Addendum to the
Water Quality Improvement Plan
for

Hickory Grove Lake

Story County, Iowa

Total Maximum Daily Load for:
Algae
Addendum to include Turbidity

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GENERAL REPORT SUMMARY

What is the purpose of this report?
This report serves as an addendum to the Hickory Grove Lake Water Quality Improvement Plan (WQIP), dated May 2021, which was previously prepared by the Iowa Department of Natural Resources (Iowa DNR), submitted and subsequently approved by the EPA. The WQIP addressed the Total Maximum Daily Load (TMDL) for Algae. Subsequent to the Hickory Grove Lake WQIP approval, the lake was placed on the 2022 303(d) list for a non-algal turbidity impairment. This addendum addresses the non-algal turbidity impairment. For a full discussion, please see the 2021 Hickory Grove Lake WQIP entitled "*Water Quality Improvement Plan for Hickory Grove Lake, Story County, Iowa, Total Maximum Daily load for: Algae*" dated May 2021 and approved by the EPA on May 19, 2021.

What is wrong with Hickory Grove Lake?
Hickory Grove Lake is listed as impaired on the 2024 303(d) list for not supporting its primary contact recreation designated use. The impairment is due to elevated levels of non-algal turbidity, which is caused by fine sediment particles and other materials suspended in the water column.

What is causing the problem?
The amount of sediment and phosphorus transported to the lake from the surrounding watershed is sufficient to cause excessive growth of algae and excessive levels of turbidity, which reduces water clarity. Phosphorus is carried to the lake in two primary forms: (1) attached to eroded soil that is transported to the lake by rainfall runoff and stream flow, and (2) dissolved phosphorus in runoff and subsurface flow (e.g., shallow groundwater). Phosphorus and sediment within the water column and on the lake bed may become resuspended under certain conditions, which can add to algae and turbidity issues. There are no allowable discharging point sources in the Hickory Grove Lake watershed; therefore, all phosphorus loads to the lake are attributed to nonpoint sources.

Nonpoint sources are discharged in an indirect and diffuse manner, and often are difficult to locate and quantify. Nonpoint sources of phosphorus in the Hickory Grove Lake watershed include gully erosion, sheet and rill erosion from various land uses, runoff and subsurface flows from lands that receive fertilizer application, grazed pasture land, poorly functioning septic systems, manure deposited by wildlife, and particles carried by dust and wind (i.e., atmospheric deposition). A portion of the phosphorus carried to the lake eventually settles to the lake bottom and accumulates. Under certain conditions, this accumulated phosphorus can become available for algal uptake and growth through an internal recycling process.

What can be done to improve Hickory Grove Lake?
Reducing phosphorus loss from pasture and row crops and implementing or improving existing structural BMPs such as terraces, grassed waterways, and constructed sediment basins in beneficial locations will significantly reduce phosphorus loads to the lake. Increasing the trapping efficiency of the existing sediment basins may be the most cost-effective structural alternative. Attention should be given to row crops on steep slopes, where the adoption of cover crops or perennial strips may be especially beneficial. Restoring watershed hydrology to mitigate streambank and gully erosion is challenging to implement, but an effective strategy for reducing sediment and phosphorus transport.

In 2012, Story County developed a Watershed Management Action Plan (WMAP) to address an *E. coli* impairment. The WMAP took a proactive approach to protecting water quality, because at the time of development, Hickory Grove Lake was not impaired for algae or turbidity. Many of the BMPs in the WMAP addressed nutrient reduction. Sections 2 & 4 of the 2021 WQIP provide a brief discussion of the BMPs that have been proposed or have been implemented.

DESCRIPTION OF HICKORY GROVE LAKE

Hickory Grove Lake (ID Code: IA 03-SSK-950) is located in Story County, approximately 2.5 miles southwest of the City of Colo. The lake is located within the 445-acre Hickory Grove Park owned and managed by the Story County Conservation Board. The lake and park area provide fishing, hiking, swimming, and other outdoor recreation activities for the public. Figure 1 is a vicinity map of the Hickory Grove Lake watershed.

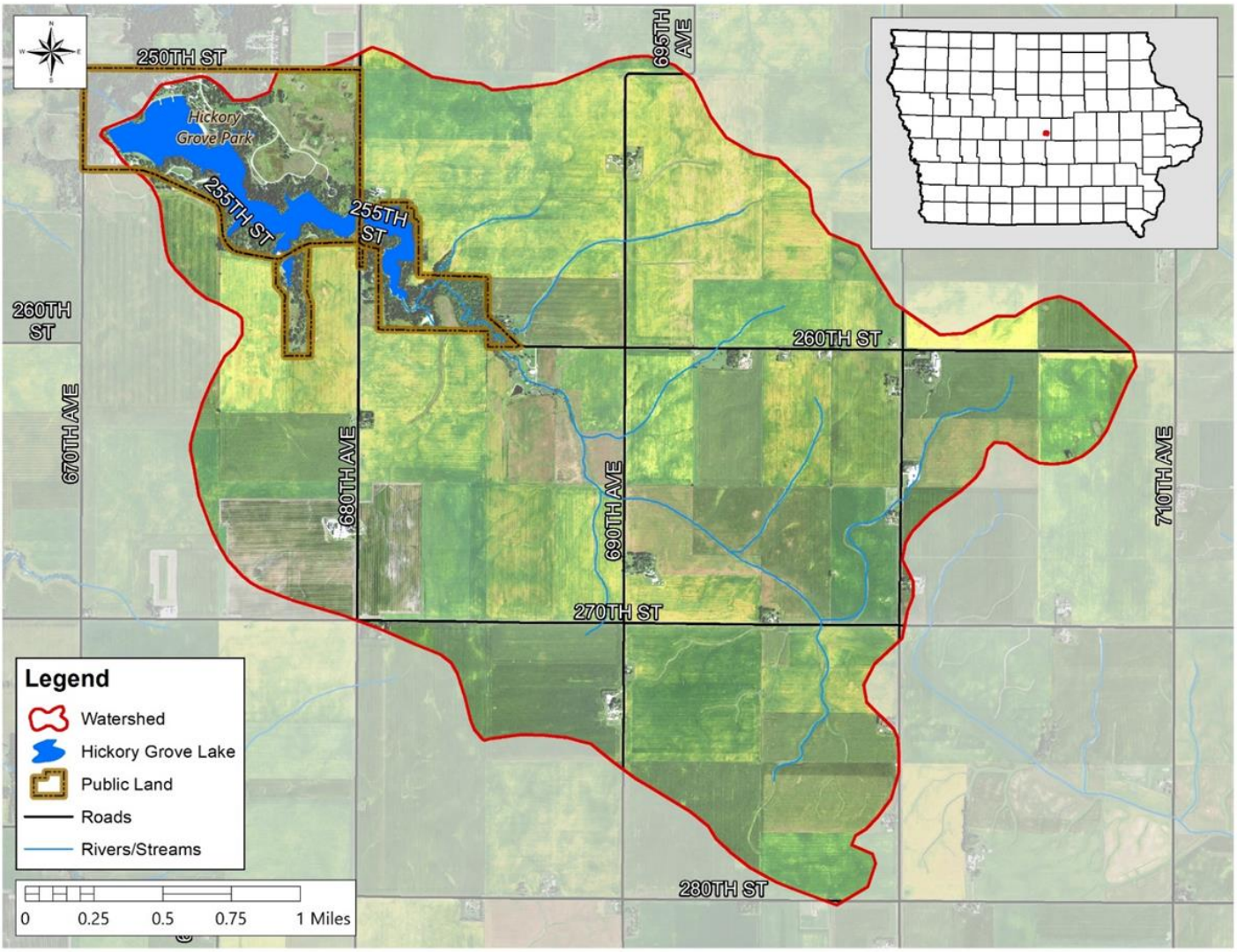

Figure 1. Hickory Grove Watershed Vicinity Map

TOTAL MAXIMUM DAILY LOAD (TMDL) FOR TURBIDITY

A Total Maximum Daily Load (TMDL) is required for Hickory Grove Lake by the Federal Clean Water Act. The WQIP for Hickory Grove Lake quantified the maximum amount of total phosphorus (TP) the lake can assimilate and still support primary contact recreation. The TMDL for algae will also address the turbidity impairment, since both are attributed to excess nutrients, particularly phosphorus. As a result, the addendum will not revisit the allowable TP load to the lake but will refer to the 2021 WQIP for allowable phosphorus loads.

For convenience, a summary of the TMDL targets presented in the 2021 Hickory Grove Lake WQIP will be provided here. For a full discussion, please see the 2021 Hickory Grove Lake WQIP entitled "*Water Quality Improvement Plan for Hickory Grove Lake, Story County, Iowa, Total Maximum Daily load for: Algae*" dated May 2021 and approved by the EPA on May 19, 2021. It should be noted that the terms turbidity, Secchi depth, and transparency are all used interchangeably to refer to the impairment of Secchi Disk Transparency.

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

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

The 2024 Section 305(b) Water Quality Assessment Report states that the primary contact recreation designated use for Hickory Grove Lake is assessed as "not supported" due to "Narrative criteria violation: aesthetically objectionable conditions". The 2024 assessment can be accessed at https://programs.iowadnr.gov/adbnet/Segments/950/Assessment/2024.

Applicable Water Quality Standards
The State of Iowa Water Quality Standards (WQS) are published in the Iowa Administrative Code (IAC), Environmental Protection Rule 567, Chapter 61. Although the State of Iowa does not have numeric criteria for sediment, nutrients, or algae (chl-a), general (narrative) water quality criteria below do apply:

61.3(2) General water quality criteria. The following criteria are applicable to all surface waters including general use and designated use waters, at all places and at all times for the uses described in 61.3(1)"a."

a. Such waters shall be free from substances attributable to point source wastewater discharges that will settle to form sludge deposits.
b. Such waters shall be free from floating debris, oil, grease, scum and other floating materials attributable to wastewater discharges or agricultural practices in amounts sufficient to create a nuisance.
c. Such waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor or other aesthetically objectionable conditions.
d. Such waters shall be free from substances attributable to wastewater discharges or agricultural practices in concentrations or combinations which are acutely toxic to human, animal, or plant life.
e. Such waters shall be free from substances attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance aquatic life.

For 303(d) listing purposes, aesthetically objectionable conditions are present in a waterbody when Carlson's Trophic State Index (TSI) for the median growing season chl-a or Secchi depth exceeds 65. In order to de-list the turbidity impairment, the median growing season for chl-a TSI and Secchi depth TSI must not exceed 63 for one 303(d) listing cycle, per DNR's 2024 de-listing methodology.

Problem Statement
Hickory Grove Lake is impaired because primary contact recreation is not fully supported due to violations of WQS. High levels of non-algal turbidity cause the impairment. This turbidity is the result of sediment loads from the watershed. Because sediment is laden with phosphorus, which contributes to algal blooms when non-algal turbidity is low, reductions in phosphorus loads will reduce turbidity and also prevent future algal blooms.

Interpreting Hickory Grove Lake Data
The 2024 305(b) assessment was based on results of the ambient monitoring program conducted from 2018-2022 by Iowa State University (ISU). All data was collected at the ambient monitoring location (STORET ID 22850001). It should be noted that samples were not collected during the sampling season from 2019 - 2021 due to the lake being drained for a lake restoration project. However, because not all impairments identified for the current assessment/listing cycle (Turbidity) are addressed in the 2021 WQIP, the waterbody remains in Category 5a (impaired; TMDL required) for the 2024 assessment/listing cycle.

Carlson's Trophic State Index (TSI) was used to evaluate the relationships between TP, algae (chl-a), and transparency (Secchi depth) in Hickory Grove Lake. TSI values are not a water quality index but an index of the trophic state of the water body. However, the TSI values for Secchi depth and chl-a can be used as a guide to establish water quality improvement targets.

If the TSI values for the three parameters are the same, the relationships between the TP, algae, and transparency are strong. If the TP TSI value is higher than the chl-a TSI, it suggests there are limitations to algal growth besides phosphorus. If the Secchi depth TSI value is higher than the chl-a TSI, it suggests that non-algal factors dominate water clarity. Figure 2 is a plot of the five-year running median TSI values, the 65 TSI threshold value (red line), and the TSI de-listing value of 63 (blue line). TSI values that exceed the 303(d)-listing threshold of 65 (for chl-a and Secchi depth) are contained within the red box. Table 1 lists the Hickory Grove Lake average and median TSI values for the 2022 and 2024 305(b) assessment periods. Review of this information indicates a downward trend in TSI Secchi depth and that from year to year water clarity flips between non-algal and algal turbidity dominating.

Figure 3 is a plot of the average and median TSI deviation values from the 2022 and 2024 305(b) assessment periods and illustrates a method for interpreting the meaning of the deviations between Carlson's TSI values for TP, Secchi depth, and chl-a. Each quadrant of the chart indicates the potential factors that may limit algal growth in a lake. A detailed description of this approach is available in *A Coordinator's Guide to Volunteer Lake Monitoring Methods* (Carlson and Simpson, 1996). If the deviation between the chl-a TSI and TP TSI is less than zero (Chl TSI < TP TSI), the data point will fall below the X-axis. This suggests phosphorus may not be the limiting factor in algal growth. The X-axis, or zero line, is related to TN:TP ratios of greater than 33:1 (Carlson, 1977). Because phosphorus is thought to become limiting at ratios greater than 10:1, TP deviations slightly below the X-axis do not necessarily indicate nitrogen limitation. In addition, for these two assessment periods, the data suggests that transparency is influenced by non-algal factors.

Points to the left of the Y-axis (Chl TSI < SD TSI) represent conditions in which transparency is reduced by non-algal turbidity. Points to the right reflect situations in which transparency is greater than chl-a levels would suggest, meaning that large particles, rather than fine clay particles, influence water clarity. Deviations to the right may also be caused by high zooplankton populations that feed on algae, keeping the algal populations lower than expected given other conditions.

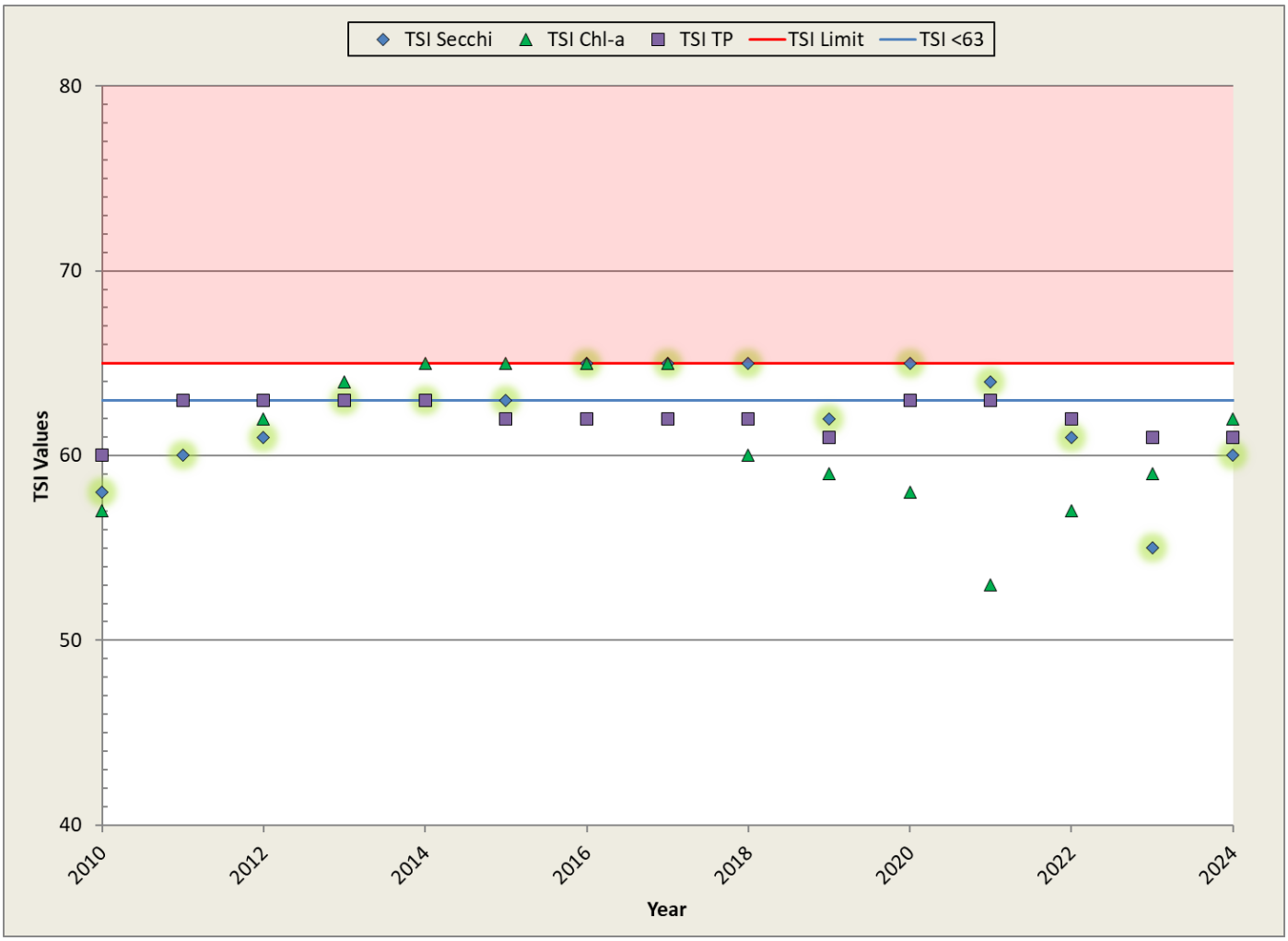

Figure 2. Five-Year Running Median TSI Values.

Table 1. Average and Median TSI Values for 2022 and 2024 Assessment Periods.

	Secchi Depth	Chl-a	Total Phosphorus
2022 Average TSI Values[1]	55	57	68
2022 Median TSI Values[1]	65	58	63
2024 Average TSI Values[2]	58	57	69
2024 Median TSI Values[2]	61	57	62

[1]Data between 2016-2020 were used for the 2022 Water Quality Assessment Period.
[2]Data between 2018-2022 were used for the 2024 Water Quality Assessment Period.

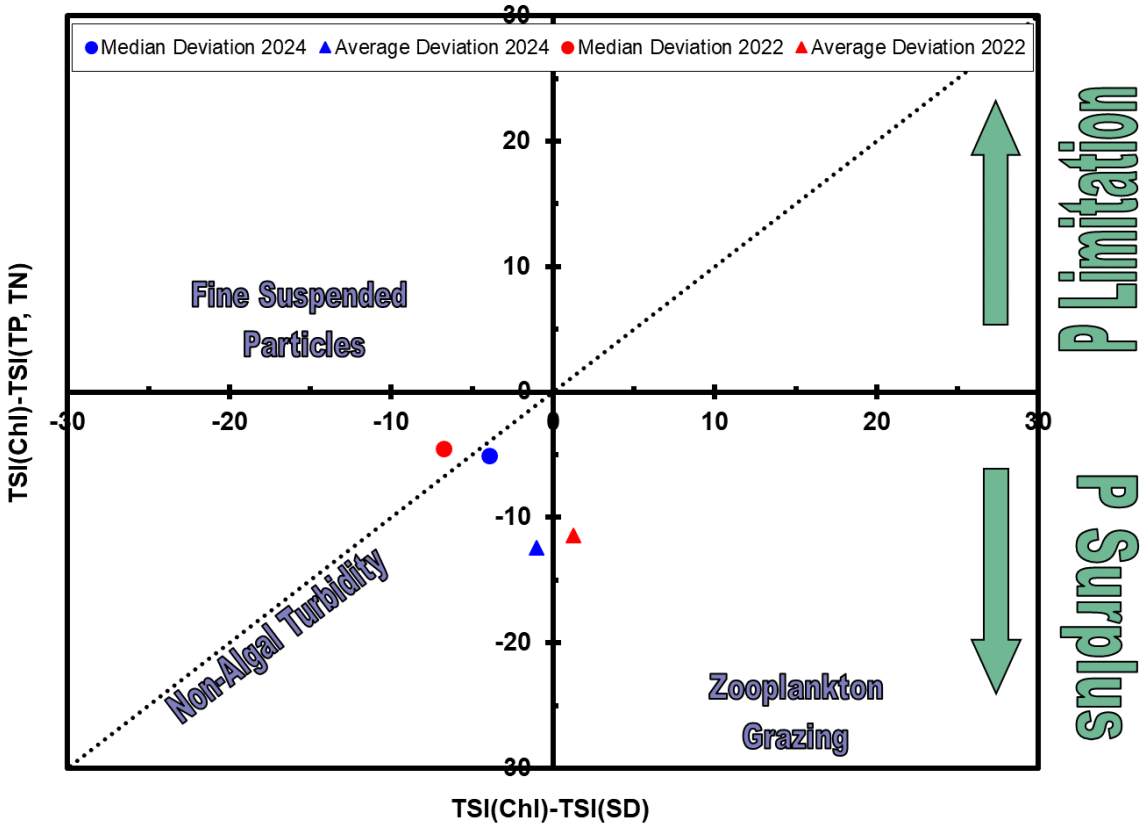

Figure 3. Average and Median TSI Deviation Values from 2022 and 2024 Assessment Periods.

TMDL Target

General Description of the Pollutant

The 2024 305(b) assessment attributes poor water quality in Hickory Grove Lake to turbidity. From the 2021 Hickory Grove Lake WQIP, modeling indicates that a TP reduction of 38% is needed to achieve TSI values of 63 or less for Secchi depth and chl-a.

Table 2 was copied from Table 3-6 of the 2021 Hickory Grove Lake WQIP and reports the simulated chl-a, TP, and Secchi depth at the ambient monitoring location for both existing and target conditions. The Secchi depth and chl-a TSI target of 63 complies with the narrative "free from aesthetically objectionable conditions" criterion. Meeting this target will result in the delisting of Hickory Grove Lake if attained in one 303(d) listing cycle, per Iowa DNR de-listing methodology. Note that TP values in Table 2 are not TMDL targets. Rather, they represent in-lake water quality resulting from TP load reductions required to obtain the chl-a and Secchi depth TSI targets in Hickory Grove Lake.

Table 2. Existing and Target Water Quality (Ambient Monitoring Location).

Parameter	2010-2016[1]	2012-2016[2]	TMDL Target Conditions
Secchi Depth (meter)	0.8	0.7	1.3
TSI (Secchi Depth)	63	65	56
Chlorophyll-a (µg/L)	32	33	27.2
TSI (Chlorophyll-a)	65	65	63
TP (µg/L)	59	56	46.9
TSI (TP)	63	62	60

[1]Analysis Period, Median Values.
[2]2018 Assessment/Listing Cycle Values.

The allowable in-lake chl-a and Secchi depth target of 63 was translated to the TP loading by performing water quality simulations using the BATHTUB model. Based on these models, the allowable annual loading capacity for TP is 3,432.5 lbs/year and the allowable maximum daily load is 29.3 lbs/day.

Waterbody Pollutant Loading Capacity (TMDL)
The TMDL establishes a chl-a and Secchi depth TSI target of 63 or less using analyses of existing water quality data (Table 3) and Carlson's trophic state index methodology. The allowable TP loading capacity was developed by performing water quality simulations using the BATHTUB model.

Decision Criteria for WQS Attainment
The narrative criteria in the water quality standards require that Hickory Grove Lake support primary contact for recreation. The metrics for WQS attainment for de-listing the impairments are a chl-a TSI and Secchi depth TSI of 63 or less for one 303(d) listing cycle.

Pollution Source Assessment
Existing Load
Using STEPL and BATHTUB to simulate annual average conditions between 2006-2021, the annual TP load to Hickory Grove Lake was estimated to be 5,528.7 lbs/yr. This analysis is based on the methods and results presented in Section 3.3 of the original 2021 WQIP. Modeling-specific details can be found in Appendices E and F of the 2021 WQIP for reference.

Identification of Pollutant Sources
The existing TP load to Hickory Grove Lake is entirely from nonpoint sources of pollution and natural background sources. Sources that would contribute to non-algal turbidity are the same as those contributing to the phosphorus load as described in the 2021 WQIP. These source contributions are detailed in Table 3-7 and illustrated in Figure 3-13 of the original WQIP document.

Reasonable Assurance
Under current EPA guidance, when a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurance that nonpoint source control measures will achieve expected load reductions. There are no permitted or regulated point source discharges contributing phosphorus to Hickory Grove Lake and the WLA is zero, therefore reasonable assurance of point source reductions is not applicable. Reasonable assurance for reduction of nonpoint sources is provided by the list of potential best management practices, found in Section 4.0 of the 2021 WQIP, that would deliver phosphorus reductions, a group of nonstructural practices that prevent transport of phosphorus, a proposed methodology for prioritizing and targeting BMPs on the landscape, and monitoring for best available data for estimating the reductions associated with implemented BMPs. Additional monitoring can be found at Story County Conservation (https://www.storycountyiowa.gov/1536/Water-Quality-Monitoring), while a Watershed Management Plan can be found on the DNR website (https://www.iowadnr.gov/environmental-protection/water-quality/watershed-improvement/watershed-planning/management-plans).

TMDL Summary

This section was copied from Section 3.5 of the 2021 WQIP approved by the EPA in 2021.

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

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

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

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

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

$$TMDL = LC = \sum WLA(0\frac{lbsTP}{year}) + \sum LA(3{,}089.2\frac{lbsTP}{year} + MOS\left(343.3\frac{lbsTP}{year}\right) = 3{,}432.5\frac{lbsTP}{year}$$

Expressed as the maximum daily load:

$$TMDL = LC = \sum WLA(0\frac{lbsTP}{day}) + \sum LA(26.4\frac{lbsTP}{day} + MOS\left(2.9\frac{lbsTP}{day}\right) = 29.3\frac{lbsTP}{day}$$

WATER QUALITY DATA

Table 3. Water Quality Data, From 2010-2024 for Hickory Grove Lake[1].

Source	Date[2]	Secchi (m)	pH	Chl-a (µg/L)	TP (µg/L)	TN (mg/L)	Secchi TSI	Chl-a TSI	TP TSI
ISU	6/21/2010	1.00	8.20	45.0	74.8	9.49	60.0	67.9	66.3
ISU	8/9/2010	0.40	7.40	6.0	73.8	3.98	73.2	48.2	66.1
ISU	9/25/2010	0.60	7.40	16.0	93.4	1.37	67.4	57.8	69.5
ISU	6/20/2011	1.70	8.30	19.0	39.3	7.68	52.4	59.5	57.1
ISU	8/8/2011	0.90	8.40	23.0	48.1	7.14	61.5	61.4	60.0
ISU	9/19/2011	0.80	8.00	36.0	59.3	2.24	63.2	65.8	63.0
ISU	6/18/2012	2.50	8.40	6.0	5.0	4.39	46.8	48.2	27.3
ISU	8/6/2012	0.70	8.80	32.0	53.0	0.95	65.1	64.6	61.4
ISU	9/19/2012	0.90	7.70	30.0	64.8	1.38	61.5	64.0	64.3
ISU	6/19/2013	0.80	9.20	33.0	155.4	7.03	63.2	64.9	76.9
ISU	8/5/2013	0.70	8.50	29.0	46.5	6.16	65.1	63.6	59.5
ISU	9/16/2013	0.30	9.60	64.0	90.5	3.81	77.3	71.4	69.1
ISU	6/23/2014	1.40	8.69	51.0	54.3	6.26	55.2	69.2	61.7
ISU	8/11/2014	0.65	8.31	56.7	55.8	5.40	66.2	70.2	62.1
ISU	9/21/2014	0.66	8.31	45.9	63.2	2.61	66.0	68.1	63.9
ISU	6/22/2015	1.80	8.40	12.0	29.9	7.07	51.5	55.0	53.1
ISU	8/10/2015	0.60	7.60	42.0	111.2	4.38	67.4	67.3	72.0
ISU	9/20/2015	1.00	8.00	41.0	44.8	4.62	60.0	67.0	58.9
ISU	6/20/2016	1.00	8.20	21.0	34.7	4.29	60.0	60.5	55.3
ISU	8/8/2016	0.70	8.70	36.0	58.9	1.02	65.1	65.8	62.9
ISU	9/20/2016	0.60	7.80	7.0	149.7	3.03	67.4	49.7	76.3
ISU	5/15/2017	4.10	8.20	1.7	18.4	5.41	39.7	35.5	46.1
ISU	6/27/2017	3.60	8.20	1.7	16.4	5.39	41.5	35.5	44.5
ISU	8/15/2017	0.50	8.70	20.0	77.2	1.65	70.0	60.0	66.8
ISU	6/12/2018	1.0	8.40	17.0	46.6	5.11	60.0	58.4	59.5
ISU	7/31/2018	0.50	8.50	20.0	74.4	4.05	70.0	60.0	66.2
ISU	9/11/2018	0.5	7.40	2.0	278.7	2.60	70.0	37.4	85.3
ISU	6/29/2022	2.60	8.58	7.3	31.0		46.2	50.1	53.6
ISU	8/17/2022	1.60	8.51	12.0	50.0	4.15	53.2	55.0	60.5
ISU	9/28/2022	0.90	8.01	26.4	60.0	2.15	61.5	62.7	63.1
ISU	6/1/2023	1.00	8.58	27.6	51.0	4.43	60.0	63.1	60.8
ISU	7/19/2023	1.23	8.47	21.9	245.0	1.56	57.1	60.9	83.4
ISU	8/30/2023	1.90	8.60	15.3	43.0	1.45	50.8	57.4	58.3
ISU	5/23/2024	0.17	7.72	23.7	436.0	7.25	86.0	61.7	91.7
ISU	7/9/2024	0.98	8.75	70.4	48.0	6.96	60.4	72.3	59.9
ISU	8/25/2024	0.85	9.01	70.0	79.0	3.35	62.3	72.3	67.1
Average[2]	**--**	**1.14**	**8.32**	**27.5**	**82.3**	**4.3**	**58**	**63**	**68**
Median[2]	**--**	**0.90**	**8.40**	**23.4**	**57.3**	**4.3**	**62**	**62**	**62**

[1]Ambient monitoring location = STORET ID 22850001

[2]TSI values calculated from the overall median (or average) water quality value of the respective parameter.

[3]Data between 2018-2022 were used for the 2024 Water Quality Assessment Period.

PUBLIC PARTICIPATION

Public involvement is important in the Total Maximum Daily Load (TMDL) process since it is the land owners, tenants, and citizens who directly manage land and live in the watershed that determine the water quality in Hickory Grove Lake.

Public Meeting

A virtual on-line presentation was posted on the DNR's YouTube channel for public viewing on March 26, 2026. A link to the presentation can be located on the Iowa DNR's website at https://www.iowadnr.gov/environmental-protection/water-quality/watershed-improvement/watershed-planning/water-quality-improvement-plans. The presentation will be available for viewing through the public comment period.

Public Comments

A press release was issued on March 26, 2026 to begin a 30-day public comment period which will end on April 27, 2026. All comments received by the DNR during the 30-day public notice period will be attached.