Addendum to the
Water Quality Improvement Plan
for

Green Valley Lake

Union County, Iowa

Total Maximum Daily Load for:
Algae, Turbidity, and Dissolved Oxygen
Addendum to include pH

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GENERAL REPORT SUMMARY

What is the purpose of this report?
This report serves as an addendum to the Green Valley Lake Water Quality Improvement Plan (WQIP), dated July 2019, 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, Turbidity, and Dissolved Oxygen. The approval letter was received by the Iowa Department of Natural Resources on October 7, 2019. A copy of this letter is attached for convenience. Subsequent to this approval, the lake was placed on the 2024 303(d) list for a pH impairment.

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

What can be done to improve Green Valley Lake?
Reducing phosphorus loss from row crops and implementing or improving existing structural BMPs such as terraces, grass waterways, and constructed sediment basins in beneficial locations will significantly reduce phosphorus loads to the lake. Special attention should be given to row crops where manure from animal feeding operations is applied. Runoff from these areas can transport high levels of nutrients into Green Valley Lake. Increasing the trapping efficiency of the existing sediment basins may be the most cost-effective structural alternative. Additionally, in-lake practices such phosphorus stabilization may be necessary in order to address algae and turbidity concerns post lake renovation.

TOTAL MAXIMUM DAILY LOAD (TMDL) FOR PH

A Total Maximum Daily Load (TMDL) is required for Green Valley Lake by the Federal Clean Water Act. The 2019 WQIP for Green Valley Lake quantified the maximum amount of total phosphorus (TP) the lake can assimilate and still support its designated uses. It is assumed that the TMDL for algae will also address the pH impairment since both are attributed to excess nutrients, particularly phosphorus. As a result, the amendment will not revisit the allowable TP load to the lake but refer to the 2019 WQIP for allowable phosphorus loads.

Problem Identification
Green Valley 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)
Drinking Water - Class C
Fish consumption - Class HH

The 2024 Section Water Quality Assessment Report for Green Valley Lake indicates that for Class A1 use, Class BLW use, and Class C use all are assessed as “not supported” due to violations of the criterion for pH. The 2024 assessment can be accessed at https://programs.iowadnr.gov/adbnet/Segments/1472/Assessment/2024.

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

Interpreting Green Valley 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). Figure 1 shows that pH exceeded the maximum criterion of nine (9) regularly from 2018-

2022. Values that exceeded the maximum criterion of nine (9) are shown as diamonds in the red shaded area. Elevated pH is often related to and a direct result of algal blooms, which affect the lake's carbonate chemistry and pH.

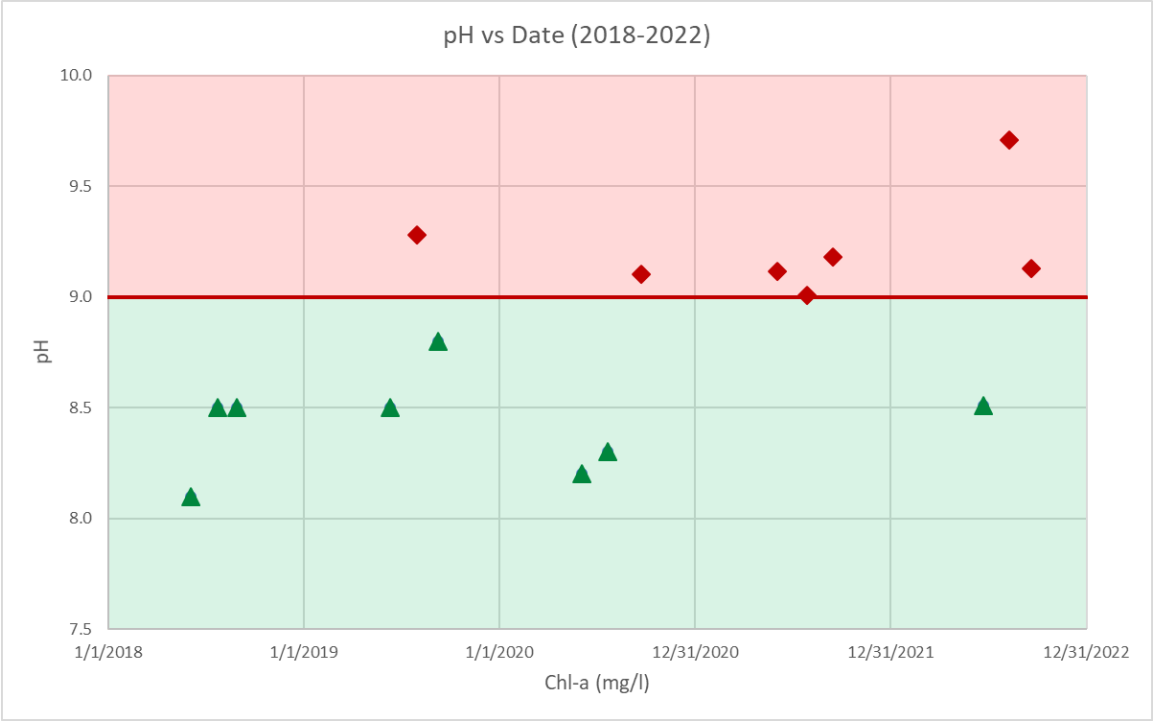

Figure 1. pH Levels in Green Valley Lake, From 2018-2022.

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

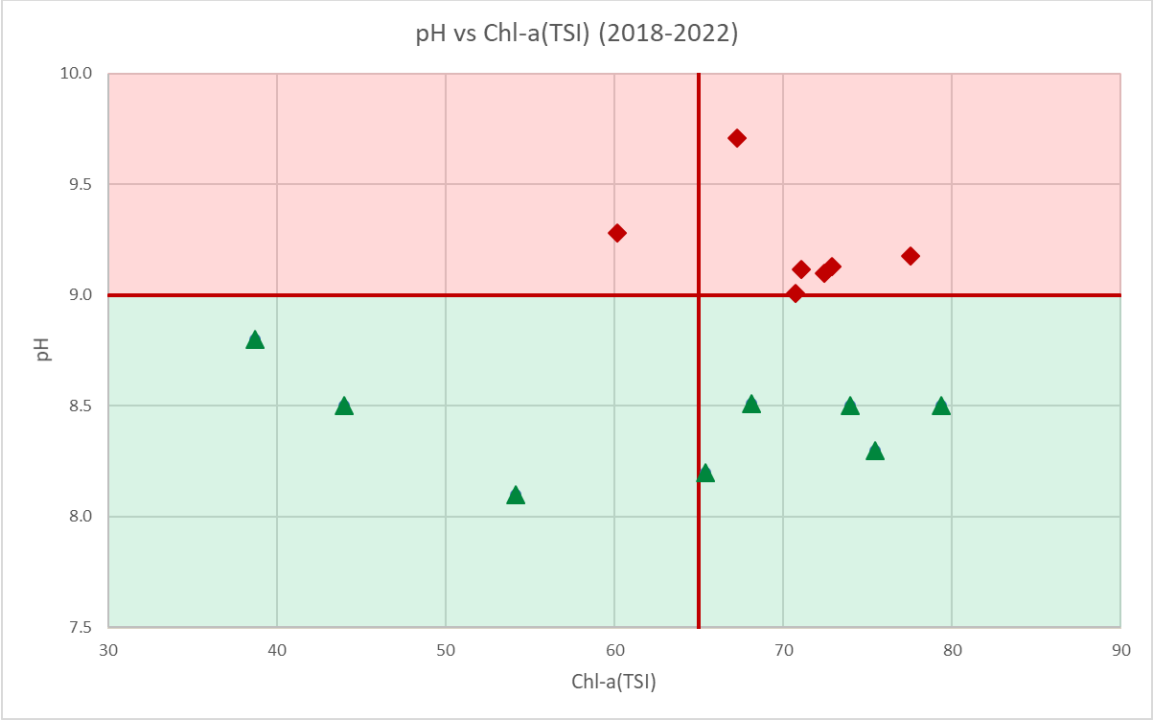

Figure 2. pH vs Chl-a TSI Values Green Valley Lake, From 2018-2022.

TMDL Target

The target for pH is a value no less than 6.5 and no greater than 9, and the target for chl-a is a TSI value of 63. Using data from 2012-2024, Figure 3 shows the relationship between pH to chl-a. It shows that when chl-a TSI values are below 63 that pH values will also be consistently less than 9 and that when chl-a TSI values are greater than 63 there is a higher chance that the pH will be greater than 9.

Between 2012 and 2024 there were a total of 39 samples collected. Of these samples, 10 had a chl-a TSI value of 63 or less and of these samples, only one (1) had a pH greater than nine (9). Conversely, when chl-a TSI values are greater than 63, pH exceeds the criterion 31% (9 of 29) of the time. This information is shown graphically in Figure 3 where the red diamonds represent pH values greater than 9, the green triangles represent pH values less than or equal to 9, the red vertical line represents a chl-a TSI value of 63, the horizontal red line represents a pH of 9, the green shaded area represents chl-a TSI values less than 63, the red shaded area represents chl-a TSI values greater than and equal to 63.

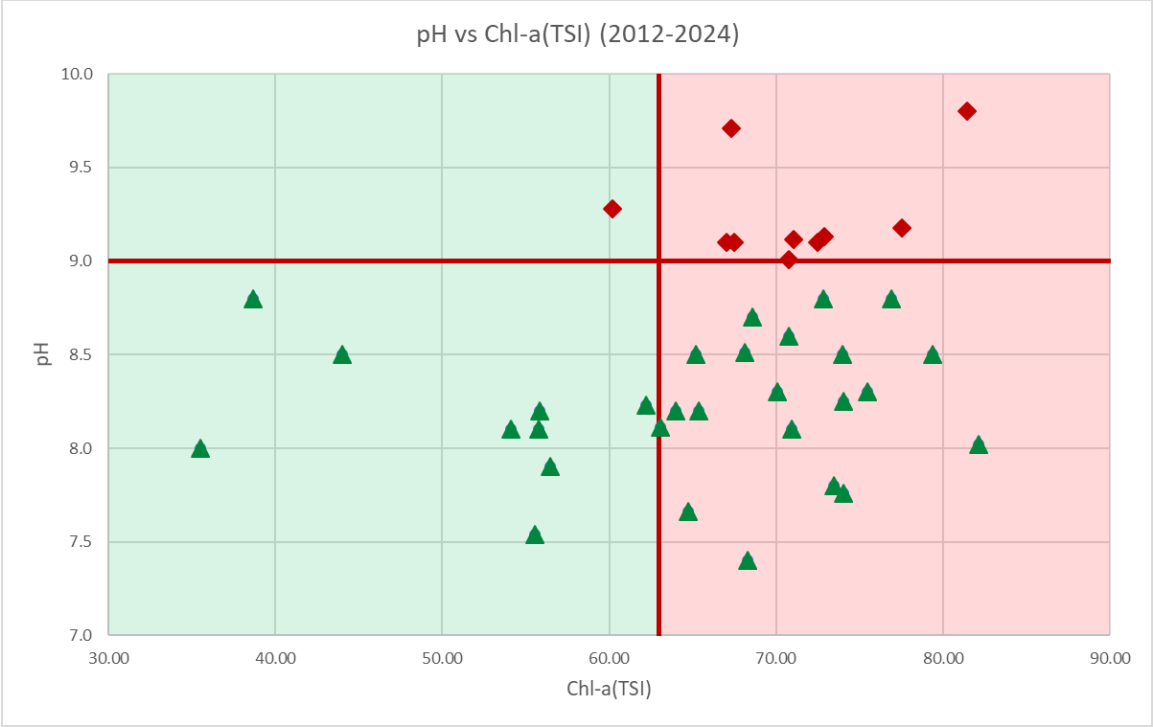

Figure 3. pH vs Chl-a TSI Value Green Valley Lake, From 2012-2024.

For convenience, a summary of the TMDL targets presented in the 2019 WQIP will be provided here. For a full discussion please see the 2019 WQIP for Green Valley Lake.

Green Valley Lake is impaired for algae, turbidity, DO, and pH. This is caused by excess phosphorus entering the system.

There are no numeric criteria associated with water clarity however, there are narrative requirements in the IAC 567-61 protecting against “aesthetically objectionable conditions.” Based on the Iowa DNR assessment methodology, aesthetically objectionable conditions are present in a waterbody when the median chl-a or Secchi depth Trophic State Index (TSI) exceeds 65. In order to de-list a lake impaired by algae from the 303(d) list, the median growing season chlorophyll-a TSI must not exceed 63 in one listing cycle, per Iowa DNR de-listing methodology. Attainment of the TSI criterion should result in compliance with the numeric pH standard.

In addition, criteria for dissolved oxygen (DO), as listed in the IAC 567-71, is to maintain a concentration of 5.0 mg/l. Excess plant and algae growth, driven by excess nutrients, can often lead to low DO levels when the aquatic plants die and are broken down by oxygen consuming organisms. Therefore, addressing the algae impairment in Green Valley Lake by targeting phosphorus will also address the organic enrichment/low DO impairment.

The allowable in-lake chlorophyll-a target of 63 was translated to the TP loading by performing water quality simulations using the BATHTUB model. Based on these models the allowable annual loading capacity for TP is 2,160 lbs/year and the allowable maximum daily load is 18.4 lbs/day.

Pollution Source Assessment

Existing annual loads were determined using the STEPL model. Using STEPL the average annual TP load to Green Valley Lake from 2002-2016 was estimated to be 7,012 lbs/year.

The target TP load, as previously indicated, is 2,160 lbs/year. To meet the target loads a reduction of approximately 70 percent of the TP load is required.

Identification of Pollutant Sources

There are no known additional sources, natural or manmade, contributing to elevated pH. Sources that would contribute to an elevated pH are the same as those contributing to the phosphorus load as described in the 2019 WQIP.

TMDL Summary

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 Green Valley Lake watershed, the general equation above can be expressed for the Green Valley Lake algae TMDL.

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

$$TMDL = LC = \sum WLA(0\,lbsTP/year) + \sum LA(1944\,lbsTP/year + MOS(216\,lbsTP/year) = \mathbf{2160\,lbsTP/year}$$

TMDL = LC = Σ WLA (0 lbs-TP/year) + Σ LA (1,944 lbs-TP/year)
+ MOS (216 lbs-TP/year) = **2,160 lbs-TP/year**

Expressed as the maximum daily load:

$$TMDL = LC = \sum WLA(0\,lbsTP/day) + \sum LA(16.6\,lbsTP/day + MOS(1.8\,lbsTP/day) = \mathbf{18.4\,lbsTP/day}$$

Table 1. Water Quality Data, From 2012-2024.

Date	Chl-a (µg/L)	Chl-a TSI	pH
6/11/2012	74.0	73	8.8
7/30/2012	61.0	71	8.1
9/12/2012	79.0	73	7.8
6/10/2013	13.0	56	8.1
7/29/2013	34.0	65	8.5
9/9/2013	14.0	56	7.9
6/16/2014	32.4	65	7.7
8/4/2014	27.3	63	8.1
9/14/2014	12.7	56	7.5
6/15/2015	30.0	64	8.2
8/3/2015	178.0	81	9.8
9/13/2015	41.0	67	9.1
6/13/2016	43.0	67	9.1
8/1/2016	56.0	70	8.3
9/13/2016	60.0	71	8.6
6/6/2017	48.0	69	8.7
7/25/2017	1.7	36	8.0
8/29/2017	112.0	77	8.8
6/5/2018	11.0	54	8.1
7/25/2018	144.0	79	8.5
8/29/2018	83.0	74	8.5
6/11/2019	3.9	44	8.5
7/31/2019	20.4	60	9.3
9/8/2019	2.3	39	8.8
6/2/2020	34.6	65	8.2
7/21/2020	96.7	75	8.3
9/22/2020	71.3	72	9.1
6/2/2021	61.7	71	9.1
7/27/2021	59.9	71	9.0
9/14/2021	119.5	78	9.2
6/21/2022	45.8	68	8.5
8/9/2022	42.1	67	9.7
9/19/2022	74.6	73	9.1
6/21/2023	25.0	62	8.2
8/8/2023	83.9	74	8.3
9/18/2023	46.7	68	7.4
6/25/2024	13.1	56	8.2
8/13/2024	191.1	82	8.0
9/30/2024	83.7	74	7.8

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 Green Valley Lake.

Public Meeting

A virtual on-line presentation was prepared to present the results of the TMDL. 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 May 29, 2025 to begin a 30-day public comment period which ends on June 30, 2025. All comments received by the DNR during the 30-day public notice period will be attached.