniques is their inability to separate individual contributions from multiple sources. This problem can be addressed by collecting samples from tributaries serving single land uses, but most tributary monitoring stations reflect multiple land uses. As a complement to empirical estimates of watershed loads, the EUTROMOD and BATHTUB water quality models described below contain routines that apply the empirical approach to estimate watershed loads.

Simple Method/Unit Area Loads/Export Coefficients:

The Simple Method, also known as unit area loads or export coefficients, is routinely used to develop estimates of pollutant loads in a watershed. A unit area load or export coefficient is a value expressing pollutant generation per unit area and unit time for a specific land use (Novotny and Olem, 1994).

The use of unit area loading or export coefficients has been used extensively in estimating loading contributions from different land uses (Beaulac 1980, Reckhow et al. 1980, Reckhow and Simpson 1980, Uttormark et al. 1974). The concept is straightforward: different land use areas contribute different loads to receiving waters. By summing the amount of pollutant exported per unit area of land use in the watershed, the total pollutant load to the receiving system can be calculated.

These export coefficients are usually based on average annual loads. The approach provides estimates of current or existing loading, as well as reductions in pollutant export for each land use required to achieve a target TMDL or LRS pollutant load. The accuracy of the estimates is dependent on good land use data, and appropriate pollutant export coefficients for the region. EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables. This watershed component of this tool can estimate phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The FLUX module of the BATHTUB software program estimates watershed nutrient loads or fluxes to a lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified.

Universal Soil Loss Equation:

The Universal Soil Loss Equation (USLE), and variations of the USLE, are the most widely used methods for predicting soil loss. When applied properly, the USLE can be used as a means to estimate loads of sediment and sediment-associated pollutants for TMDLs or LRSs. The USLE is empirical, meaning that it was developed from statistical regression analyses of a large database of runoff and soil loss data from numerous watersheds. It does not describe specific erosion processes. The USLE was designed to predict long-term average annual soil erosion for combinations of crop systems and management practices with specified soil types, rainfall patterns, and topography.

Required model inputs to the USLE consist of:

- Rainfall erosivity index factor
- Soil-erodibility factor
- Slope length factor reflecting local topography
- Cropping-management factor
- Conservation practice factor

Most of the required inputs for application of the USLE are tabulated by county Natural Resources Conservation Service (NRCS) offices.

There are also variants to the USLE: the Revised USLE (RUSLE) and the Modified USLE (MUSLE). The RUSLE is a computerized update of the USLE incorporating new data and making some improvements. The basic USLE equation is retained, but the technology for evaluating the factor values has been altered and new data introduced to evaluate the terms for specific conditions. The MUSLE is a modification of USLE, with the rainfall energy factor of the USLE replaced with a runoff energy factor. MUSLE allows for estimation of soil erosion on an event-specific basis.

While the USLE was originally designed to consider soil/sediment loading only, it is also commonly used to define loads from pollutants that are tightly bound to soils. In these situations, the USLE is used to define the sediment load, with the result multiplied by a pollutant concentration factor (mass of pollutant per mass of soil) to define pollutant load.

The USLE is among the simplest of the available models for estimating sediment and sediment-associated loads. It requires the least amount of input data for its application and consequently does not ensure a high level of accuracy. It is well suited for screening-level calculations, but is less suited for detailed applications. This is because it is an empirical model that does not explicitly represent site-specific physical processes. Furthermore, the annual average time scale of the USLE is poorly suited for model calibration purposes, as field data are rarely available to define erosion on an annual average basis. In addition, the USLE considers erosion only, and does not explicitly consider the amount of sediment that is delivered to stream locations of interest. It is best used in situations where data are available to define annual loading rates, which allows for site-specific determination of the fraction of eroded sediment that is delivered to the surface water.

Generalized Watershed Loading Functions Model (AVGWLF)/MapShed:

The Generalized Watershed Loading Functions Model (AVGWLF) simulates runoff and sediment loadings from mixed-use watersheds. It is a continuous simulation model (i.e., predicts how concentrations change over time) that uses daily time steps for weather data and water balance calculations. Sediment loadings are provided on a monthly basis. AVGWLF requires the user to divide the watershed into any number of distinct groups, each of which is labeled as rural or urban. The model does not spatially distribute the source areas, but simply aggregates the loads from each area into a watershed total; in other words, there is no spatial routing. Erosion and sediment yield for rural areas are estimated using monthly erosion calculations based on the USLE (with monthly rainfall-runoff coefficients). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are then applied to the calculated erosion to determine how much of the sediment eroded from each source area is delivered to the watershed outlet. Erosion from urban areas is considered negligible.

GWLF provides more detailed temporal results than the USLE, but also requires more input data. Specifically, daily climate data are required as well as data on processes related to the hydrologic cycle (e.g., evapotranspiration rates, groundwater recession constants). By performing a water balance, it has the ability to predict concentrations at a watershed outlet as opposed to just loads. It lacks the ability to calculate the sediment delivery ratio; however, a delivery ratio can be specified by the user. Because the model performs on a continuous simulation basis, it is more amenable to site-specific calibration than USLE. It is noted that Penn State University, developers of AVGWLF, is discontinuing support of the AVGWLF model in support of the MapShed model. MapShed essentially duplicates the functionality of AVGWLF model, but used non-commercial GIS software.

Long Term Hydrologic Impact Analysis (L-THIA):

L-THIA is a web-based screening level model to evaluate the changes in runoff, recharge, nutrients and sediment loads due to proposed land use changes. L-THIA gives long-term average annual runoff for a land use configuration, based on actual long-term climate data (30 yrs of daily precipitation data) for that area. By using many years of climate data in the analysis, L-THIA focuses on the average impact, rather than an extreme year or storm.

Data input requirements for L-THIA are minimal and include long-term precipitation, area of actual and the proposed land use changes and hydrologic soil groups of land use changes. The user can choose basic or detailed input options depending on the choices of land use that need to be evaluated. An ArcView 3.x GIS version of L-THIA is available which allows the user to prepare input, conduct simulations and process results within the GIS environment. This advanced version of L-THIA can be applied with minimum level of GIS skills.

L-THIA employs the curve number (CN) approach to estimate runoff. Antecedent moisture content (AMC) in the soil is estimated by precipitation data and CN is adjusted in accordance with the changes in AMC. Nonpoint source pollution masses are estimated based on Event Mean Concentration (EMC) data and estimated runoff. Built in EMC values can be replaced with site specific values. L-THIA will generate estimated runoff volumes and depths, and expected nonpoint source pollution loadings to water bodies. Results can be displayed in tables, bar charts, and pie charts. As a quick and easy-to-use approach, L-THIA's results can be used to generate community awareness of potential long-term problems and to support planning aimed at minimizing disturbance of critical areas. L-THIA is an ideal tool to assist in the evaluation of potential effects of land use change and to identify the best location of a particular land use so as to have minimum impact on a community's natural environment.

Spreadsheet Tool for Estimating Pollutant Load (STEPL):

Spreadsheet Tool for Estimating Pollutant Load (STEPL), developed for EPA Office of Water by Tetra-Tech, Inc., employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs). STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It computes watershed surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices.

For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

Annualized Agricultural Nonpoint Source Pollution Model (AnnAGNPS)

The Agricultural Nonpoint Source Pollution Model (AGNPS) is a joint USDA-Agricultural Research Service and -Natural Resources Conservation Service system of computer models developed to predict nonpoint source pollutant loadings within agricultural watersheds. AnnAGNPS is one component (or module) of AGNPS and is a watershed-scale, continuous simulation model that operates on a daily time step and is designed to predict the impact of management on water, sediment, nutrients, and pesticides in agricultural watersheds. The sheet and rill erosion model internal to AnnAGNPS is based upon RUSLE, with additional routines added to allow for continuous simulation and more detailed consideration of sediment delivery.

AnnAGNPS was originally developed for use in agricultural watersheds, but has been adapted to allow consideration of construction sources. AnnAGNPS provides more spatial detail than GWLF and is therefore more rigorous in calculating the delivery of eroded sediment to the receiving water. This additional computational ability carries with it the cost of requiring more detailed information describing the topography of the watershed, as well as requiring more time to set up and apply the model.

Hydrologic Simulation Program – FORTRAN (HSPF):

The Hydrologic Simulation Program – FORTRAN (HSPF) uses continuous rainfall and other meteorological records to compute stream flow hydrographs and pollutographs. HSPF is well suited for mixed-use (i.e., containing both urban and rural land uses) watersheds, as it contains separate sediment routines for pervious and impervious surfaces. HSPF is an integrated watershed/stream/reservoir model, and simulates sediment routing and deposition for different classes of particle size. HSPF was integrated with a geographical information system (GIS) environment with the development of Better Assessment Science Integrating point and Nonpoint Sources (BASINS). Although BASINS was designed as a multipurpose analysis tool to promote the integration of point and nonpoint sources in watershed and water quality-based applications, it also includes a suite of water quality models. One such model is Nonpoint Source Model (NPSM). NPSM is a simplified version of HSPF that is linked with a graphical user interface within the GIS environment of BASINS. LSPC is another variant of the HSPF model, consisting of the equations used by HSPF recoded into the C++ programming language.

HSPF provides a more detailed description of urban areas than AnnAGNPS and contains direct linkage to a receiving water model. This additional computational ability carries with it the cost of requiring more detailed model inputs, as well as requiring more time to set up and apply the model. The BASINS software can automatically incorporate existing environmental databases (e.g., land use, water quality data) into HSPF, although it is important to verify the accuracy of these sources before using them in the model.

Storm Water Management Model (SWMM):

The Storm Water Management Model (SWMM) is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. SWMM is designed to be able to describe both single events and continuous simulation over longer periods of time. SWMM is commonly used to simulate urban hydraulics, although its sediment transport capabilities are not as robust as some of the other models described here.

Soil & Water Assessment Tool (SWAT):

The Soil & Water Assessment Tool (SWAT) is a basin-scale, continuous-time model designed for agricultural watersheds. It operates on a daily time step. Sediment yield is calculated with the Modified Universal Soil Loss Equation. It contains a sediment routing model that considers deposition and channel erosion for various sediment particle sizes. SWAT is also contained as part of EPA's BASINS software. SWAT is a continuous time model (i.e., a long-term yield model). The model is not designed to simulate detailed, single-event flood routing. SWAT was originally developed strictly for application to agricultural watersheds, but it has been modified to include consideration of urban areas and can be used in mixed-use watersheds.

Appendix E.
Candidate Water Quality Methodologies and Modeling Frameworks

Candidate water quality methodologies and modeling frameworks are described below.

Spreadsheet Approaches:

A wide range of simple methods are available to describe the relationship between pollutant loads and receiving water quality, for a variety of situations including rivers and lakes. These methods are documented in Mills et al. (1985). These approaches do not require specific computer software, and are designed to be implemented on a hand calculator or computer spreadsheet. These approaches have the benefit of relatively low data requirements, as well as being easy to apply. Because of their simplistic nature, these approaches are best considered as screening procedures incapable of producing highly accurate results. They do provide good initial estimates of the primary cause-effect relationships.

The load duration curve approach is foremost among the spreadsheet approaches. The load duration curve approach uses stream flows and observed concentrations for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results in what is called a flow duration curve; 2) translating the flow duration curve into a load duration curve by multiplying the flows by the water quality standard; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature.

EUTROMOD:

EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, distributed by the North American Lake Management Society (Reckhow 1990). The modeling system first estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The model accounts for both point and nonpoint source loads. Statistical algorithms are based on regression analyses performed on cross-sectional lake data. These algorithms predict in-lake phosphorus, nitrogen, hypolimnetic dissolved oxygen, chlorophyll, and trihalomethane precursor concentrations, and transparency (Secchi depth). The model also estimates the likelihood of blue-green bacteria dominance in the lake. Lake morphometry and hydrologic characteristics are incorporated in these algorithms. EUTROMOD also has algorithms for estimating uncertainty associated with the trophic state variables and hydrologic variability and estimating the confidence interval about the most likely values for the various trophic state indicators.

BATHTUB:

BATHTUB is a software program for estimating nutrient loading to lakes and reservoirs, summarizing information on in-lake water quality data, and predicting the lake/reservoir response to nutrient loading

(Walker 1986). It was developed and is distributed by the U.S. Army Corps of Engineers. BATHTUB consists of three modules: FLUX, PROFILE, and BATHTUB (Walker 1986). The FLUX module estimates nutrient loads or fluxes to the lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified. PROFILE is an analysis module that permits the user to display lake water quality data. PROFILE algorithms can be used to estimate hypolimnetic oxygen depletion rates, area-weighted or mixed layer average constituent concentrations, and similar trophic state indicators. BATHTUB is the module that predicts lake/reservoir responses to nutrient fluxes. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

BATHTUB contains a number of regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, chlorophyll concentrations, and Secchi depth (transparency). Uncertainty estimates are provided with predicted trophic state variables. There are several options for estimating uncertainty based on the distribution of the input and in-lake data. Both tabular and graphical displays are available from the program.

QUAL2E/QUAL2K:

QUAL2K is a one-dimensional water quality model that assumes steady-state flow, but allows simulation of diurnal variations in dissolved oxygen and temperature. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model simulates the following state variables: temperature, dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, inorganic phosphorus, organic phosphorus, algae, and conservative and non-conservative substances. One of the QUAL2K developers is a LimnoTech team member and therefore our team is qualified to customize QUAL2K for application to Illinois impaired water bodies. The predecessor to QUAL2K, called QUAL2E, is also available and has been successfully applied in the development of many Illinois TMDLs, but is no longer officially supported by EPA.

The primary advantages of using QUAL2K (and QUAL2E) include its widespread use and acceptance, and ability to simulate all of the conventional pollutants of concern. Its disadvantage is that it is restricted to one-dimensional, steady-state analyses.

WASP7:

WASP7 is EPA's general-purpose surface water quality modeling system. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model can be applied in one, two, or three dimensions and is designed for linkage with the hydrodynamic model DYNHYD5. WASP7 has also been successfully linked with other one, two, and three dimensional hydrodynamic models such as RIVMOD, RMA-2V and EFDC. WASP7 can also accept user-specified advective and dispersive flows. WASP7 provides separate submodels for conventional and toxic pollutants. The EUTRO7 submodel describes up to eight state variables in the water column and bed sediments: dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphorus, and phytoplankton. The TOXI7 submodel simulates the transformation of up to three different chemicals and three different solids classes.

The primary advantage of using WASP7 is that it provides the flexibility to describe almost any water quality constituent of concern, along with its widespread use and acceptance. Its primary disadvantage is that it contains limited hydrodynamic capabilities and must often obtain hydrodynamic results from other models.

CE-QUAL-RIV1:

CE-QUAL-RIV1 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. Water quality state variables consist of temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, dissolved iron, and dissolved manganese. The effects of algae and macrophytes can also be included as external forcing functions specified by the user.

The primary advantage of CE-QUAL-RIV1 is its direct link to an efficient hydrodynamic model. This makes it especially suitable to describe river systems affected by dams or experiencing extremely rapid changes in flow. Its primary disadvantage is that it simulates conventional pollutants only, and contains limited eutrophication kinetics. In addition, the effort and data required to support the CE-QUAL-RIV1 hydrodynamic routines may not be necessary in naturally flowing rivers.

HSPF:

HSPF (Hydrological Simulation Program - FORTRAN) is a one-dimensional modeling system for simulation of watershed hydrology, point and nonpoint source loadings, and receiving water quality for both conventional pollutants and toxicants (Bicknell et al. 1993). It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The water quality component of HSPF allows dynamic simulation of both conventional pollutants (i.e., dissolved oxygen, nutrients, and phytoplankton) and toxics. The toxics routines combine organic chemical process kinetics with sediment balance algorithms to predict dissolved and sorbed chemical concentrations in the upper sediment bed and overlying water column. HSPF is also linked into EPA's BASINS modeling system.

The primary advantage of HSPF is that it exists as part of a linked watershed/receiving water modeling package. Nonpoint source loading and hydrodynamic results are automatically linked to the HSPF water quality submodel, such that no external linkages need be developed.

CE-QUAL-W2:

CE-QUAL-W2 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. CE-QUAL-W2 simulates variations in water quality in the longitudinal and lateral directions, and was developed to address water quality issues in long, narrow reservoirs. Water quality state variables consist of temperature, algae, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, and dissolved iron.

The primary advantage of CE-QUAL-W2 is the ability to simulate the onset and breakdown of vertical temperature stratification and resulting water quality impacts. It will be the most appropriate model for those cases where these vertical variations are an important water quality consideration. In unstratified systems, the effort and data required to support the CE-QUAL-W2 hydrodynamic routines may not be necessary.

EFDC:

EFDC (Environmental Fluid Dynamics Code) is a three-dimensional hydrodynamic and water quality model supported by the U. S. EPA Ecosystems Research Division. EFDC simulates variations in water quality in the longitudinal, lateral and vertical directions, and was developed to address water quality issues in rivers, lakes, reservoirs, wetland systems, estuaries, and the coastal ocean. EFDC transports salinity, heat, cohesive or noncohesive sediments, and toxic contaminants that can be described by equilibrium partitioning between the aqueous and solid phases. Unique features of EFDC are its ability to simulate wetting and drying cycles, and that it includes a near field mixing zone model that is fully coupled with a far-field transport of salinity, temperature, sediment, contaminant, and eutrophication variables. It also contains hydraulic structure representation, vegetative resistance, and Lagrangian particle tracking. EFDC accepts radiation stress fields from wave refraction-diffraction models, thus allowing the simulation of longshore currents and sediment transport.

The primary advantage of EFDC is the ability to combine three-dimensional hydrodynamic simulation with a wide range of water quality modeling capabilities in a single model. The primary disadvantages are that data needs and computational requirements can be extremely high.

Final Stage 3 Report

Horseshoe Lake

Prepared for:
Illinois EPA

August 26, 2016

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Horseshoe Lake Watershed Total Maximum Daily Load Final Stage 3 Report

Prepared for:
Illinois EPA

August 26, 2016

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Executive Summary

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is called the 303(d) list. The State of Illinois submitted final 2012 303(d) list (IEPA 2012) to USEPA for approval on 12/20/2012. The draft 2014 303(d) list has gone through the public review and comment period. These reports are available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. This report focuses on assessments based on the 2012 303(d) list. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Load Reduction Strategies (LRSs) are being completed for causes that do not have numeric standards. LRSs for causes of impairment with target criteria will consist of loading capacity, percentage reduction for nonpoint sources, margin of safety and reserve capacity, if applicable.

Horseshoe Lake is listed on the 2012 Illinois Section 303(d) List of Impaired Waters (IEPA, 2012) as not meeting its designated uses. This document presents the TMDL designed to allow Horseshoe Lake to fully support its designated uses. The LRS for Horseshoe Lake is also presented. The report covers each step of the TMDL process and is organized as follows:

- Problem Identification
- Required TMDL Elements
- Watershed Characterization
- Description of Applicable Standards and Numeric Targets
- Development of Water Quality Model
- TMDL Development
- Public Participation and Involvement
- Adaptive Implementation Process

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1

Problem Identification

The impaired lake addressed in this TMDL is listed below (Table 1), with the parameters (causes) it is listed for, and the impairment status of each designated use, as identified in the 2012 303(d) list (IEPA, 2012). TMDLs are currently only being developed for pollutants that have numerical water quality standards. Load Reduction Strategies (LRSs) are being developed for pollutants that do not have numerical water quality standards. Those causes that are the focus of this report are shown in bold font.

Table 1. Impaired Waterbody Summary

Waterbody/ Segment Name	Use Support [2]	Size (acres)	Impairment Cause	Potential Sources
Horseshoe Lake (Alexander County) IL_RIA	Aesthetic Quality (N), Aquatic Life (F), Fish Consumption (X), Primary Contact (X), Secondary Contact (X)	1,890	**Phosphorus (Total), TSS**, Aquatic Algae	Crop Production (crop land or dry land), Runoff from Forest/Grassland/Parkland

[1] Bold font indicates cause will be addressed in this report by a TMDL or LRS. Other potential causes of impairment listed for these water bodies are not subject to TMDL or LRS development at this time.

[2] F = Fully supporting, N = Not supporting, X = Not assessed

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Required TMDL Elements

USEPA Region 5 guidance for TMDL development requires TMDLs to contain specific components. Each of those components is summarized here for the total phosphorus TMDL.

Horseshoe Lake

1. Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking: Horseshoe Lake, HUC 071401080302. The pollutant of concern addressed in this TMDL is phosphorus. Potential sources include Crop Production (crop land or dry land) and runoff from forest, grassland, and parkland. Horseshoe Lake is ranked medium priority on the 2012 Illinois EPA 303(d) list (IEPA 2012).
2. Description of Applicable Water Quality Standards and Numeric Water Quality Target: The General Use water quality criteria for phosphorus in Illinois lakes is 0.05 mg/l. For this TMDL, the numeric water quality target was set at the water quality criterion for total phosphorus of 0.05 mg-P/l.
3. Loading Capacity – Linking Water Quality and Pollutant Sources: The water quality model BATHTUB was applied to determine that the maximum phosphorus load that will maintain compliance with the phosphorus standard is an average load of 4.2 kg/day (9.3 lbs/day) between April and July, with the total load not to exceed 512 kg (1,130 lbs) over this period. This allowable load corresponds to an approximately 88% reduction from existing loads.
4. Load Allocations (LA): The load allocation given to non-point source loads from watershed sources is 3.78 kg/day (8.33 lbs/day) for the period April - July.
5. Wasteload Allocations (WLA): There are no point sources that discharge in the watershed. No WLA was set for this watershed.
6. Margin of Safety: The TMDL contains an explicit margin of safety corresponding to 10% of the loading capacity, or 0.42 kg/day (0.93 lbs/day). (This value was set to reflect the uncertainty in the BATHTUB model predictions.
7. Seasonal Variation: The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The April-July duration for the seasonal loading was determined based on a calculation of phosphorus residence time in Horseshoe Lake of two weeks to a month. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.
8. Reasonable Assurances: Reasonable assurances for point sources are not included because there are no permitted point sources in the watershed.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed

- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Details regarding past studies of the lake are provided in the Stage 1 Report.

9. Monitoring Plan to Track TMDL Effectiveness: The implementation plan includes a monitoring plan to track effectiveness.
10. Transmittal Letter: A transmittal letter will accompany this TMDL document.
11. Public Participation: Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local agencies in summer 2013 to gather and share information and initiate the TMDL process. Phone calls and emails were also used to identify and acquire data and information (listed in the Stage 1 Report). A public meeting was conducted in Tamms, Illinois in December 2013 and one additional public meeting is planned.

3

Clean Water Act Section 319

Section 319 of the Clean Water Act represents the USEPA's primary nonpoint-source water pollution control program. There are nine components that the USEPA requires to obtain Section 319 funding. Each of those components is addressed or referenced below.

a. *Identification of causes and sources that will need to be controlled to achieve load reductions estimated within the plan*

The causes and sources of impairment in the Horseshoe Lake watershed are described in Chapter 3 of the Horseshoe Lake Stage 1 Report, and repeated below.

Cause of impairment	Potential Sources
Phosphorus (Total)	Waterfowl, runoff from cropland or Forest/Grassland/Parkland, stream bank erosion, erosion of highly erodible soils, failing septic systems, resuspension of bottom sediments.
Total suspended solids	

b. *Estimate of the load reductions expected for the management measures described in component c*

The TMDL calculation contained within this report calculates that a load reduction of 88% of existing phosphorus loads. In order to meet permissible TSS accumulation rates, TSS loads will be limited to 33,424 lbs/day. A TSS target of 31 mg/l will also need to be met for the tributaries to Horseshoe Lake. More information on the expected load reductions can be found in Chapter 7 of this report.

c. *Description of the nonpoint-source management measures that need to be implemented in order to achieve the load reductions estimated in component b; and identification of critical areas*

Management measures and identification of critical areas are described in detail in Section 9 of this report.

d. *Estimate of the amounts of technical and financial assistance needed; costs; and the sources and authorities (e.g., ordinances) that will be relied upon to implement the plan*

Each implementation strategy and cost is discussed in Section 9.3 of this report with a discussion of funding sources and authorities in Section 9.4. Various state and federal authorities have developed funding mechanisms described in these sections.

e. *Information and public education component; and early and continued encouragement of public involvement in the design and implementation of the plan*

   Documentation of public meetings held to discuss both the Stage 1 Report and this report are contained in this document. The Stage 1 public meeting is documented in Chapter 8 of the Stage 1 Report, and the Stage 3 public meeting is documented in Chapter 8 of this report. Public involvement, including the establishment of a watershed group as one of the first implementation activities, is recommended in Section 9.3.10.

f. *Implementation schedule*

   The implementation plan may begin following acceptance of this TMDL and securement of funding for the implementation measures. Section 9.3.10 describes an implementation schedule. Because controls are voluntary, a strict schedule is not provided.

g. *Description of interim, measurable milestones for determining whether NPS measures or other actions are being implemented*

   The monitoring program described in Section 9.5 is designed to establish baseline tributary quality, and track effectiveness of controls as they are implemented. Reductions in tributary TSS or TP concentrations following implementation of watershed controls can be calculated from the monitoring data and compared to the TMDL and LRS target reductions.

h. *Criteria to measure success and reevaluate the plan*

   A reduction in TSS and phosphorus as described in this report would indicate a successful plan, but it is expected that the attainment of these goals will take many years and the implementation of voluntary controls. Although significant reductions are required to meet the TMDL and LRS targets, incremental reductions in loads delivered to the lake will help improve conditions and as such the quality of the lake should be reassessed periodically based on IEPA monitoring data, to assess progress. Ongoing IEPA monitoring of Horseshoe Lake will generate data to reevaluate the use assessment over time. If there are any substantial changes to the land use or land cover within the watershed, or the occurrence of a large flooding event, then the source loads, and predictions of lake water quality may be impacted, and the plan may need to be reevaluated.

i. *Monitoring component to evaluate effectiveness of implementation efforts over time*

   Monitoring is discussed in Section 9.5.

4

Watershed Characterization

The Stage 1 report for the Horseshoe Lake watershed describes watershed characteristics, and identification of sources contributing to total phosphorus and TSS impairments. Watershed characterization activities were focused on gaining an understanding of key features of the watersheds, including geology and soils, climate, land cover, hydrology, urbanization and population growth, point source discharges and watershed activities.

The Horseshoe Lake watershed is located in Alexander County in southwestern Illinois. Horseshoe Lake is a 1,890 acre lake created from a natural oxbow of the Mississippi River. The lake supports a flooded forest of bald Cyprus and water tupelo and is situated within the 10,200-acre Horseshoe Lake State Fish and Wildlife Area.

Figure 1 shows a map of the watershed, and includes waterways, roads and other key features. There are no NPDES-permitted dischargers in the watershed.

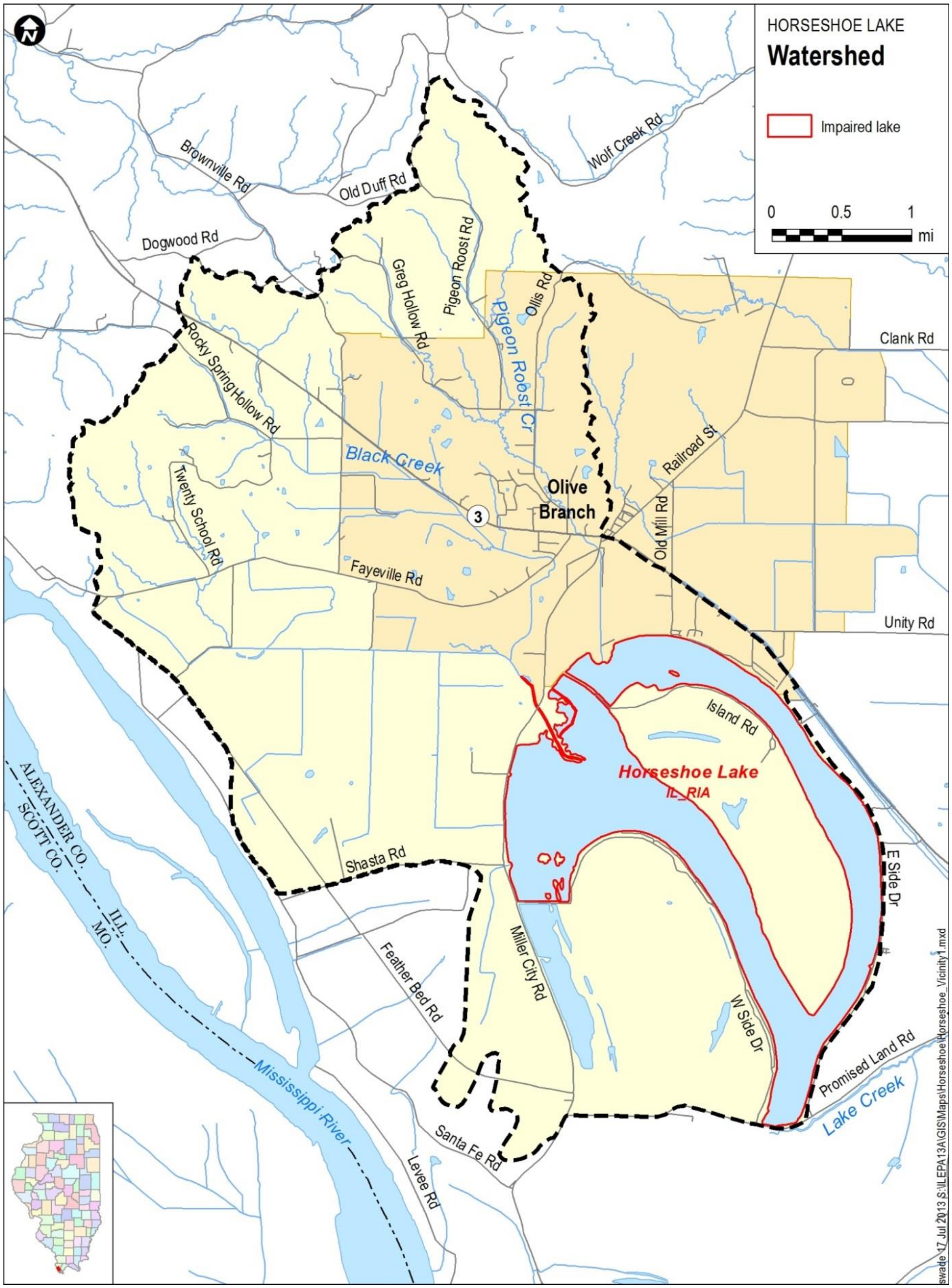

Figure 1. Base Map of the Horseshoe Lake Watershed

5

Description of Applicable Standards and Numeric Targets

A water quality standard includes the designated uses of the waterbody, water quality criteria to protect designated uses, and an antidegradation policy to maintain and protect existing uses and high quality waters. This section discusses the applicable designated uses, use support, and criteria for Horseshoe Lake.

5.1 Designated Uses

The waters of Illinois are classified by designated uses, which include: public and food processing water supplies, aquatic life, fish consumption, primary contact, secondary contact, indigenous aquatic life, and aesthetic quality (IEPA, 2012). The designated use applicable to the project watershed is aesthetic quality, which is not supporting. IEPA also assesses use support for aquatic life, and determined that the aquatic life use was being fully supported.

5.1.1 General Use

General Use Standards (35 Ill. Adm. Code Part 302, Subpart B) apply to almost all waters of the state and are intended to protect aquatic life, wildlife, agricultural, primary contact, secondary contact, and most industrial uses. These General Use Standards are also designed to ensure the aesthetic quality of the state's aquatic environment and to protect human health from disease or other harmful effects that could occur from ingesting aquatic organisms taken from surface waters of the state (IEPA, 2012).

5.1.2 Aesthetic Quality

The Aesthetic Quality Index (AQI) is the primary tool used to assess aesthetic quality for inland lakes. The AQI represents the extent to which pleasure boating, canoeing and aesthetic enjoyment are attained at a lake. The AQI is calculated from the Trophic State Index, the percent surface area macrophyte coverage during the peak growing season (June through August) and the median concentration of nonvolatile suspended solids.

The State of Illinois uses the Aesthetic Quality Index (AQI) to assess if a lake is supporting the aesthetic quality use. The AQI is the sum of the median Trophic State Index (TSI) (Carlson, 1977), and scores based on percent macrophyte coverage and NVSS concentration.

AQI evaluation factors and scoring for Horseshoe Lake were presented in the Stage 1 report, confirming that the 2009 data support the listing of Horseshoe Lake due to non-support (fair) of the aesthetic quality use.

5.2 Water Quality Criteria

Illinois has established a numeric water quality criteria for total phosphorus. As described below, IEPA also previously had guidelines for identifying TSS as a cause of impairment, but has since changed their assessment methodology. A comparison of available water quality data to these criteria and guidelines is provided in the Stage 1 report.

5.2.1 Total Phosphorus

The identification of phosphorus as a cause in lakes over 20 acres, is based on the total phosphorus numeric criteria of 0.05 mg/l (IEPA, 2012). Phosphorus is confirmed as a cause, based on the fact that all of the 2009 total phosphorus measurements are greater than 0.05 mg/l.

5.2.2 Total Suspended Solids

Horseshoe Lake was first identified as impaired due to total suspended solids on the 2006 303(d) list. In the 2012 assessments, IEPA implemented changes in their assessment methodology, removing total suspended solids as a possible cause of aesthetic quality use impairment; however, Horseshoe Lake is still identified as impaired due to total suspended solids (as well as total phosphorus) based on past assessments. The total suspended solids cause was therefore confirmed applying the methodology used to put Horseshoe Lake on the 303(d) list.

The identification of TSS as a cause of impairment is based on a median surface nonvolatile suspended solids concentration greater than 3 mg/l. The median surface nonvolatile suspended solids concentration in Horseshoe Lake was 7 mg/l in 2009. This is based on an analysis of 2009 data from three lake stations, confirming TSS as a cause of impairment. Nonvolatile suspended solids concentrations in Horseshoe Lake in 2003 were also examined. In 2003, the median surface nonvolatile suspended solids concentration in Horseshoe Lake equaled 9 mg/l, based on 15 samples collected between April and October, 2003 at the three sampling locations.

5.3 Development of TMDL and LRS Targets

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint.

For the Horseshoe Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

When appropriate numeric standards do not exist, surrogate parameters must be selected to represent protection of the designated use. A surrogate parameter ("acceptable" rate of volume loss in the lake) is selected as the LRS target for TSS. The linkage between the LRS target and TSS is appropriate because TSS loads to the lake and resulting sedimentation affect the capacity (i.e. volume) of the lake. Sedimentation is a natural process, such that selection of an acceptable volume loss of zero is typically not feasible. The target for the TSS LRS is a rate of volume loss less than or equal to 0.25% of the volume of the lake, based on direction from IEPA which was based on guidelines from the Illinois 2010 Integrated Water Quality Draft Report (IEPA, 2010). The most recent calculation of lake volume was described in Bogner (1985) as 5947 acre-feet. There are conflicting reports as to whether Horseshoe Lake has gained or lost volume since 1985, so the TSS LRS assumes the 1985 calculated volume represents the baseline volume for the lake (Bogner, 1985, Butts and Singh, 1997). 0.25% of 5947 acre-feet yields a maximum acceptable volume loss (i.e. TSS accumulation volume) of 14.9 acre-feet per year.

IEPA has recently developed a LRS target of 31 mg/l TSS for Horseshoe Lake tributaries. The TSS target is set as both the tributary target of 31 mg/l and the in-lake target based on a maximum acceptable volume loss of 14.9 acre-feet per year.

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6

Development of Water Quality Model

The BATHTUB water quality model was used to define the relationship between external phosphorus loads and the resulting concentrations of total phosphorus in the lake. The following sections:

- summarize the model selection process,
- provide an overview of the BATHTUB model,
- present the model inputs used in BATHTUB, and
- describe the model application and comparison of model output to data.

The remainder of this section describes the TSS modeling to support the TSS LRS.

6.1 BATHTUB Model

6.1.1 Model Selection

A detailed discussion of the model selection process is provided in the Stage 1 report, and the BATHTUB model (Walker, 1986) was selected to estimate the loading capacity of the lake. BATHTUB can predict the relationship between phosphorus load and resulting in-lake phosphorus. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. BATHTUB has been used previously for several reservoir TMDLs in Illinois, and has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (Ernst et al., 1994).

BATHTUB is a software program for predicting the lake/reservoir response to nutrient loading. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

BATHTUB contains a number of empirical regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, chlorophyll concentrations, and Secchi depth (transparency). Both tabular and graphical displays are available from the program.

6.1.2 Modeling Approach

The approach to be taken for the total phosphorus TMDL consists of using existing empirical data to define current loads to the lake, and using the BATHTUB model to define the extent to which these loads must be reduced to meet water quality standards. This approach was taken because phosphorus concentrations exceed the water quality standard by up to a factor of 9. This indicates that phosphorus loads will need to be reduced to a small fraction of existing load in order to attain water quality standards.

The dominant land use is agriculture. This level of load reduction is likely not attainable in the near future, if at all. Implementation plans for agricultural sources will require voluntary controls, applied on an incremental basis. The approach taken for this TMDL, which requires no additional data collection and can be conducted immediately, will expedite implementation efforts.

6.1.3 BATHTUB Model Inputs

This section gives an overview of the model inputs required for BATHTUB application, and how they were derived. The following categories of inputs are required for BATHTUB:

- Model Options
- Global Variables
- Reservoir Segmentation
- Tributary Loads

6.1.3.a Model Options

BATHTUB provides a multitude of model options to estimate nutrient concentrations in a reservoir. Model options were entered as shown in Table 2, and the rationale for these options discussed below. No conservative substance was being simulated, so this option was not needed. The second order available phosphorus option was selected for phosphorus, as it is the default option for BATHTUB. Nitrogen was not simulated because phosphorus is the nutrient of concern.

Chlorophyll a and transparency were not simulated. The Fischer numeric dispersion model was selected, which is the default approach in BATHTUB for defining mixing between lake segments. Phosphorus calibrations were based on lake concentrations. No nitrogen calibration was required. The use of availability factors was not required and estimated concentrations were used to generate mass balance tables.

Table 2. BATHTUB Model Options

Model	Model Option
Conservative substance	Not computed
Total phosphorus	2nd order, available phosphorus
Total nitrogen	Not computed
Chlorophyll-a	Not computed
Transparency	Not computed
Longitudinal dispersion	Fischer-numeric
Phosphorus calibration	Concentrations
Nitrogen calibration	None
Error analysis	Model and Data
Availability factors	Ignored
Mass-balance tables	Use estimated concentrations

6.1.3.b Global Variables

The global variables required by BATHTUB consist of:

- The averaging period for the analysis
- Precipitation, evaporation, and change in lake levels
- Atmospheric phosphorus loads

BATHTUB is a steady state model, whose predictions represent concentrations averaged over a period of time. A key decision in the application of BATHTUB is the selection of length of time over which inputs and outputs should be modeled. The length of the appropriate averaging period for BATHTUB application depends upon what is called the nutrient residence time, i.e. the average length of time that phosphorus spends in the water column before settling or flushing out of the lake. Guidance for the BATHTUB model recommends that the averaging period used for the analysis be at least twice as large as nutrient residence time for the lake of interest. For lakes with a nutrient residence time on the order of one to three months, a seasonal (e.g. spring-summer) averaging period is recommended. The nutrient residence time under current conditions is approximately one to three months. The nutrient residence time will increase as nutrient loads are reduced to allowable levels for meeting the TMDL target. Therefore, the averaging period used in the model needs to account for both scenarios. For Horseshoe Lake, a seasonal period of April-July was used as the averaging period.

Precipitation inputs were taken from the observed long term annual average precipitation data and scaled for the April-July simulation period. This resulted in a precipitation value of 23.0 inches. Evaporation was set equal to values suggested by NOAA Technical Reports 33 and 34. This resulted in an evaporation value of 22.4 inches. There was no assumed increase in storage during the modeling period, to represent steady state conditions. The values selected for precipitation and change in lake levels have little influence on model predictions. Atmospheric phosphorus loads were specified using default values provided by BATHTUB.

6.1.3.c Reservoir Segmentation

BATHTUB provides the capability to divide the reservoir under study into a number of individual segments, allowing prediction of the change in phosphorus concentrations over the length of each segment. The segmentation schemes selected for Horseshoe Lake were designed to provide one segment for each of the primary lake sampling stations. Horseshoe Lake was divided into three segments as shown in Figure 2. The areas of segments and watersheds for each segment were determined by Geographic Information System (GIS).

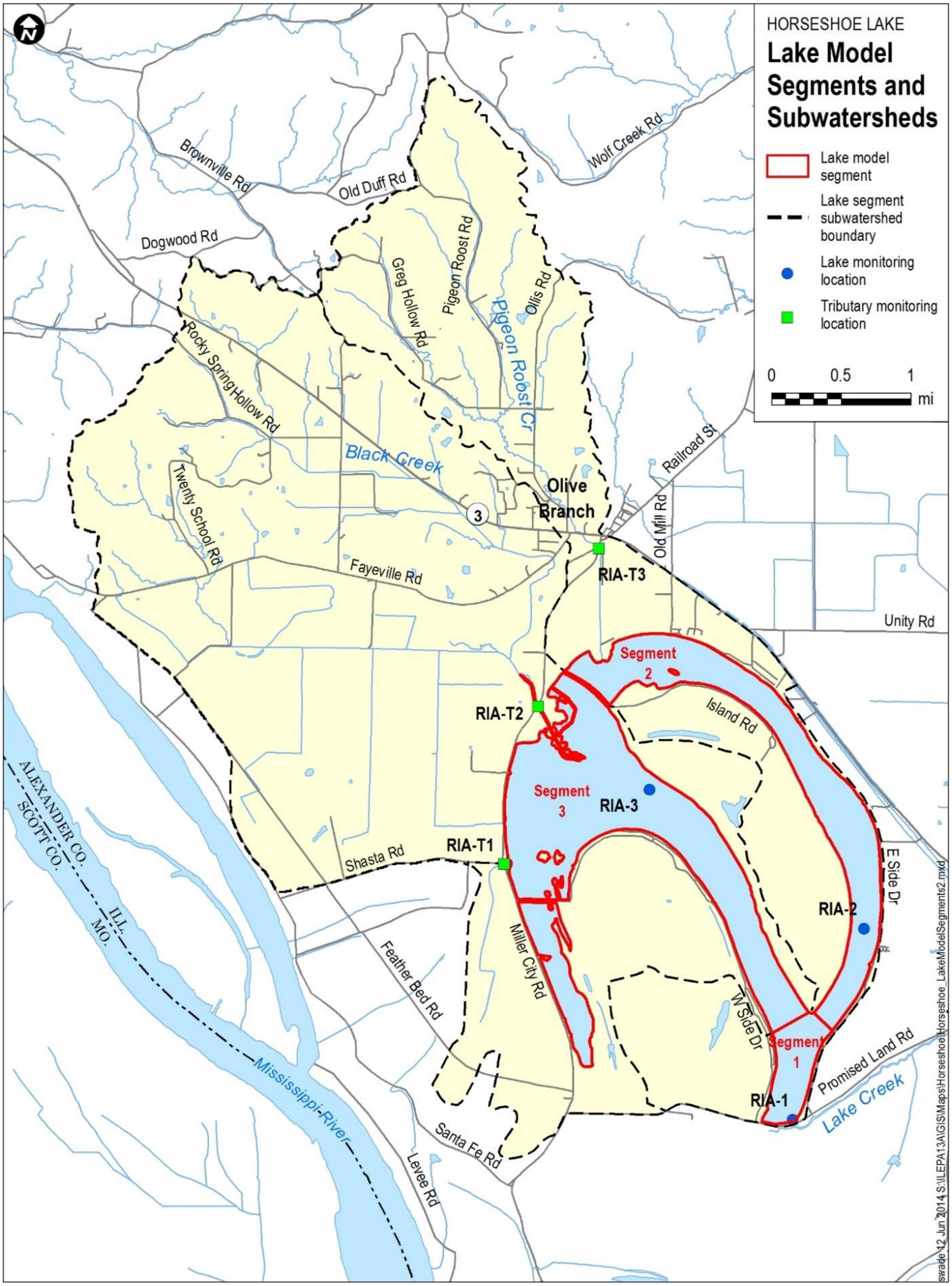

Figure 2. Horseshoe Lake Segmentation Used in BATHTUB

BATHTUB requires that a range of inputs be specified for each segment. These include segment surface area, length, total water depth, and depth of thermocline and mixed layer. Segment-specific values for segment depths (total, thermocline and mixed layer) were calculated from the lake monitoring data, while segment lengths and surface areas were calculated via GIS. A complete listing of all segment-specific inputs is provided in Attachment 1.

6.1.3.d Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Flows to each segment were estimated using observed flows at the USGS gaging station at Massac Creek near Paducah, Kentucky (05140206), adjusted through the use of drainage area ratios as follows:

Flow into segment = Flow at USGS gage * Segment-specific drainage area ratio

Drainage area ratio = Drainage area of watershed contributing to model segment

Drainage area of watershed contributing to USGS gage

Segment-specific drainage area ratios were calculated via GIS information.

Total phosphorus concentrations for each major lake tributary were based upon 2013 springtime measurements taken near the mouth of each tributary. Concentrations for small tributaries and direct drainage were set equal to the measured concentrations for a nearby major tributary. A complete listing of all segment-specific flows and tributary concentrations is provided in Attachment 1.

6.1.4 BATHTUB Calibration

BATHTUB model calibration consists of:

1. Applying the model with all inputs specified as above
2. Comparing model results to observed phosphorus data
3. Adjusting model coefficients to provide the best comparison between model predictions and observed phosphorus data.

The BATHTUB model was initially applied with the model inputs as specified above. Observed lake data for the year 2009 were used for calibration purposes, and tributary data for the year 2013 were used. Precipitation patterns in both 2009 and 2013 were similar, and these years provided the most robust observed datasets for lake and tributary data. The April-July observed lake data were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average phosphorus concentrations. Model results using default model parameters initially under-predicted the observed phosphorus data in all three lake segments. Phosphorus loss rates in BATHTUB reflect a typical “net settling rate” (i.e. settling minus sediment release) observed in a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected via the addition of an internal phosphorus load of 65 mg/m2/day in the near-dam segment (Segment 1) and 10 $mg/m^2/day$ in the east segment (Segment 2). No additional internal phosphorus load was required for the west segment (Segment 3). The resulting modeled and observed total phosphorus concentrations are shown in Table 3. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 1.

Table 3. Segment Modeled vs. Observed Total Phosphorus Concentration

Segment	Modeled Concentration (ug/L)	Observed Concentration (ug/L)
Dam (Segment 1)	402	451
East (Segment 2)	382	448
West (Segment 3)	345	302
Area-weighted Lake Average	360	362

6.2 Total Suspended Solids Model

Various studies have been completed in the past examining sedimentation in Horseshoe Lake. Bogner et al. (1985) calculated that the long-term annual sedimentation in Horseshoe Lake amounted to 33,900 tons per year for 1951-1984. Consequently, it was observed that the lake is decreasing in depth by 0.47 inches per year based on data from this time frame.

Lee et al. (1986) note that two previous surveys of the lake were conducted by IDOC personnel: a 1951 survey by O. M. Price (Price, 1980) and a 1980 survey by Don Garver (Conlin, 1981) (Lee et al, 1986), but that the analysis of these surveys is limited due to a lack of information on the 1951 survey and the limited detail of the 1980 survey. A study by Bogner et al. (1985) focuses on the long-term average sedimentation from the watershed and is a more appropriate figure to use. It should be noted, however, that changes in the sediment load in the lake may have been affected by significant flooding in 1993 and 2011, which occurred due to levee breaching. Butts and Singh (1997) suggest that the 1993 flood may have scoured the lake bottom in several locations. These reports have conflicting evidence as to whether Horseshoe Lake has increased or decreased in volume since the volume reported for 1984 in Bogner.

6.2.1 Model Selection

The TSS load reduction strategy is based on a relationship between sediment loading and volume loss in the lake.

6.2.2 Modeling Approach

A linear model was used to predict the reduction in TSS load necessary to limit the volume loss in the lake to 0.25% of the total volume, or 14.9 acre-feet per year, assuming a baseline volume of 5947 acre-feet. It was assumed that the total volume of the lake is equal to the total volume of the lake as calculated in Bogner (1985). It was also assumed the TSS has a unit weight of 18.9 pounds per cubic foot as reported in the same report.

7

TMDL and LRS Development

This section presents the development of the Total Maximum Daily Load and Load Reduction Strategy for Horseshoe Lake. It begins with a description of how the total loading capacity was calculated, and then describes how the loading capacity is allocated among point sources, non-point sources, and the margin of safety. A discussion of critical conditions and seasonality considerations is also provided along with a discussion of reserve capacity.

7.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

7.1.1 Total Phosphorus

The loading capacity was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of the water quality objective. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Initial BATHTUB load reduction simulations indicated that Horseshoe Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional internal sediment phosphorus source for future scenarios. The resulting load, with calibrated tributary concentrations and no additional sediment phosphorus load yields an average phosphorus load of 34.6 kg/day (76.3 lbs/day) and a concentration of 0.189 mg/L. This exceeds the phosphorus target of 0.05 mg/L, so reductions in the tributary loads are necessary. The loading capacity was an average of 4.2 kg/day (9.3 lbs/day) over the April to July period, with the total load over this period not to exceed 512 kg (1,129 lbs). This allowable load corresponds to an approximately 88% reduction from existing loads, estimated as 4,221 kg (9,306 lbs) over the April to July period.

7.1.2 Total Suspended Solids

As described previously, the total suspended solids load to Horseshoe Lake is limited to a volume less than 0.25% of the lake's volume, which is assumed to be 5947 acre-feet. This calculation yields 14.9 acre-feet per year of allowed TSS accumulation. Using a unit weight of 18.9 pounds per cubic foot, the sediment load to Horseshoe Lake is reduced to 15,161 kg/day (33,424 lbs/day) from all sources.

In addition, the IEPA annual average target of 31 mg/l TSS for Horseshoe Lake tributaries is considered. Available tributary data from 2013, collected at the mouths of the tributaries during or shortly after wet weather events, average 18 mg/l, 6 mg/l, and 25 mg/l for three monitored tributaries. The average tributary concentrations are less than the TSS target. Due to the limited size of the tributary database (8 samples total), additional monitoring is recommended to ensure the available data are representative of longer-term tributary concentrations. For the TSS LRs, the load capacity for Horseshoe Lake is equal to 15,161 kg/day (33,424 lbs/day) from all sources.

7.2 Allocation

This section describes the allocation of total phosphorus loads. For load reduction strategies, the load capacity is not divided into a WLA, LA or MOS.

7.2.1 Total Phosphorus

There are no point sources in the watershed, and therefore there is no wasteload allocation given for Horseshoe Lake. The entire loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The loading capacity is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 4.2 kg/day (9.3 lbs/day), and an explicit margin of safety of 10% (discussed below in Section 6.5), this results in a load allocation for Horseshoe Lake of 3.78 kg/day (8.33 lbs/day).

7.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon a seasonal period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

7.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate loads over a seasonal to annual averaging period. Model results indicate that the average phosphorus residence time in Horseshoe Lake is on the order of one to three months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

7.5 Margin of Safety

7.5.1 Total Phosphorus

The TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit total phosphorus load allocated to the margin of safety is 0.42 kg/day (0.93 lbs/day) for Horseshoe Lake.

7.6 Reserve Capacity

The Horseshoe Lake watershed is located entirely within Alexander County. Alexander County's population decreased slightly between 2000 and 2010. In 2000, Alexander County had a population of 9,590 and in 2010, 9,501 people were counted by the U.S. Census Bureau. In 2010, Olive Branch, the largest community is the Horseshoe Lake watershed had a population of 864.

The population of Alexander County is projected to increase by approximately 400 residents, through 2020 (Stage 1 report). Assuming that this growth will be observed throughout Alexander County, only a small increase in population would be expected in the Horseshoe Lake watershed. As such, it was determined that a reserve capacity was not needed for the TMDL.

7.7 TMDL Summary

Table 4 summarizes the Total Phosphorus TMDL and the TSS LRS for Horseshoe Lake.

Table 4: TMDL and LRS Summary

Allocation	Total Phosphorus	Total Suspended Solids
Load Capacity (LC)	4.2 kg/day (9.3 lbs/day)	15,161 kg/day (33,424 lbs/day)
Wasteload Allocation (WLA)	None	N/A
Load Allocation (LA)	3.78 kg/day (8.33 lbs/day)	N/A
Margin of safety (10% of LC)	0.42 kg/day (0.93 lbs/day)	N/A

N/A = not applicable

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8

Public Participation and Involvement

This section summarizes the results of a November 19, 2015 public meeting, at which Illinois EPA Planning Unit TMDL project managers, along with their consultant presented the results of the Stage 3 Draft report for the Horseshoe Lake watershed.

On October 22, 2015, a public meeting was announced for presentation of the Stage 3 TMDL report and was posted to the Illinois EPA website at the following address: http://www.epa.state.il.us/public-notices/. The public notice was also published in The Cairo Citizen newspaper on Thursday, November 5, 2015. The public meeting was held at 2:30 pm on Thursday, November 19, 2015 in Tamms, Illinois at the Alexander/Pulaski NRCS Service Center.

This meeting provided an opportunity for local agencies and the general public to provide input on the Stage 3 TMDL report. Prior to the meeting, Illinois EPA posted the draft Stage 3 Report for the Horseshoe Lake watershed to their website http://www.epa.state.il.us/water/tmdl/report/horseshoe-lake/stage-3-report.pdf

The meeting was attended by seven local interested individuals, three Illinois EPA staff members and one staff member from the TMDL consultant (LimnoTech). Attendees signed in and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage 3 methods and findings by LimnoTech. This was followed by a general question and answer session.

The primary concern expressed at the meeting was that there were limited options for funding and manpower to create a watershed group to assist in the implementation of the recommended BMPs, conduct public education and outreach activities, and to implement a monitoring program. The Illinois EPA staff provided some information on the Section 319 CWA Nonpoint Source Grant Program as a funding mechanism for implementing some of the BMPs recommended in the Stage 3 TMDL report. Contact information for Illinois EPA staff and the TMDL consultant were provided to those interested to allow for follow-up questions. All attendees were asked to submit their comments and concerns to Illinois EPA by December 21, 2015.

The Agency entertained questions and concerns from the public through December 21, 2015. One letter was received from the Illinois Farm Bureau.

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9

Adaptive Implementation Process

Horseshoe Lake is listed on the 2012 Illinois Section 303(d) List of Impaired Waters (IEPA, 2012 as water bodies that are not meeting their designated uses. As such, these lakes were targeted as high priority waters for TMDL development. After acceptance of the TMDL by EPA, the next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. Adaptive management recognizes that proceeding with some initial improvement efforts is better than waiting to find a "perfect" solution. In an adaptive management approach, the TMDL and the watershed to which it applies are revisited over time to assess progress and make adjustments that continue to move toward achieving the TMDL's goals. Adaptive management may be conducted through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

9.1 Implementation Approach

The approach to be taken for TMDL development and implementation is based upon discussions with Illinois EPA and modeled on TMDLs previously approved by EPA. The approach consists of the following steps, with the first three steps corresponding to TMDL development and the latter two steps corresponding to implementation:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources. Note that although this is the approach that was initially agreed-upon, a simple watershed model has been applied for this watershed to address comments received by the Nonpoint Source Section.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lakes can assimilate and still attain water quality standards.
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards.
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives.

The adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps one through three are described in previous sections of this report. This section represents Steps Four and Five of the process.

9.2 Sources and Critical Areas

Sources of total phosphorus and total suspended solids have been previously discussed in the Stage 1 report, and include agricultural sources, release from existing lake bottom sediments under anoxic conditions, recreation activities such wildlife reserve areas, failing private sewage disposal systems and streambank erosion. This section provides a ball-park loading estimate for watershed sources and streambank erosion, confirming the importance of those two sources. Guidance regarding locations to implement BMPs to maximize the benefit is also provided in this section under the discussion of critical areas.

As described in Section 7.1.1., initial BATHTUB load reduction simulations indicated that Horseshoe Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This implementation plan describes options for addressing this loading source, as well as loads from other sources, such as failing private sewage disposal systems and wildlife that could not be easily quantified.

9.2.1 Land cover-specific watershed loads

The online tool Great Lakes Regional L-THIA Model (available at lthia.agriculture.purdue.edu) was used to estimate load contributions by land use in the watershed. This tool integrates information on land cover, regional climate, and soil hydrologic group to estimate average annual runoff. A model default event mean concentration (EMC) is then applied by land use to estimate loading. While these numbers are more sophisticated than a unit-area-loading technique, due to the inclusion of hydrologic soil group, they are best used to identify the relative load generated by land cover, and are less accurate in predicting an absolute runoff load (Figure 3). L-THIA predicts that the largest phosphorus and sediment runoff loads are generated by general agriculture, which includes both row crops (such as corn or soybeans) and small grains (like wheat). On a watershed-wide basis, general agriculture contributes 96% of TP loading and 98% of sediment loading in an average year while only comprising roughly 30% of the total watershed area.

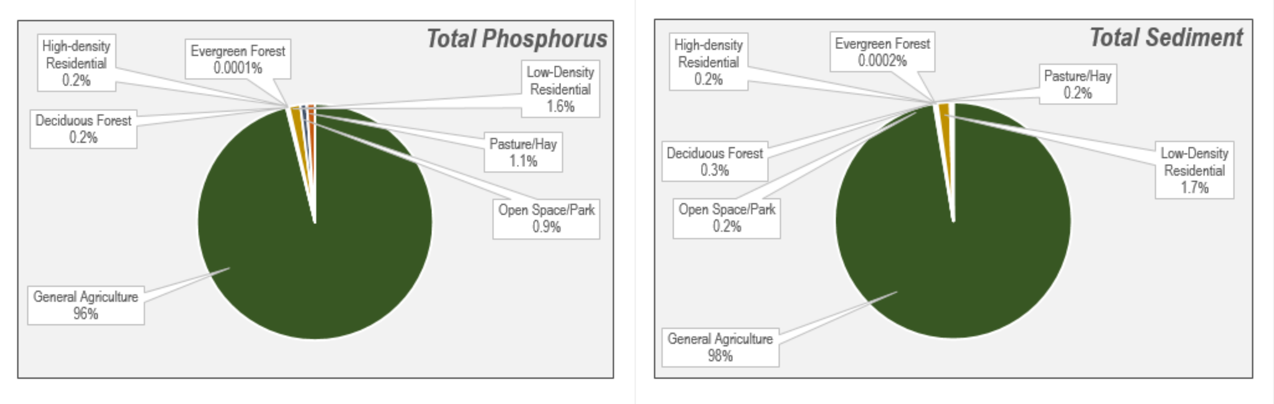

Figure 3 Total Phosphorus (L) and Total Sediment (R) by Land Use as a Percent of Total Export

Although model-predicted values are estimates, their values are useful for obtaining a look at potential loading reductions by BMPs. L-THIA predicts approximately 7,518 pounds of TP and 433,726 pounds of sediment are generated annually from general agriculture uses. Low-density residential areas were estimated to provide the next highest loads with an annual average of 121 lbs. of TP and 7,608 lbs. of sediment (Table 5). It should be noted that these estimates are for landside loads only and do not account for in-stream transformations including settling and bank erosion.

Table 5 L-THIA Estimated TP and Sediment Loading by Land Cover for an Average Year

Land cover	**Total Phosphorus Load (lbs.)**	**Total Sediment Load (lbs.)**
General Agriculture	7,517.9	433,726.3
Deciduous Forest	15.7	1,256.4
Evergreen Forest	0.0	0.7
High-Density Residential	14.2	891.8
Low-Density Residential	121.4	7,608.5
Urban Open Space	69.2	880.6
Pasture/Hay	86.4	1,099.0
Total Sum	***7,825***	***445,463***

9.2.2 Streambank erosion loads

Eroding streambanks have been identified by IEPA as a potential source of phosphorus and sediment (IEPA, 2014). Streambank erosion, and some stabilization in the form of rip-rap was observed during the Stage 1 site visit. An attempt was made to contact the local SWCD to get more site-specific information regarding locations of streambank erosion, but there was no response.

The Illinois Nutrient Loss Reduction Strategy (IWRC-IISG et al., 2015) notes that as much as 30-50% of total waterway sediment can be traced to eroding stream banks; treating these banks can reduce up to 1,050 pounds of sediment and 983 pounds of total phosphorus per treated stream mile.

9.2.3 Critical areas

Tributary monitoring data collected in 2013 showed significantly higher phosphorus and TSS concentrations at the mouth of Black Creek (Figure 4, station RIA-T2), and the unnamed tributary to Horseshoe Lake located at Miller City Road (Figure 4, station RIA-T1), compared to the mouth of Pigeon Roost Creek (Figure 4, station RIA-T3). Implementation actions should therefore be prioritized for the Black Creek watershed and the watershed for the unnamed tributary upstream of station RIA-T1). Monitoring data are not available for the island area located in Horseshoe Lake, or other areas that drain to the lake via surface runoff and small unnamed streams, but it is expected that the load contributed by these areas may be higher due to their proximity to the lake. As such, phosphorus and TSS controls on these lands are expected to have a bigger impact than those on lands located farther from the lake.

Modeling results indicate that agricultural runoff is a significant source of total phosphorus and TSS loads. Therefore, within the prioritized areas, it is recommended that those BMPs focused on agricultural load reduction (nutrient management plans, conservation tillage, grassed waterways, conservation buffers and sediment control basins) be implemented first on agricultural cropland, especially agricultural lands located on erodible soils (Figure 4). The IDOA (2011) survey indicates 93-100% of corn and small grain fields may be tilled using conventional methods, and as such, conservation tillage is recommended for consideration for those crops.

If larger sediment control basins are desired to maximize the runoff area treated in priority watersheds, they could be placed at the mouth of Black Creek and the unnamed tributary entering on the west side of Horseshoe Lake.

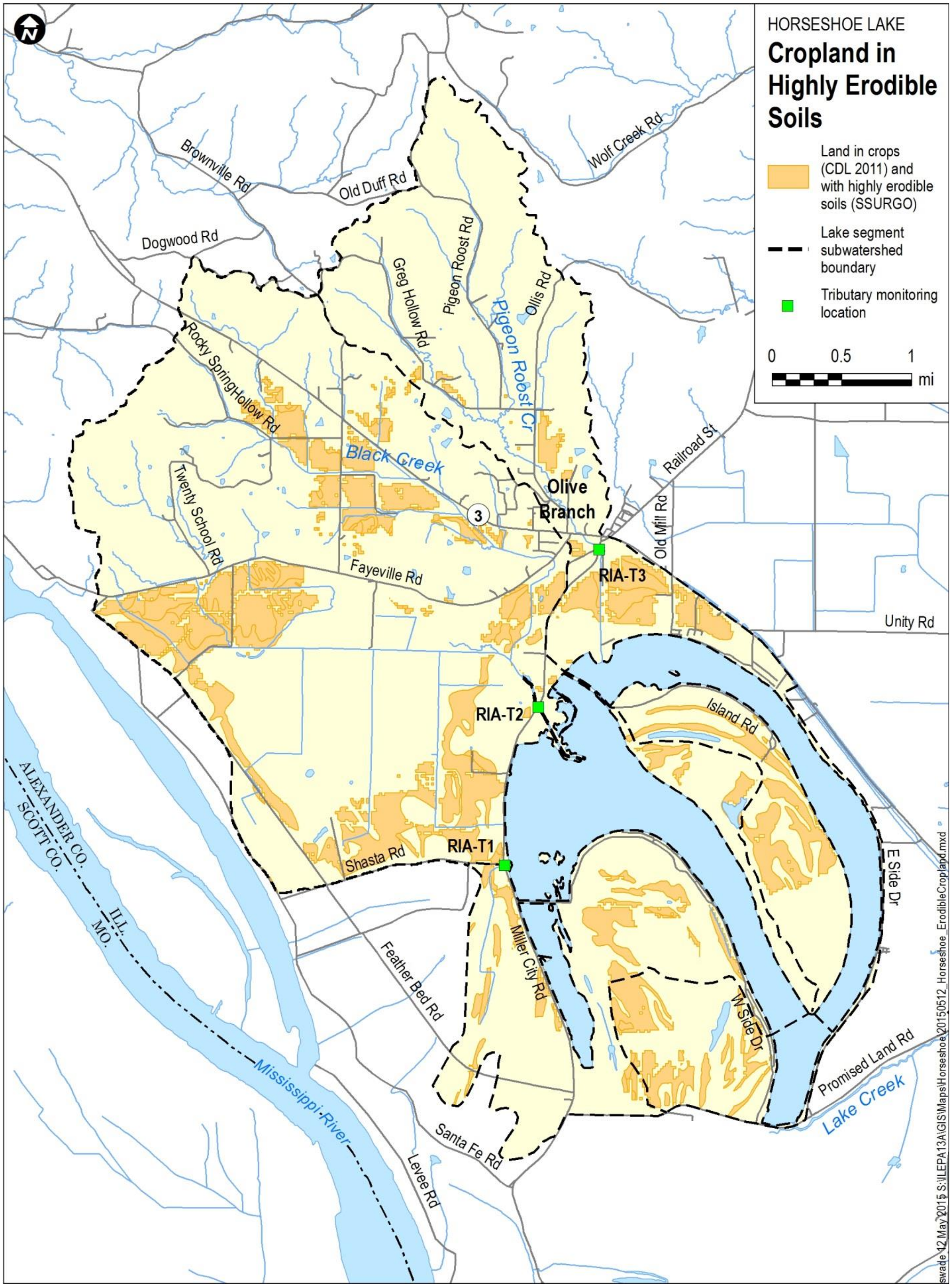

Figure 4. Cropland Areas Located on Erodible Soils

9.3 Implementation Alternatives

Based on the objectives for the TMDL, information obtained at the public meetings, ideas presented in past studies of Horseshoe Lake, and experience in other watersheds, a number of alternatives have been identified for the implementation phase of these TMDLs. These alternatives are focused on those sources suspected of contributing phosphorus and TSS loads to the lake, and are:

- Nutrient Management Plans
- Conservation Tillage
- Conservation Buffers
- Sediment Control Basins
- Grassed Waterways
- Private Sewage Disposal System Inspection and Maintenance Program
- Phosphorus Inactivation
- Streambank Stabilization

Each of these alternatives is described briefly below, including information about their costs and effectiveness in reducing phosphorus inputs. Costs have been updated from their original sources, based on literature citations, to 2014 costs using the Engineering News Record Construction Cost Index, as provided by the Natural Resource Conservation Service (NRCS) (http://www.economics.nrcs.usda.gov/cost/priceindexes/index.html).

It should be noted that there is usually a wide range in the effectiveness of the various practices; this is largely due to variations in climate, soils, crops, topography, design, construction, and maintenance of the practices (NRCS, 2006). Establishing the effectiveness of alternatives for phosphorus reduction is complicated by the different forms in which phosphorus can be transported. Some practices are effective at reducing particulate phosphorus, but may exacerbate the transport of dissolved phosphorus, the more bioavailable form (NRCS, 2006).

9.3.1 Nutrient Management Plans

Nutrient management plans are designed to minimize nutrient losses from agricultural lands, and therefore minimize the amount of phosphorus transported to the lakes. Because agriculture is the most common land use in the watershed, controls focused on reducing phosphorus loads from these areas are expected to help reduce phosphorus loads delivered to the lakes. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and ground waters (EPA, 2003). The majority of phosphorus lost from agricultural land is transported via surface runoff (vs. leaching through the soil, as occurs for nitrogen), mostly in particulate form attached to eroded soil particles. A nutrient management plan identifies the amount, source, time of application, and placement of each nutrient needed to produce each crop grown on each field each year, to optimize efficient use of all sources of nutrients (including soil reserves, commercial fertilizer, legume crops, and organic sources) and minimize the potential for losses that lead to degradation of soil and water quality (UIUC, 2005).

Steps in developing a nutrient management plan include (UIUC, 2005):

- Assess the natural nutrient sources (soil reserves and legume contributions).
- Identify fields or areas within fields that require special nutrient management precautions.
- Assess nutrient needs for each field by crop.

- Determine quantity of nutrients that will be available from organic sources, such as manure or industrial or municipal wastes.
- Allocate nutrients available from organic sources.
- Calculate the amount of commercial fertilizer needed for each field.
- Determine the ideal time and method of application.
- Select nutrient sources that will be most effective and convenient for the operation.

A U.S. Department of Agriculture study reported that average annual phosphorus application rates were reduced by 36 lbs/acre when nutrient management practices were adopted (EPA, 2003). Nutrient management is generally effective, but for phosphorus, most fertilizer is applied to the surface of the soil and is subject to transport (NRCS, 2006). In an extensively cropped watershed, the loss of even a small fraction of the fertilizer-applied phosphorus can have a significant impact on water quality.

Costs of developing nutrient management plans have been estimated at $8 to $25/acre (EPA, 2003). These costs are often offset by the savings associated with using less fertilizer. For example, a study in Iowa showed that improved nutrient management on cornfields led to a savings of about $5/acre (EPA, 2003).

It is believed that some soil testing is currently being done in the watershed, but it may need to be done more often, and testing should be performed in such a way as to differentiate the sources of the phosphorus (for example, whether the top three inches have high levels), as this will affect the mechanism of transport to the lakes, and the alternatives selected (NRCS, 2005).

9.3.2 Conservation Tillage

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (UIUC, 2005). This reduction in erosion also reduces the amount of phosphorus and TSS lost from the land and delivered to the lake. The Natural Resources Conservation Service (NRCS) has replaced the term conservation tillage with the term crop residue management, or the year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (UIUC, 2005). Conservation tillage/crop residue management systems are recognized as cost-effective means of significantly reducing soil erosion and maintaining productivity. The most recent Illinois Soil Transect Survey (IDOA, 2011) suggests that 45% of the land under soybean production in Alexander County is farmed using conventional methods, while 55% is farmed using reduced till, mulch till, or no-till. It further suggests that 93% -100% of corn and small grain fields, respectively are farmed with conventional methods. Additional conservation tillage measures might want to be considered as part of this implementation plan, particularly for cornfields and small grains.

Conservation tillage practices have been reported to reduce total phosphorus loads by 45% (EPA, 2003). In general, conservation tillage and no-till practices are moderate to highly effective at reducing particulate phosphorus, but exhibit low or even negative effectiveness in reducing dissolved phosphorus (NRCS, 2006). A wide range of costs has been reported for conservation tillage practices, ranging from $15/acre to $105/acre in capital costs (EPA, 2003). For no-till, costs per acre provided in the Illinois Agronomy Handbook for machinery and labor range from $45 to $83 per acre, depending on the farm size and planting methods used (UIUC, 2005). In general, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (UIUC, 2005).

9.3.3 Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants (NRCS, 1999), generally by slowing the rate of runoff, while filtering sediment and nutrients. Additional benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. (NRCS, 1999).

Filter strips and similar vegetative control methods can be very effective in reducing nutrient transport. The relative gross effectiveness of filter strips in reducing total phosphorus has been reported as 75% (EPA, 2003). Reduction of particulate phosphorus is moderate to high, while effectiveness for dissolved phosphorus is low to negative (NRCS, 2006).

Costs of conservation buffers vary from about $250/acre for filter strips of introduced grasses or direct seeding of riparian buffers, to approximately $450/acre for filter strips of native grasses or planting bare root riparian buffers, to more than $1,300/acre for riparian buffers using bare root stock shrubs (NRCS, 2005). These costs are highly variable. Another source reports cost as $7 per treated acre of cropland per year (Miller et al., 2012).

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Partners for Conservation Fund, provides cost sharing for conservation practices including field borders and filter strips (http://www.agr.state.il.us/C2000). The Department of Agriculture distributes funding for the cost-share program to Illinois' soil and water conservation districts (SWCDs), which prioritize and select projects. The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever (http://www.treesforever.org/Illinois_Buffer_Partnership), VIEW guides a committee of local stakeholders through a watershed landscape planning process. Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

9.3.4 Sediment Control Basins

Sediment control basins trap sediments (and nutrients bound to that sediment) before they reach surface waters (EPA, 2003). These can be placed near the mouth of the streams or on agricultural land, where they capture runoff from a smaller area. A 1992 study by Lee (1992) describes a sediment detention basin feasibility study, evaluating different alternatives. Lee found that a single detention basin located near the discharge point of Black Creek and Pigeon Roost Creek would reduce sediment loads the most, likely more than land treatment. A sediment detention basin at this location is estimated to detain 5,455 tons of sediment per year versus 3,539 tons of sediment for smaller detention basins located in upland watersheds.

Lee (1992) estimated the cost of the single detention basin at $1,140,000, which does not include operations or maintenance costs.

9.3.5 Grassed Waterways

Grassed waterways are another alternative to consider for these watersheds. A grassed waterway is a natural or constructed channel that is planted with suitable vegetation to reduce erosion (NRCS, 2000). Grassed waterways are used to convey runoff without causing erosion or flooding, to reduce gully erosion, and to improve water quality. They may be used in combination with filter strips, and are effective at reducing soil loss, with typical reductions between 60 and 80 percent (Lin et al, 1999). Grassed waterways cost approximately $2,300/acre, not including costs for tile or seeding (MCSWCD, 2006).

9.3.6 Private Sewage Disposal System Inspection and Maintenance Program

The community of Olive Branch is served by public sewer with a treatment plant located outside of the watershed. Most of the watershed outside of Olive Branch, and some of the population within Olive Branch, discharge to private septic and aeration system. Unsewered areas primarily use individual surface discharging sewage disposal systems (Stage 1 Report. It has been estimated that statewide, between 20 and 60 percent of surface discharging systems are failing or have failed (IEPA, 2004b), suggesting that such systems may be a significant source of pollutants. The Southern 7 Health Department estimated that that most septic systems in this area are up to code and that any septic systems that are not up to code will be required to hook up to the public sewer within Olive Branch. At the present time, these systems are not routinely inspected; inspections occur only when complaints are received. A more proactive program to maintain functioning systems and address nonfunctioning systems could be developed to minimize the potential for releases from private sewage disposal systems. This alternative would require the commitment of staff time for Health Department personnel; cost depends on whether the additional inspection activities could be accomplished by existing MCHD staff or would require additional personnel.

9.3.7 Phosphorus Inactivation

Phosphorus inactivation involves application of aluminum salts or calcium compounds to the lake to reduce phosphorus in the water column and slow its release from sediments (McComas, 1993). This can be an effective means of mitigating excess phosphorus in lakes and reservoirs (NALMS, 2004). Addition of aluminum sulfate (alum) is most common, but compounds such as calcium carbonate and calcium hydroxide (lime) can also be used (McComas, 1993). When alum is added to lake water, a series of chemical hydrolysis steps leads to the formation of a solid precipitate that has a high capacity to absorb phosphates. This flocculent material settles to the lake bottom, removing the phosphorus from the water column and providing a barrier that retards release of phosphorus from the sediments (NALMS, 2004). Aluminum concentrations in lake water are usually at acceptable levels for drinking water shortly after alum application (NALMS, 2004).

This alternative is best used in combination with a reduction in phosphorus inputs from watershed sources. If the external phosphorus load is being addressed, and most of the phosphorus comes from in-place sediments, a single dose treatment will likely be sufficient (Sweetwater, 2006). If watershed sources are not controlled, repeated treatments will be needed. Often, it is possible to do repeat dosing over several years, giving a partial dose every three to five years (Sweetwater, 2006). Studies have indicated that the effectiveness of alum at controlling internal phosphorus loading in stratified lakes averaged 80% over several years of observation (Welch and Cooke, 1999). Costs for phosphorus inactivation are approximately $1,300 to $1,600 per acre (Sweetwater, 2006). This translates to a cost of approximately $2,400,000 to $3,100,000 for Horseshoe Lake. These costs could be prohibitively expensive, particularly if watershed sources are not addressed. This alternative is therefore primarily recommended only in concert with watershed load reductions.

9.3.8 Streambank stabilization

There are roughly 44 miles of streams in the Horseshoe Lake watershed, based on the National Hydrology Dataset high resolution data for Illinois. IEPA has previously identified streambank erosion as a potential source of phosphorus and sediment to Horseshoe Lake. During a site visit in June 2014, streambank stabilization was observed on Pigeon Roost Creek near the lake, but other opportunities for stabilizing streambank erosion should be investigated, as loads from this source enter directly into the streams and can be significant.

9.3.9 Summary

This TMDL calculates an 88% reduction in existing TP loads is needed, after the internal phosphorus load from the lake sediments is eliminated in order to meet the TMDL target. This translates to a TP load reduction of 4,221 kg (9,306 lbs.) over the April to July period from watershed sources. Although the most recent TSS measurements indicate compliance with the TSS LRS target, controls that will reduce sediment loads are included in Table 6. The reduction of sediment loads to the lake will not only reduce associated phosphorus loads, but will also help slow the capacity loss of the lake due to sedimentation.

Table 6 summarizes the alternatives identified for the Horseshoe Lake TMDLs, providing information, where available, on cost and effectiveness. TP and TSS load reductions are estimates based on L-THIA modeling and pollutant reductions from literature; they do not explicitly account for the conservation practices discussed in Section 3.5 of the Stage 1 Report on Horseshoe Lake. These estimates indicate that, in Alexander County, around 7% of corn lands and 55% of soybeans lands are receiving some form of conservation tillage, either reduced or no-till. The table below makes some generalized estimates about the types of pollutant reductions that could be realized by wide-spread adoption of various BMPs. Except where noted, percent effectiveness and annualized cost estimates are provided by the 2012 Agricultural BMP Handbook for Minnesota (Miller et al., 2012). Cost estimates were not always provided. Phosphorus rate reduction resulting from implementation of nutrient management plans was estimated to reduce TP export by 7% and save the farmer money while doing so, this estimate was provided by the Illinois Nutrient Loss Reduction Strategy (IWRC-IISG et al., 2015).

The alternatives and this implementation plan are all voluntary, and as such each alternative should be evaluated by the local stakeholders to identify those most likely to provide the necessary load reductions, based on site-specific conditions in the watersheds, funding, and their willingness to implement each alternative.

9.3.10 Schedule

There are no point sources of TP and TSS to Horseshoe Lake. Because nonpoint source controls are voluntary, an important initial activity, following completion and approval of the TMDL, is the establishment of a watershed group. This group should be comprised of interested stakeholders representing state agencies (IDNR, NRCS, IEPA), the Horseshoe Lake Fish and Wildlife Area, residents of Olive Branch, the agricultural community and the Southern 7 Health Department. Group activities should include public education and outreach to inform watershed residents of the problems with Horseshoe Lake, and to solicit input on controls that stakeholders are willing to implement. Monitoring is another activity the watershed group should implement. Prior to monitoring, it is recommended that a laboratory be identified for sample analysis. IEPA may be able to help with that. Funding for those selected controls can then be pursued through the programs identified in Section 9.4

Implementation of control actions should begin as soon as funding or agreement by landowners is gained. Due to cost, it is recommended that agricultural controls be implemented first, based on the willingness of landowners to implement the controls. Agricultural controls should occur concurrently with septic maintenance. It is recommended that sediment control basins be implemented only after agricultural controls have been implemented, due to the cost. Phosphorus inactivation is only recommended after watershed controls have been implemented, as the cost of this alternative is very high.

Monitoring, discussed in Section 9.5, can commence immediately to help establish a baseline for assessing stream condition. If sediment control basins are implemented, then TP and TSS monitoring at the basin inlet and outlet is recommended to assess the effectiveness of the basins in trapping TP and TSS loads.

Table 6. Summary of Implementation Alternatives

Alternative	*Cost Cost/area treated*	*Total Cost*	*Maximum expected pollutant reduction assuming full implementation on applicable land uses (existing controls are not accounted for in this table)*			
			Phosphorus Reduction (%)	*Sediment Reduction (%)*	*Phosphorus Reduction (lbs)*	*Sediment Reduction (lbs)*
Nutrient Management Plans[1]	\$8 to \$25/acre	\$(25,654.91) Cost savings	7%	0%	526	-
Conservation Tillage[2]	\$15 to \$105/acre	\$ 103,444.73	61%	69%	4,586	299,271
Conservation Buffers[2]	\$250-\$450/acre	\$ 31,483.18	57%	56%	4,285	242,887
Sediment Control Basins[2]	\$1,140,000	\$ -	72%	77%	5,413	333,969
Grassed Waterways	\$2,300/acre	Need acreage of agricultural land with gully erosion to calculate cost and load reduction				
Private Sewage Disposal System Inspection & Maintenance	Variable. Cost would be low if existing staff could accomplish.					
Phosphorus Inactivation[3]	\$1,300 - \$1,600/acre	\$2,400,000 to \$3,100,000	80%			
Streambank Stabilization[5]	\$45,619 per stream mile[6]				983 pounds/ treated stream mile	1,050 pounds / treated stream mile

[1] Assumes 100% adoption on agricultural lands (4,498 acres). L-THIA estimates agricultural lands generate roughly 7,500 pounds phosphorus/yr and 434,000 pounds sediment/yr. Reduction percentages and costs provided by the Illinois Nutrient Loss Reduction Strategy, Table 3.14.

[2] Assumes 100% adoption on agricultural lands (4,498 acres). L-THIA estimates agricultural lands generate roughly 7,500 pounds phosphorus/yr and 434,000 pounds sediment/yr. Reduction percentages and costs provided by the Agricultural BMP Handbook for Minnesota, Table 46, Appendix B.

[3] Assumes entire lake is treated, and should only be used in concert with watershed reductions. Phosphorus reduction is from Welch and Cooke, 1999. Per-acre costs are from Sweetwater, 2006.

[4] There are roughly 44 miles of streams in the Horseshoe Lake watershed. Locations of eroding streambanks will need to be identified.

[5] Costs provided by the Agricultural BMP Handbook for Minnesota for rip-rap reimbursement, assuming 1' high banks on both sides of a stream. Load reductions are from The Illinois Nutrient Loss Reduction Strategy (IWRC-IISG et al., 2015)

Costs and reduction percentages can be highly variable, and site-specific results may differ from the literature cited and modeled results, as well as assumptions noted above.

9.4 Reasonable Assurance

The U.S. EPA requires states to provide reasonable assurance that the load reductions identified in the TMDL will be met. Reasonable assurance for point sources means that NPDES permits will be consistent with any applicable wasteload allocation contained in the TMDL. In terms of reasonable assurance for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. There are no point sources in the watershed.

For nonpoint sources, reasonable assurance means that nonpoint source controls are specific to the pollutant of concern, implemented according to an expeditious schedule and supported by reliable delivery mechanisms and adequate funding (U.S. EPA, 1999).

One of the most important aspects of implementing nonpoint source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Funding is available from a variety of sources, including the following:

- *Illinois Nutrient Management Planning Program*, cosponsored by the Illinois Department of Agriculture (IDOA) and IEPA (http://age-web.age.uiuc.edu/bee/Outreach/lwmc/lwm21.htm). This program targets funding to Soil and Water Conservation Districts (SWCDs) for use in impaired waters. The nutrient management plan practice cost share is only available to landowners/operators with land in TMDL watersheds. The dollar amount allocated to each eligible SWCD is based on their portion of the total number of cropland acres in eligible watersheds.
- *Clean Water Act Section 319 grants* to address nonpoint source pollution (http://www.epa.state.il.us/water/financial-assistance/non-point.html). Section 319 of the Clean Water Act provides Federal funding for states for the implementation of approved nonpoint source (NPS) management programs. Funding under these grants has been used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. Funds can be used for the implementation of watershed management plans, including the development of information/education programs, and for the installation of best management practices.
- *Partners for Conservation Fund* (http://www.agr.state.il.us/C2000) is a program designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources while providing additional high-quality opportunities for outdoor recreation. This program includes the Priority Lake and Watershed Implementation Program and the Clean Lakes Program.
- *Conservation Practices Cost-Share Program*. Another component of Partners for Conservation Fund, the Conservation Practices Program (CPP) focuses on conservation practices, such as terraces, filter strips and grass waterways that are aimed at reducing soil loss on Illinois cropland to tolerable levels. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.
- *Conservation Reserve Program* administered by the Farm Service Agency (http://www.nrcs.usda.gov/programs/crp/). The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation.

- *Agricultural Conservation Easement Program* http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/easements/acep/). NRCS's Agricultural Conservation Easement Program (ACEP) is a voluntary program offering landowners the opportunity to protect, restore, and enhance agricultural and wetlands on their property. The NRCS provides technical and financial support to help landowners with their restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection.
- *Environmental Quality Incentive Program* sponsored by NRCS (general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/il/programs/financial/eqip/). The Environmental Quality Incentives Program (EQIP) provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. EQIP also includes the Wildlife Habitat Incentive Program (WHIP) which provides both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat.
- In 2015, Trees Forever is placing a special emphasis on working with no-till farmers interested in establishing Science-based Trials of Rowcrops Integrated with Prairies (STRIPS), which is a promising practice to reduce soil erosion. Additional information is available at www.prairiestrips.org which suggests 90% sediment reductions are possible with implementation of STRIPS.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability
- Use the results of future monitoring to conduct adaptive management.

9.5 Monitoring and Adaptive Management

Future monitoring is needed to assess the effectiveness of the various restoration alternatives and conduct adaptive management. Illinois EPA conducts a variety of lake and stream monitoring programs (IEPA, 2002). Ongoing stream monitoring programs include: a statewide 213-station Ambient Water Quality Monitoring Network; an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream Survey Program that conducts approximately 20-30 stream surveys each year. The ongoing Illinois EPA Lake Monitoring Program includes: an Ambient Lake Monitoring Program that samples approximately 50 lakes annually; an Illinois Clean Lakes Program that typically monitors three to five projects each year; and a Volunteer Lake Monitoring Program that encompasses over 170 lakes each year. Horseshoe Lake is monitored by IEPA. Beyond this IEPA monitoring, local agencies and watershed organizations are encouraged to conduct additional monitoring to assess sources of pollutants and evaluate changes in water quality in the lakes.

It is recommended that IEPA monitoring of Horseshoe Lake continue, and that tributary monitoring at stations RIA-T1, RIA-T2 and RIA-T3 be conducted on a monthly basis between April and October, during a mix of dry and wet weather conditions to assess progress as controls are implemented. It is recommended that tributary sampling occur at the same time as IEPA in-lake monitoring, which will facilitate any future updates to the BATHTUB modeling, if desired. If resources allow, TP and TSS should also be collected at the point where other tributaries enter Horseshoe Lake, to assess their impact on the lake water quality. Recommendations are summarized in Table 7.

Table 7. Recommended TP and TSS monitoring

Location	Schedule	Frequency
Unnamed tributary at station RIA-T1	April through October	1/month during dry and wet weather conditions to establish baseline and assess water quality improvements
Black Creek at station RIA-T2	April through October	1/month during dry and wet weather conditions to establish baseline and assess water quality improvements
Pigeon Roost Creek at station RIA-T3	April through October	Monitoring to ensure loads in this watershed remain small compared to the other two tributary watersheds
Other tributaries to the Lake	April through October	Recommend analyzing TP and TSS from one sample collected during wet weather, and then continuing sampling, only if the concentrations are comparable to those measured at RIA-T1 and RIA-T2.
Sediment control basin inlet	Wet weather events	If sediment control basins are implemented, this monitoring will help assess the effectiveness of this control
Sediment control basin outlet	Wet weather events	

Note: Tributary station locations are shown in Figure 4.

The recommended and ongoing monitoring efforts will provide the basis for assessing the effectiveness of the control alternatives and will inform any future adaptive management decisions. This monitoring will also help identify which alternatives should be expanded, and which require adjustments to meet the TMDL goals.

10

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Attachment 1:
BATHTUB model inputs and results

Horseshoe Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **4** **Area-Wtd Mean**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	47.7	0.45	49.8%	361.7		98.8%
CHL-A MG/M3				162.5		100.0%
SECCHI M				0.2		1.6%
TP-ORTHO-P MG/M3				298.6		99.2%
ANTILOG PC-1				15570.8		99.9%
ANTILOG PC-2				12.6		89.8%
ZMIX / SECCHI				3.5		29.4%
CHL-A * SECCHI				35.2		96.0%
CHL-A / TOTAL P				0.4		90.2%
FREQ(CHL-a>10) %				100.0		100.0%
FREQ(CHL-a>20) %				99.8		100.0%
FREQ(CHL-a>30) %				98.7		100.0%
FREQ(CHL-a>40) %				96.2		100.0%
FREQ(CHL-a>50) %				92.4		100.0%
FREQ(CHL-a>60) %				87.6		100.0%
CARLSON TSI-P	59.8	0.11	49.8%	88.8		98.8%
CARLSON TSI-CHLA				80.2		100.0%
CARLSON TSI-SEC				82.3		98.4%

Horseshoe Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 1 Dam

Variable	Predicted Values---> **Mean**	**CV**	**Rank**	Observed Values---> **Mean**	**CV**	**Rank**
TOTAL P MG/M3	50.5	0.45	52.3%	451.0		99.4%
CHL-A MG/M3				153.0		100.0%
SECCHI M				0.2		2.1%
TP-ORTHO-P MG/M3				400.0		99.7%
ANTILOG PC-1				13953.5		99.9%
ANTILOG PC-2				12.7		90.3%
ZMIX / SECCHI				5.1		54.1%
CHL-A * SECCHI				35.0		95.9%
CHL-A / TOTAL P				0.3		80.6%
FREQ(CHL-a>10) %				100.0		100.0%
FREQ(CHL-a>20) %				99.9		100.0%
FREQ(CHL-a>30) %				99.0		100.0%
FREQ(CHL-a>40) %				96.8		100.0%
FREQ(CHL-a>50) %				93.2		100.0%
FREQ(CHL-a>60) %				88.5		100.0%
CARLSON TSI-P	60.7	0.11	52.3%	92.3		99.4%
CARLSON TSI-CHLA				79.9		100.0%
CARLSON TSI-SEC				81.3		97.9%

Horseshoe Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 2 East

	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	39.9	0.47	41.9%	448.0		99.4%
CHL-A MG/M3				222.0		100.0%
SECCHI M				0.2		2.1%
TP-ORTHO-P MG/M3				354.0		99.5%
ANTILOG PC-1				19865.5		100.0%
ANTILOG PC-2				16.3		96.2%
ZMIX / SECCHI				2.9		20.1%
CHL-A * SECCHI				50.7		98.8%
CHL-A / TOTAL P				0.5		92.8%
FREQ(CHL-a>10) %				100.0		100.0%
FREQ(CHL-a>20) %				100.0		100.0%
FREQ(CHL-a>30) %				99.8		100.0%
FREQ(CHL-a>40) %				99.3		100.0%
FREQ(CHL-a>50) %				98.2		100.0%
FREQ(CHL-a>60) %				96.4		100.0%
CARLSON TSI-P	57.3	0.12	41.9%	92.2		99.4%
CARLSON TSI-CHLA				83.6		100.0%
CARLSON TSI-SEC				81.3		97.9%

Horseshoe Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 3 West

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	51.7	0.45	53.4%	302.0		98.0%
CHL-A MG/M3				130.0		100.0%
SECCHI M				0.2		1.4%
TP-ORTHO-P MG/M3				255.0		98.8%
ANTILOG PC-1				13341.9		99.9%
ANTILOG PC-2				10.4		82.0%
ZMIX / SECCHI				3.6		31.3%
CHL-A * SECCHI				26.4		91.1%
CHL-A / TOTAL P				0.4		89.2%
FREQ(CHL-a>10) %				100.0		100.0%
FREQ(CHL-a>20) %				99.7		100.0%
FREQ(CHL-a>30) %				98.0		100.0%
FREQ(CHL-a>40) %				94.4		100.0%
FREQ(CHL-a>50) %				89.1		100.0%
FREQ(CHL-a>60) %				82.6		100.0%
CARLSON TSI-P	61.1	0.11	53.4%	86.5		98.0%
CARLSON TSI-CHLA				78.4		100.0%
CARLSON TSI-SEC				83.0		98.6%

Horseshoe Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component: **TOTAL P** **Segment:** **1** **Dam**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
4	1	Lake Seg 1 DD	1.5	5.5%	92.8	6.9%	64
PRECIPITATION			1.0	3.7%	16.9	1.3%	17
TRIBUTARY INFLOW			1.5	5.5%	92.8	6.9%	64
ADVECTIVE INFLOW			24.2	90.8%	1203.8	89.1%	50
NET DIFFUSIVE INFLOW			0.0	0.0%	37.2	2.8%	
***TOTAL INFLOW			26.6	100.0%	1350.7	100.0%	51
ADVECTIVE OUTFLOW			25.6	96.4%	1294.6	95.8%	50
***TOTAL OUTFLOW			25.6	96.4%	1294.6	95.8%	50
***EVAPORATION			1.0	3.6%	0.0	0.0%	
***RETENTION			0.0	0.0%	56.1	4.2%	

Hyd. Residence Time = 0.0255 yrs
Overflow Rate = 45.5 m/yr
Mean Depth = 1.2 m

Horseshoe Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 2 East**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
3	1	Pigeon Roost	3.8	45.3%	34.6	13.8%	9
PRECIPITATION			4.6	54.7%	78.3	31.3%	17
TRIBUTARY INFLOW			3.8	45.3%	34.6	13.8%	9
NET DIFFUSIVE INFLOW			0.0	0.0%	137.0	54.8%	
***TOTAL INFLOW			8.4	100.0%	249.8	100.0%	30
ADVECTIVE OUTFLOW			3.9	46.8%	156.1	62.5%	40
***TOTAL OUTFLOW			3.9	46.8%	156.1	62.5%	40
***EVAPORATION			4.4	53.2%	0.0	0.0%	
***RETENTION			0.0	0.0%	93.7	37.5%	

Hyd. Residence Time =	0.4466	yrs
Overflow Rate =	1.5	m/yr
Mean Depth =	0.7	m

Horseshoe Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 3 West**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	T1 - Unnamed	3.8	13.5%	242.6	15.9%	64
2	1	Black	16.2	57.7%	1144.9	75.0%	71
PRECIPITATION			8.1	28.8%	138.6	9.1%	17
TRIBUTARY INFLOW			20.0	71.2%	1387.6	90.9%	69
***TOTAL INFLOW			28.1	100.0%	1526.2	100.0%	54
ADVECTIVE OUTFLOW			20.3	72.0%	1047.7	68.6%	52
NET DIFFUSIVE OUTFLOW			0.0	0.0%	174.2	11.4%	
***TOTAL OUTFLOW			20.3	72.0%	1221.8	80.1%	60
***EVAPORATION			7.9	28.0%	0.0	0.0%	
***RETENTION			0.0	0.0%	304.3	19.9%	

Hyd. Residence Time = 0.1665 yrs
Overflow Rate = 4.4 m/yr
Mean Depth = 0.7 m

Horseshoe Lake

Overall Water & Nutrient Balances

Overall Water Balance

Averaging Period = 0.33 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	3	T1 - Unnamed	6.6	3.8	0.00E+00	0.00	0.58
2	1	3	Black	28.2	16.2	0.00E+00	0.00	0.58
3	1	2	Pigeon Roost		3.8	0.00E+00	0.00	
4	1	1	Lake Seg 1 DD	2.5	1.5	0.00E+00	0.00	0.58
PRECIPITATION				7.8	13.7	0.00E+00	0.00	1.75
TRIBUTARY INFLOW				37.3	25.3	0.00E+00	0.00	0.68
***TOTAL INFLOW				45.1	38.9	0.00E+00	0.00	0.86
ADVECTIVE OUTFLOW				45.1	25.6	0.00E+00	0.00	0.57
***TOTAL OUTFLOW				45.1	25.6	0.00E+00	0.00	0.57
***EVAPORATION					13.3	0.00E+00	0.00	

Horseshoe Lake

Overall Mass Balance Based Upon **Predicted** **Outflow & Reservoir Concentrations**
Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	3	T1 - Unnamed	242.6	13.9%	0.00E+00		0.00	64.0	36.9
2	1	3	Black	1144.9	65.5%	0.00E+00		0.00	70.5	40.6
3	1	2	Pigeon Roost	34.6	2.0%	0.00E+00		0.00	9.1	
4	1	1	Lake Seg 1 DD	92.8	5.3%	0.00E+00		0.00	64.0	36.8
PRECIPITATION				233.8	13.4%	1.37E+04	100.0%	0.50	17.1	30.0
TRIBUTARY INFLOW				1514.9	86.6%	0.00E+00		0.00	60.0	40.6
***TOTAL INFLOW				1748.8	100.0%	1.37E+04	100.0%	0.07	44.9	38.8
ADVECTIVE OUTFLOW				1294.6	74.0%	3.44E+05		0.45	50.5	28.7
***TOTAL OUTFLOW				1294.6	74.0%	3.44E+05		0.45	50.5	28.7
***RETENTION				454.2	26.0%	3.42E+05		1.29		

Overflow Rate (m/yr)	3.3	Nutrient Resid. Time (yrs)	0.1574
Hydraulic Resid. Time (yrs)	0.2252	Turnover Ratio	2.1
Reservoir Conc (mg/m3)	48	Retention Coef.	0.260

Horseshoe Lake

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Dispersion--------> Velocity km/yr	Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Dam	0	25.6	0.0255	45.5	47.9	905.1	29.2	0.0
2	East	1	3.9	0.4466	1.5	14.1	338.4	44.6	12.9
3	West	1	20.3	0.1665	4.4	43.4	2312.4	156.5	139.5

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Dam	0.6	1.2	1.2	1.2	0.7	0.5	2.6
2	East	2.6	0.7	0.7	6.3	1.7	0.4	15.3
3	West	4.6	0.7	0.7	7.2	3.4	0.6	11.3
Totals		7.8	0.7			5.8		

Horseshoe Lake

Segment & Tributary Network

--------Segment: 1 Dam
Outflow Segment: 0 Out of Reservoir
Tributary: 4 Lake Seg 1 DD Type: Monitored Inflow

--------Segment: 2 East
Outflow Segment: 1 Dam
Tributary: 3 Pigeon Roost Type: Monitored Inflow

--------Segment: 3 West
Outflow Segment: 1 Dam
Tributary: 1 T1 - Unnamed Type: Monitored Inflow
Tributary: 2 Black Type: Monitored Inflow

Horseshoe Lake

Description:

Global Variables	Mean	CV
Averaging Period (yrs)	0.3333	0.0
Precipitation (m)	0.584	0.0
Evaporation (m)	0.568	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

							Internal Loads (mg/m2-day)											
		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Dam	0	1	0.564	1.158	1.22	1.158	0	0	0	0	0	0	0	0	0	0	0
2	East	1	1	2.61	0.67	6.31	0.67	0	0	0	0	0	0	0	0	0	0	0
3	West	1	1	4.62	0.73	7.22	0.73	0	0	0	0	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	451	0	0	0	153	0	0.2286	0	0	0	400	0	0	0	0	0
2	0	0	448	0	0	0	222	0	0.2286	0	0	0	354	0	0	0	0	0
3	0	0	302	0	0	0	130	0	0.2032	0	0	0	255	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Horseshoe Lake
Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	**Trib Name**	**Segment**	**Type**	**km^2**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	T1 - Unnamed	3	1	6.57	3.79	0	0	0	64.02	0	0	0	0.051	0	0	0
2	Black	3	1	28.2	16.24	0	0	0	70.5	0	0	0	0.094	0	0	0
3	Pigeon Roost	2	1	0	3.79	0	0	0	9.12	0	0	0	0.048	0	0	0
4	Lake Seg 1 DD	1	1	2.52	1.45	0	0	0	64.02	0	0	0	0.051	0	0	0

Model Coefficients	**Mean**	**CV**
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Attachment 2:
Responsiveness Summary

This responsiveness summary responds to substantive questions and comments on the final Horseshoe Lake Watershed (Alexander County) Total Maximum Daily Load (TMDL) and Load Reduction Strategy (LRS) Report received during the public comment period through December 22, 2015 (determined by postmark). The summary includes questions and comments from the November 19, 2015 public meeting as discussed below.

What is a TMDL?

A Total Maximum Daily Load (TMDL) is the sum of the allowable amount of a pollutant that a water body can receive from all contributing sources and still meet water quality standards or designated uses. Each contributing source of the pollutant will be assigned an amount of pollutant which it cannot exceed if the TMDL is to be met. This amount is called an "allocation." A TMDL is developed for each waterbody segment that is impaired by pollutants that have numeric water quality standards.

What is a Load Reduction Strategy (LRS)?

Load Reduction Strategy is a methodology developed by the Agency to address impairments for those pollutants that are listed on the Illinois Integrated Water Quality Report-303(d) list that do not have numeric water quality standards. LRSs are not a substitute for TMDL development but are used as planning tools until a TMDL is developed. As with a TMDL, this involves determining the loading capacity and load reduction necessary in order for the water body to meet "Full Use Support" for its designated uses. The endpoints used will vary among watersheds and are also dependent on available data, and stakeholders input for the parameters that a LRS is being developed.

Background

The Horseshoe Lake watershed is located in Alexander County in southwestern Illinois. Horseshoe Lake is a 1,890 acre lake created from a natural oxbow of the Mississippi River. The lake supports a flooded forest of bald cyprus and water tupelo and is situated within the 10,200-acre Horseshoe Lake State Fish and Wildlife Area.

The causes of the impairment (Aesthetic Quality) in the Horseshoe Lake watershed are total phosphorus and total suspended solids. The sources of impairment have been identified to be waterfowl, runoff from cropland or forest/grassland/parkland, stream bank erosion, erosion of highly erodible soils, failing septic systems, and resuspension of bottom sediments. The Clean Water Act and USEPA regulations require that states develop TMDLs for waters that do not meet water quality standards and have been placed on the Section 303(d) List. TMDL load allocations and reductions for total phosphorus along with the LRS for total suspended solids are presented in the report.

Public Meeting

A public meeting was held at Alexander/Pulaski NRCS Service Center in Tamms, IL at 2:30 pm on November 19, 2015. The purpose of the meeting was to provide the public with an opportunity to comment on the final draft TMDL report and to provide additional data that may be included in the TMDL development process. The Illinois EPA ("Agency") announced the public notice by placing a display ad in the local newspaper in the watershed (The Cairo Citizen Journal).

The public notice gave the date, time, location, and purpose of the meeting. It also provided references to obtain additional information about this specific watershed, the TMDL Program, and other related issues. The public notice was also mailed to citizens and organizations in the watershed by first class mail. The draft TMDL report was available for review at the Alexander/Pulaski NRCS Service Center in Tamms, IL and on the Agency's website at http://www.epa.illinois.gov/public-notices/index. Seven people attended in the public meeting.

Questions/Comments

1. **Who makes up Illinois' Pollution Control Board?**

   Response: The Illinois Pollution Control Board (Board) is an independent agency created in 1970 by Environmental Protection Act. Under the Act, the Board is responsible for adopting Illinois' environmental regulations and deciding contested environmental regulations. There are five Board members who are appointed by the Governor. For more information please refer to the Illinois Pollution Control Board's website: http://www.ipcb.state.il.us/.

2. **Illinois EPA may not have taken into consideration in the draft TMDL report septic system runoff due to faulty records.**

   Response: As described in Section 6.1.3.d of the Stage 3 report, phosphorus loads to the lake were calculated based on estimated flows and measured phosphorus concentrations collected by the Agency at the mouth of three tributaries. Septic contributions upstream of the tributary sampling locations are therefore reflected in the measured phosphorus concentrations.

3. Were septic systems evaluated as being possible point sources?

Response: Septic systems were evaluated as a nonpoint source, because by definition they are not considered to be a point source. Nonpoint source loads to Horseshoe Lake were calculated based on tributary concentrations that integrate all upstream sources (the tributaries were monitored near their mouth). As such, septic systems were included in the watershed nonpoint source load to the lake and were evaluated as part of the modeling.

4. Were the past two years that were filled with excessive rainfall compared with previous year's samples?

Response: No comparisons were made using the last two years of data for the tributaries. Tributary data were only available for 2013, so it was not possible to compare these data with previous data.

Lake stations were sampled in 2000, 2001, 2003 and 2009. Preliminary lake data were also available for 2013 (1 station) and 2014 (3 stations). The most recent final data available (2009) were used for this study. A comparison of 2009 to 2014 total phosphorus concentrations for the same 2-month period (selected for comparability) shows a slightly higher lake-wide average phosphorus concentration in 2014 compared to 2009.

5. Was excessive rain taken into consideration for runoff?

Response: Runoff quantity for BATHUB was based on observed flows at the USGS gaging station at Massac Creek near Paducah, Kentucky, adjusted through the use of drainage area ratios for each tributary. Total phosphorus concentrations were based upon 2013 springtime measurements taken near the mouth of each tributary. These inputs reflect 2013 rainfall conditions.

6. Did the draft TMDL study factor-in filling of the lake due to the river flooding from both the Ohio and Mississippi Rivers (the rivers backed into the lake in 1993, 1995, 2002, 2011 and 2014).

Response: The model simulated the most recent period for which there were final data (2009). Phosphorus loads from past flooding of the lake are expected to be reflected in the internal phosphorus load described in Section 6.1.4 of the Stage 3 report.

7. In the past 20 years, over 100,000 geese yearly have been wintering on the lake. Was this factored in the study?

Response: The model identified a significant internal phosphorus load from the bottom lake sediments. The historical contribution from geese is therefore included with the sediment phosphorus flux (phosphorus coming out of the lake sediment and into the water column).

8. **Has the Agency considered in the study, the 1993 levee break, which may have led to pollution of the land surrounding the lake?**

   Response: Any phosphorus deposited on the land historically, which is being transported to the lake, would be accounted for by the 2013 spring tributary monitoring. The spring 2013 tributary phosphorus data were used to calculate phosphorus loads to the lake.

9. **Will there be further samples obtained?**

   Response: There will be no additional monitoring required for this TMDL report. However, monitoring of Horseshoe Lake will continue as part of the Agency's Ambient Lake Monitoring Program (ALMP) to track the effectiveness of the implementation plans and best management practices (BMPs) discussed in Section 9.5 (Monitoring and Adaptive Management) of the TMDL report.

10. **Is the Total Maximum Daily Load/ Load Reduction Strategy program completely voluntary?**

    Response: The wasteload allocation applies to point sources (wastewater treatment plants) and is addressed through the NPDES permitting program, while the load allocation for nonpoint sources is a voluntary measure. The Agency is committed to work with local experts familiar with nonpoint sources of pollution in the watershed to develop best management practices on a watershed based approach as discussed in the report. The involvement of land owners, local agencies, and other institutions with an interest in watershed management will be important for successful implementation of this TMDL.

11. **If the watershed comes up with a planning group is there a potential source of funding for reduction implementation strategies?**

    Response: The Agency administers the 319 cost share funding program for watershed based improvement plans. Grants are available to local units of government and other organizations to protect water quality in Illinois. Projects must address water quality issues relating directly to nonpoint source pollution. Funds can be used for the implementation of watershed based plans, including the development of information/ education programs and for the installation of best management practices (BMPs).

NRCS and SWCD have Farm Bill funds and other grant possibilities for watershed projects planned for addressing water quality issues in Illinois.

12. **How many times were samples taken, and where were the samples collected? Can we obtain sample locations, values, and times?**

Response: Monitoring for Horseshoe Lake was conducted in 2000, 2003, and 2009. The Stage 1 report contains all historic final monitoring data and the results are presented in Appendix C. Three lake stations were monitored each year once a month between April and October. Figure 5 in the Stage 1 report shows the monitoring locations (RIA-1, RIA-2, and RIA-3).

The tributaries to Horseshoe Lake were sampled in April, May and June of 2013, the monitoring locations are shown in Figure 8, while the monitoring data are presented in Table 14 of the Stage 1 report. In addition, a new location, RIA-4 was monitored in 2013 to include tributary flows to the lake.

13. **Seeing as there is not a whole lot of concern within and around the community, how do we prepare a watershed group?**

Response: Please refer to the link for the Guidance for Developing Watershed Action Plans in Illinois - May 2007 (CMAP/Illinois EPA): http://www.epa.state.il.us/water/watershed/publications/watershed-guidance.pdf.

14. **With little manpower at USDA NRCS (Natural Resources Conservation Service) and the Pulaski-Alexander Soil & Water Conservation District, how can the necessary 319 information be acquired and a watershed plan put together?**

Response: We recommend looking into other local resources, or potentially hiring a consultant that may be able to help develop the watershed based plan. Refer to link above again for additional guidance.

15. **Is the 319 grant program the only option for funding or is there a 50/50 cost share plan through the RCPP (Regional Conservation Partnership Program)?**

Response: Please visit the local county NRCS office to find information for the programs that qualify for funding.

16. In other watersheds that have tried implementing reduction strategies have you seen massive improvements and/or goals achieved?

Response: The Agency issued the Nutrient Load Reduction Strategy on July 2015, and workgroups are making progress in developing strategies to address nutrient impairments in Illinois waters.

17. The draft report notes that one of the sampling locations as "unnamed tributary near Shasta Road" drains to the lake. The majority of the water does not actually drain to Horseshoe Lake, but instead flows north into Black Creek.

Response: The map below shows that the unnamed tributary near Shasta Road where one of the samples was collected and drains to Horseshoe Lake. Please also refer to comment # 12.

Image from Bing Maps.