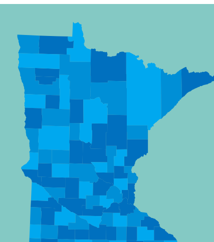
Water quality standards

Framework for developing and evaluating site-specific sulfate standards for the protection of wild rice (December 2023)

MINNESOTA POLLUTION CONTROL AGENCY



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Acronyms, abbreviations, and units of measurement

Acronym	Meaning
C.F.R.	Code of Federal Regulations
CWA	Clean Water Act
DNR	Minnesota Department of Natural Resources
EPA	U.S. Environmental Protection Agency
Minn. R.	Minnesota Rules
MPCA	Minnesota Pollution Control Agency
NPDES	National Pollutant Discharge Elimination System
SONAR	Statement of Need and Reasonableness
SSS	Site-specific standard
TEK	Traditional ecological knowledge
USGS	U.S. Geological Survey
WQS	Water quality standards
WR	Wild rice water
CFS	Cubic feet per second
g/m^2	Grams per square meter
mg/L	Milligrams per liter
µg/L	Micrograms per liter

Introduction

Water quality standards (WQS) are critical regulatory tools for protecting aquatic resources from adverse pollutant impacts. Each WQS specifies the condition(s) under which protection of a specific beneficial use is expected to be achieved (a numeric concentration threshold or narrative description of those conditions). A standard, also referred to as a criterion in federal rule, is generally developed on a statewide or ecoregional basis, and it is presumed that meeting the standard is sufficient to sustain the beneficial use at those broad geographic scales. However, due to substantial natural variability in the hydrologic, chemical, and biological characteristics of aquatic ecosystems – as well as in how the ecosystems respond to pollutants – no WQS is perfectly suited to every waterbody. In some instances, a numeric water quality standard may be more stringent than is strictly necessary to protect the beneficial use in a specific waterbody; in others, it may not be sufficiently stringent to ensure protection. In these instances, it may be appropriate to consider a site-specific modification to the statewide or ecoregional WQS for that specific waterbody.

The Clean Water Act (40 C.F.R. 131.11, Image 1) and Minnesota Rules (Minn. R. 7050.0220, subp. 7, Image 2) provide the flexibility to tailor WQS to waterbodies where unique circumstances alter the typical or expected relationship between a pollutant and the protected beneficial use.

Image 1: Excerpts from the U.S. Code of Federal Regulations at 40 C.F.R. § 131.1. and 40 C.F.R. § 131.11.

United States Code of Federal Regulations
Title 40, Chapter I, Subchapter D, Part 131

40 CFR § 131.1. Scope

This part describes the requirements and procedures for developing, reviewing, revising, and approving water quality standards by the States as authorized by section 303(c) of the Clean Water Act.

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40 CFR § 131.11. Criteria

(a) Inclusion of pollutants:

(1) States must adopt those water quality criteria that protect the designated use. Such criteria must be based on sound scientific rationale and must contain sufficient parameters or constituents to protect the designated use. For waters with multiple use designations, the criteria shall support the most sensitive use.

(2) Toxic pollutants. States must review water quality data and information on discharges to identify specific water bodies where toxic pollutants may be adversely affecting water quality or the attainment of the designated water use or where the levels of toxic pollutants are at a level to warrant concern and must adopt criteria for such toxic pollutants applicable to the water body sufficient to protect the designated use. Where a State adopts narrative criteria for toxic pollutants to protect designated uses, the State must provide information identifying the method by which the State intends to regulate point source discharges of toxic pollutants on water quality limited segments based on such narrative criteria. Such information may be included as part of the standards or may be included in documents generated by the State in response to the Water Quality Planning and Management Regulations (40 CFR part 130).

(b) Form of criteria: In establishing criteria, States should:

(1) Establish numerical values based on:

(i) 304(a) Guidance; or

(ii) 304(a) Guidance modified to reflect site-specific conditions; or

(iii) Other scientifically defensible methods;

(2) Establish narrative criteria or criteria based upon biomonitoring methods where numerical criteria cannot be established or to supplement numerical criteria.

This flexibility comes through the development and application of site-specific standards (SSS) reflecting localized environmental conditions. Development of a SSS for a particular waterbody may be initiated by the Minnesota Pollution Control Agency (MPCA) or requested by an external party if available information indicates that “a site-specific modification is more appropriate” than the existing statewide or ecoregional standard (Minn. R. 7050.0220, subp. 7, Image 2). Like all water quality standards, a SSS must comply with all requirements for WQS found in Minn. R. 7050 and 7052, including the need to protect downstream uses. For a request to receive approval, the proposed modification must demonstratively protect the beneficial use and be based on the best available science. The MPCA evaluates all relevant data and information, including recent scientific publications, to determine whether a SSS is justified.

Image 2: Excerpt from Minnesota Rules pertaining to site-specific standards, at Minn. R. 7050.0220, subp. 7

Minnesota Administrative Rules
Chapter 7050, Part 0220

SPECIFIC WATER QUALITY STANDARDS BY ASSOCIATED USE CLASSES

Subpart 7. Site-specific modifications of standards

A. The standards in this part and in parts 7050.0221 to 7050.0227 are subject to review and modification as applied to a specific surface water body, reach, or segment. If site-specific information is available that shows that a site-specific modification is more appropriate than the statewide or ecoregion standard for a particular water body, reach, or segment, the site-specific information shall be applied.

B. The information supporting a site-specific modification can be provided by the commissioner or by any person outside the agency. The commissioner shall evaluate all relevant data in support of a modified standard and determine whether a change in the standard for a specific water body or reach is justified.

C. Any effluent limit determined to be necessary based on a modified standard shall only be required after the discharger has been given notice of the specific proposed effluent limits and an opportunity to request a hearing as provided in part 7000.1800.

This document pertains to Minnesota’s Class 4A numeric sulfate standard of 10 mg/L – created in 1973 to protect the ecologically and culturally significant wild rice plant that grows in numerous lakes, streams, and wetlands – and potential site-specific modifications to that standard. It provides a framework for developing and evaluating site-specific standards that ensures the beneficial use, “production of wild rice”, will be protected within the waterbody of interest. Development of a SSS for a specific waterbody requires an understanding of the wild rice beneficial use, documentation of the extent and condition of wild rice in that location, collection and analysis of water-column sulfate concentration data, and a thorough exploration of scientific information regarding the way in which sulfate impacts wild rice within that specific environmental context. Evaluations of SSS applications will include determinations on whether an applicant has followed the recommendations provided in this document, used a scientifically defensible method for developing a proposed numeric sulfate value, provided sufficient data and information to demonstrate that the wild rice beneficial use will be protected at the proposed numeric sulfate value, and adequately explained why the characteristics of the environmental setting (chemical, hydrologic, biological, and/or physical) warrant a SSS that deviates from the statewide standard of 10 mg/L sulfate (i.e., why the SSS is "more appropriate" than the statewide WQS).

The goals of this framework are to:

1. Describe what constitutes protection of the wild rice beneficial use
2. Establish expectations for applicants requesting a SSS and for agency staff reviewing those applications
3. Identify informational needs that should be satisfied before advancing a SSS and encourage data collection consistent with meeting those needs.

This framework provides process guidance, rule language interpretations, and technical background to help inform the development and evaluation of SSS applications. None of its contents should be construed to represent a rulemaking proposal. Consequently, this framework does not alter, contravene, or supersede the statewide 10 mg/L Class 4A sulfate standard that is established within Minnesota Rule. If a SSS application is deemed acceptable by MPCA, it then proceeds through a formal approval process (described below), culminating in the modification of the statewide sulfate standard for *only* the specific waterbody(ies) described in the application. Adoption of a SSS for one location does not change the structure or implementation of the statewide sulfate standard in other locations.

Because the framework does not bear the weight or effect of rule, it may be changed at any time. The MPCA expects to periodically update this document in response to new scientific findings or the emergence of other relevant information.

Evaluation and approval process

As required in 40 C.F.R. 131.11 and Minn. R. 7050.0220, subp. 7, the MPCA will evaluate the merits of a SSS application based primarily on whether it successfully demonstrates the following:

1. The proposed SSS protects the wild rice designated use

2. The proposed SSS was derived using scientifically defensible methods

3. The proposed SSS is more appropriate than the currently-applicable statewide WQS

The burden of proof for these demonstrations rests with the applicant. Applicants may solicit feedback from MPCA prior to and during preparation of a SSS proposal. After receiving a completed proposal, MPCA may request additional data collection, contextual information, technical analysis, or other relevant material if reviewers find the demonstrations to be lacking in any regard. Applications that clearly do not meet agency expectations may be immediately rejected without such requests.

Review of a submitted SSS application can be an iterative process, with MPCA requesting information or revision from the applicant and the applicant responding, potentially multiple times. The MPCA bears no obligation to act upon an application within any specific timeframe. If MPCA determines that the SSS application sufficiently justifies modifying the WQS for the described waterbody(ies), MPCA will develop a SSS package containing a technical support document and other relevant materials explaining the agency's rationale for approval.

Next, the SSS package will be public noticed for at least 45 days. During that time, MPCA will provide opportunities for the public to submit written comments and to participate in a public meeting. Any comments made during the public notice period will be taken into consideration by MPCA at that time. If, at the conclusion of the public notice period, MPCA still believes that approval of the SSS application is appropriate, it will send the SSS package to the federal EPA for review. EPA will then approve (within 60 days) or disapprove (within 90 days) the proposed SSS based on whether it is "sufficient to protect the designated use and whether the supporting scientific methods and assumptions are valid and adequate" (EPA, 2017).

Unless and until final approval from EPA is received, the statewide standard remains in effect, under Minnesota rule and for all Clean Water Act (CWA) programs, for the waterbody(ies) considered in the SSS application. This means that MPCA will review permit limits according to the statewide Class 4A standard of 10 mg/L sulfate, not a SSS that is under development or under review. The MPCA will not delay permitting decisions if a permittee wishes to collect data for a potential SSS application. Furthermore, any permit limit decision is public noticed and reviewed by EPA separately from the SSS review process, providing an additional opportunity to the public to provide input.

If the SSS package receives final approval from EPA, MPCA may require future sulfate monitoring and/or wild rice monitoring as a condition of NPDES wastewater discharge permits upstream from the waterbody. The MPCA may also choose to visit the waterbody as part of regular water quality monitoring. If any facilities discharging sulfate-containing effluent to the waterbody would cause or contribute to an exceedance of the SSS, MPCA will impose new or lower (more stringent) wastewater limits for sulfate in discharge permits. If the wild rice population in the waterbody declines in productivity to such an extent that the beneficial use can no longer be considered attained or protected, then MPCA will reconsider the SSS – possibly removing the SSS (and thereby reverting to the 10 mg/L statewide sulfate standard in that location) or replacing it with a new SSS to ensure the beneficial use is protected. Any proposal to replace or remove a SSS must also proceed through a formal approval process, as described above.

Understanding the beneficial use

Beneficial uses are surface water uses by people, aquatic communities, and wildlife that are recognized in Minnesota's water quality standards and classified within Minn. R. 7050.0140 as:

Class 1: Domestic consumption

Class 2: Aquatic life and recreation

Class 3: Industrial consumption

Class 4: Agriculture and wildlife

Class 5: Aesthetic enjoyment and navigation

Class 6: Other uses and protection of border waters

Class 7: Limited resource value waters

Multiple beneficial use classes are assigned, or "designated", to each surface water of the state or segment thereof, as described in Minn. R. 7050.0400 to Minn. R. 7050.0470. In the context of the following discussion, which identifies and interprets important use-focused rule language, the distinction between "beneficial use" and "designated use" is unimportant and these terms may be considered interchangeable.

What is the Class 4A wild rice beneficial use?

Minnesota's Class 4 water quality standards are intended to protect the "the agriculture and wildlife designated public uses and benefits" of waters of the state (Minn. R. 7050.0224, subp. 1). The 4A subclass designation applies to waterbodies for which water quality must be sufficient "to permit their use for irrigation without significant damage or adverse effects upon any crops or vegetation usually grown in the waters or area" (Minn. R. 7050.0224, subp. 2; Image 3). In 1973, Minnesota adopted a Class 4A sulfate WQS of "10 mg/L, applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels". This rule language, also located within Minn. R. 7050.0224, subp. 2, established a unique subset of waterbodies within the 4A subclass ("water used for the production of wild rice") and provided a numeric sulfate standard (10 mg/L) applicable to those waterbodies. The phrase "production of wild rice" is understood to represent the beneficial use.

Image 3: Minnesota Rules pertaining to Class 4 water quality standards, at Minn. R. 7050.0224, subp. 1-2. Underlining and shading added to emphasize portions relating to wild rice and/or sulfate.

Minnesota Administrative Rules
Chapter 7050, Part 0224

SPECIFIC WATER QUALITY STANDARDS FOR CLASS 4 WATERS OF THE STATE; AGRICULTURE AND WILDLIFE

Subpart 1. General

The numeric and narrative water quality standards in this part prescribe the qualities or properties of the waters of the state that are necessary for the agriculture and wildlife designated public uses and benefits. Wild rice is an aquatic plant resource found in certain waters within the state. The harvest and use of grains from this plant serve as a food source for wildlife and humans. In recognition of the ecological importance of this resource, and in conjunction with Minnesota Indian tribes, selected wild rice waters have been specifically identified [WR] and listed in part 7050.0470, subpart 1. The quality of these waters and the aquatic habitat necessary to support the propagation and maintenance of wild rice plant species must not be materially impaired or degraded. If the standards in this part are exceeded in waters of the state that have the class 4 designation, it is considered indicative of a polluted condition which is actually or potentially deleterious, harmful, detrimental, or injurious with respect to the designated uses.

Subpart 2. Class 4A waters

The quality of class 4A waters of the state must be such as to permit their use for irrigation without significant damage or adverse effects upon any crops or vegetation usually grown in the waters or area. In addition, the following standards apply:

Substance, Characteristic, or Pollutant	Class 4A Standard
Boron (B)	0.5 mg/L
Sulfates (SO_4)	10 mg/L, applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels.
Radioactive materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use.

Items A and B apply to the quality of class 4A waters of the state, with the exception of the numeric sulfate standard applicable to waters used for production of wild rice.

A. Determining whether irrigation water quality would cause significant damage or adverse effects must consider the following items in the area where the water is applied for irrigation: crop types, soil types, climate, and irrigation practices.

B. Irrigation water quality must be protected over the growing season as an average.

Minnesota rule and MPCA rulemaking documents do not formally define “production” with regards to wild rice, but the term was widely used at the time of rulemaking to describe the growth and harvesting of wild rice in natural stands as well as in cultivated paddies. The MPCA interprets “production of wild rice” to mean the continued generation of wild rice biomass (vegetative and reproductive), consistent with the understanding of “production” described in the agency’s 2017 wild rice rulemaking SONAR (MCPA, 2017c) as well as the general definition of ecological production used by environmental scientists. Therefore, the intent of the Class 4A sulfate WQS of 10 mg/L is to protect the continued generation of wild rice biomass, and any proposal for a site-specific modification of that standard must demonstrate that the continued generation of wild rice biomass will be protected.

Rule amendments in 1998 added a wild rice narrative standard, applicable to 24 selected waterbodies (formally designated “wild rice waters”, denoted by “[WR]”, in Minn. R. 7050.0470), and introduced the beneficial use “harvest and use of grains from this plant as a food source for wildlife and humans” (Minn. R. 7050.0224, subp. 1; Image 3), where “this plant” refers to wild rice. The amendments also included the condition that “The quality of these waters and the aquatic habitat necessary to support the propagation and maintenance of wild rice plant species must not be materially impaired or degraded.” The central motivation for these amendments, as explained in rulemaking documents (e.g., MPCA, 1997), was to encourage broad-scale protections of wild rice, prevent decline in Minnesota’s wild rice populations, and preserve as much wild rice genetic diversity as possible. The amendments neither altered nor removed any rule language related to the sulfate standard in Minn. R. 7050.0224, subp. 2. Therefore, the 10 mg/L sulfate standard linked to “water used for production of wild rice” also applies to these 24 wild rice waters. Any application for a site-specific sulfate standard in one of the 24 wild rice waters should demonstrate that both beneficial uses (i.e., “production of wild rice” and “harvest and use of grains…as a food source for wildlife and humans”) will be met by the proposed SSS, as well as provide additional evidence that the “propagation and maintenance” of wild rice stands in the waterbody will not be “materially impaired or degraded”.

Where does the beneficial use apply?

All surface waters of the state of Minnesota are classified as Class 4A waters (Minn. R. 7050.0415, subp. 2). However, not every Class 4A water is subject to the Class 4A sulfate WQS of 10 mg/L – only those which MPCA has determined are “waters used for the production of wild rice” (viewable online: MPCA public data viewer of water used for production of wild rice). The narrative language in Minn. R. 7050.0224, subp. 1 does not apply to all waters used for production of wild rice, but it does apply to a small subset (see: 24 wild rice waters [WR] listed in rule at Minn. R. 7050.0470).

MPCA is taking an expansive approach to identifying waters used for production of wild rice, listing waterbodies that support an existing wild rice beneficial use as well as those that demonstrate the potential to attain the beneficial use in the future. Federal regulations state that “a water quality standard defines the water quality goals of a water body …” (40 C.F.R. 131.2) and that “designated uses are those specified in water quality standards for each water body or segment whether or not they are being attained” (40 C.F.R. 131.3(f)). Consistent with these regulations, MPCA exercises its authority to define where designated uses should be applied, including waterbodies where the use has yet to be attained.

Designations of waters used for the production of wild rice are based on documentation of wild rice presence in primary sources, including various wild rice inventories, biological monitoring reports, agency databases, and responses to public requests for wild rice data and information. Recognizing the often-cyclical pattern of wild rice growth and high degree of natural variability in wild rice population sizes, MPCA does not require a specific population-size threshold to be met for the purpose of assigning a designation. The MPCA has instead determined that documentation of current or historical wild rice presence – recorded observations, harvest histories, measurements of population extent or other wild rice growth metrics, or other reliable evidence – is sufficient to consider a waterbody to be a water used for the production of wild rice.

For some waters, extensive harvest records or other data indicate sustained and robust wild rice populations, thereby enabling a determination that the Class 4A wild rice beneficial use is an "existing use" for CWA purposes (i.e., "uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards" (40 C.F.R. 131.3(e)). In other instances, available documentation provides evidence of only minimal stands or sparse rice that does not presently meet the Class 4A wild rice beneficial use, yet MPCA recognizes that these waterbodies could, in the future, be home to sufficient wild rice to attain the beneficial use. MPCA also includes these waterbodies in its list of waters used for the production of wild rice; their inclusion furthers the agency's goal of wild rice protection in the state.

It is important to understand that the process of designating a beneficial use (i.e., assigning a beneficial use to a specific waterbody – in this case a water used for the production of wild rice) differs from the process of demonstrating that a beneficial use is attained within a waterbody. The former process, conducted exclusively by MPCA (but benefitting from external input), determines where water quality standards protections apply. The latter process, required for approval of a SSS, must be performed by the applicant (an external party, unless the SSS proposal was initiated internally by MPCA), with whom the sole burden of proof rests. The applicant must demonstrate that the wild rice beneficial use is currently attained and will still be attained in the future under the proposed SSS. If available data and research findings do not indicate that wild rice will be protected under a sulfate standard that differs from 10 mg/L, then a SSS is not appropriate for the waterbody.

Is the beneficial use protected?

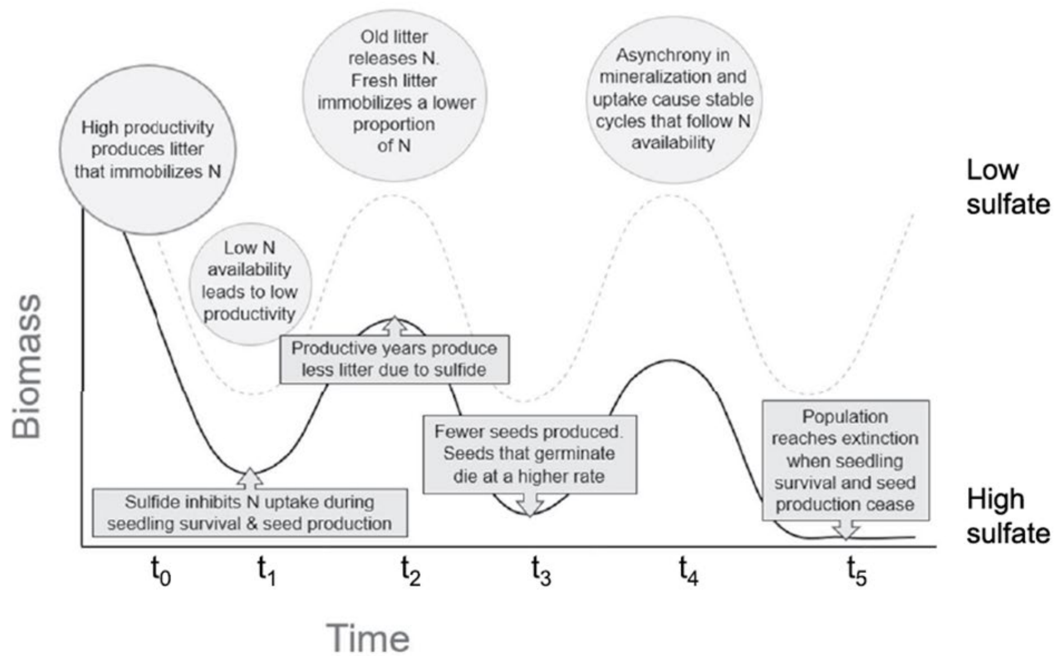
The Class 4A beneficial use "production of wild rice" must be shown as achievable under any SSS proposal that would modify the 10 mg/L sulfate WQS for a particular waterbody. MPCA interprets "production of wild rice" to mean the continued generation of wild-rice vegetative and seed biomass. Thus, applications for a SSS must demonstrate that the proposed numeric sulfate concentration will allow wild rice to not only persist in the short term but also to sustain itself – undergo production across multiple growth cycles and generations – into the long-term future.

For the purpose of evaluating site-specific standard requests, the MPCA will require a demonstration that the waterbody(ies) of interest have and will maintain a wild rice population that is productive, meaning a population that is self-sustaining and that at least occasionally achieves a robust level of production.*

*(*Exception: applications for a SSS that is more stringent than the existing 10 mg/L sulfate WQS need not demonstrate that the beneficial use is currently met, as non-attainment of the use may be part of the rationale for seeking a SSS. However, such applications must demonstrate that the beneficial use will be met in the future under the proposed standard.)*

It is essential to understand that the wild rice beneficial use has an inherent generational or population-over-time component, which must be considered when developing a protective site-specific standard. Important information regarding the analysis of population stability in wild rice, including a helpful conceptual model depicting population oscillations under scenarios of low- and high-sulfate loading (Figure 1), can be found in published research by LaFond-Hudson et al. (2022) and should be consulted prior to embarking upon an SSS application.

Figure 1. Conceptual model depicting wild rice population oscillations and contrasting population stabilities under low-sulfate and high-sulfate loading scenarios (from LaFond-Hudson et al., 2022).



For wild rice, an annual grain plant, to successfully reproduce and sustain itself over generations, it must generate sufficient quantities of viable seeds that self-sow and germinate in subsequent years. A self-sustaining population of wild rice is regularly and observably present in the waterbody (i.e., does not exist only theoretically in the seed bank), and it recurs naturally on an annual basis or following multi-year boom-bust cycles (Pastor and Walker, 2006; Walker et al., 2010) without trending towards local extirpation. A single boom-bust cycle is defined as a period of high biomass production (boom) followed by a period of low biomass production (bust) and then gradual recovery. Boom-bust cycles, which often span 3-5 years, can occur due to delays in nutrient cycling caused by slow decomposition of plant litter (Pastor and Walker, 2006; Walker et al., 2010). In waters that do not exhibit measurable boom-bust cycles, long-term population trends can be examined without considerations of cyclicity.

It is possible for a population of wild rice to appear self-sustaining yet undergo only very low levels of production. In this situation, the beneficial use is not met because the population may be unhealthy and/or in jeopardy of disappearance. One cannot be confident in the successful, continued production of wild rice biomass if the population does not occasionally achieve robust levels of production. An application for a SSS should not be approved if: 1) wild rice persists across a period of long-term monitoring but appears to be "barely hanging on" and/or highly vulnerable to extirpation; 2) the wild rice population is understood to be a shadow of its former self, as compared to documented historical norms, and therefore exists in a substantially degraded state (see later discussion on historical context);

or 3) the wild rice population is determined to be unhealthy in some manner that could prevent it from being resilient under existing or future stressors (i.e., it is unlikely to be able to maintain or return to a normal level of production after a perturbation due to one or more environmental stressors).

Applications pertaining to any of the 24 wild rice [WR] waters listed in Minn. R. 7050.0470 must additionally address the beneficial use protections found in Minn. R. 7050.0224, subp.1. These applications must therefore demonstrate that the proposed numeric sulfate concentration will 1) support the "propagation and maintenance" of wild rice in the waterbody; 2) protect an existing wild rice population that is characterized by levels of productivity which enable "harvest and use of grains…as a food source for wildlife and humans", or otherwise maintain water quality conditions that could support such a population in the future; and 3) not contribute to any material impairment or degradation of the wild rice aquatic habitat.

Gathering wild rice is essential to the culture and well-being of sovereign Native nations. Losses of wild rice have been linked to cultural disruptions and negative health consequences (Ballinger, 2018; Fond du Lac Band of Lake Superior Chippewa, 2018). Access to and harvesting of wild rice maintains religious, ceremonial, medicinal, subsistence, and economic needs for members of those Nations. In many parts of Minnesota, Native nations possess reserved treaty rights to harvest wild rice. Any site-specific sulfate standard for the protection of wild rice must support the exercise of applicable tribal treaty rights to gather wild rice as well as protect downstream water quality standards established by nations that are treated as a state ("Treatment as a State" status) under the Clean Water Act.

Developing a site-specific sulfate standard

The MPCA has historically followed one of two broad approaches when developing a site-specific standard. The first is to consider the use of national recommended ambient water quality criteria provided by the U.S. Environmental Protection Agency (EPA) (e.g., ammonia in the Red River of the North or selenium in the lower Minnesota River), which may be especially appropriate if developed more recently than the existing statewide or ecoregional standard. The second is to independently develop the expression of, and scientific rationale for, a SSS (e.g., specific conductance on the Rock River or phosphorus in Lake Byllesby). In general, the first approach is more streamlined because the scientific information justifying the selected pollutant threshold has already been assembled and evaluated by EPA. Since no federal water quality criteria exist for the protection of wild rice from elevated sulfate, MPCA and applicants must pursue the second approach when developing a site-specific modification of the statewide 10 mg/L Class 4A sulfate standard. Because there is no pre-existing quantitative goal or threshold defined in rule to demonstrate that the beneficial use is met in site-specific contexts, significant work must be undertaken to develop, *de novo*, the scientific basis for a SSS. Supporting information must establish the appropriateness of the site-specific modification.

There is an abundance of important scientific information, produced between 2010 and 2017 when the MPCA conducted a review of its existing statewide standard, as well as in more recent publications, that should be considered in a SSS proposal (see references provided in this document as a starting point). For example, recent research has provided important insights into the effects of elevated sulfate on wild rice plant growth and reproduction, population cycles, sediment porewater chemistry in the rooting zone, and root plaque development (Johnson et al., 2019; LaFond-Hudson et al., 2022; LaFond-Hudson et al. 2018). Because research concerning sulfate and wild rice continues to be relatively active, requests for a SSS should include a meaningful evaluation of all relevant scientific information available as of the date of submission.

Defining the numeric standard

A numeric water quality standard is defined by three components: magnitude, duration, and frequency. When developing a numeric SSS, it is important to specify and justify all three components.

Magnitude: level of sulfate in water, expressed as a concentration (mg/L)

Duration: period of time over which sulfate measurements are averaged

Frequency: how often the magnitude may be exceeded

The current Class 4A statewide sulfate standard has a magnitude of 10 mg/L. The duration and frequency of the standard are expressed in the narrative statement “during periods when the rice may be susceptible to damage by high sulfate levels” (Minn. R. 7050.0224, subp. 2). The MPCA expects that a proposed site-specific standard would define the magnitude, duration, and frequency in numeric (not narrative) terms. In its 2018 attempt to amend the Class 4A sulfate standard, the MPCA proposed using a 365-day average as the duration and a one-in-ten-year exceedance as the frequency. MPCA believes that the earlier-proposed duration and frequency remains scientifically defensible.

Determining the magnitude of the standard

An applicant for a sulfate SSS must determine an appropriate surface water sulfate concentration (magnitude) for the waterbody of interest using a scientifically defensible method that clearly illustrates the association between the selected magnitude and the production of wild rice at that location. Measuring the ambient sulfate concentration across seasons in multiple portions of the waterbody is an essential precursor to this process, as is monitoring and description of the local wild rice population, which should include long-term data collection on population variables like abundance and density that yield valuable insight into the level of wild rice biomass or productivity in the waterbody (see later recommendations). The applicant’s selected method for determining the magnitude of a proposed SSS should be described in full detail. Any applicant who proposes a numeric sulfate value that is less stringent than the existing statewide standard must clearly demonstrate the occurrence of a productive wild rice population under current conditions.

One possible method for determining the magnitude of a sulfate SSS is to apply the current ambient sulfate concentration in the waterbody – acceptable only if the wild rice population is productive and appears healthy. There should be no reason to suspect that the population is undergoing sustained decline, has already experienced substantial decline, or will be in jeopardy of substantial decline or extirpation in the future. This method requires long-term monitoring of both surface water sulfate concentrations and the wild rice population (multiple metrics). If there is no significant increase in average sulfate concentration over time and wild rice is demonstrated to be productive and healthy (including clear indication that it is not declining in abundance over time), then the current ambient sulfate concentration could be used as the magnitude for a numeric site-specific sulfate standard. Because defining the “current” sulfate concentration may not be straightforward, MPCA expects an applicant pursuing this method to provide detailed analysis of spatial and temporal variability in the sulfate concentration across the waterbody.

Other methods for independently developing and justifying the proposed magnitude of a site-specific standard may be acceptable, but the MPCA is not presently aware of any that would establish a clear connection between a given sulfate concentration and the ecological production of wild rice within the site-specific context. Applicants intending to pursue a novel method are encouraged to contact MPCA for discussion and early feedback.

Providing detailed supporting data and analyses

Wild rice plant biology and sulfur biogeochemistry is complex, and there is significant natural variability in hydrology and other features of aquatic environments that support wild rice. Consequently, MPCA is unable to prescribe a fixed, step-by-step approach to developing a SSS that would suffice in all circumstances. Scientific data and information provided in support of a SSS application will need to be uniquely tailored to the specific waterbody in question. Applications for a SSS should include close examination of the local environmental context in which the proposed standard would apply, as well as consideration and description of all relevant data — historical and recent — available for the location of interest. Understanding the present and historical condition of the waterbody, and the totality of factors that potentially affect the local wild rice population, is necessary to determine whether a SSS is appropriate for the location of interest.

The MPCA expects an applicant to provide multiple lines of scientific evidence (see recommendations throughout this section) to demonstrate that the proposed sulfate concentration value will enable the waterbody to support a productive wild rice population and to establish whether the beneficial use is currently attained in the waterbody. Provision of supplementary data, additional site context, and corroborating analyses may strengthen the SSS application and help MPCA to reach a determination on its merits. Prior to initiating data collection and information gathering to support a future SSS proposal, the prospective applicant should carefully review the MPCA's recommendations in each of the following areas.

Long-term monitoring of wild rice

The MPCA expects an applicant for a SSS to thoroughly characterize and evaluate wild rice production within the area of interest. An application should include long-term wild-rice monitoring data – including multiple measures of growth or productivity – that is evaluated alongside measurements of sulfate concentration, water depth, and other variables related to the production or condition of wild rice. The applicant should discuss how these waterbody-specific data relate to findings in the scientific literature – including field studies, mesocosm experiments, and laboratory tests – and also describe how modern conditions compare to historical measurements and observations (see framework section regarding historical context).

There are many aspects of wild rice growth and productivity that can be measured, including stand area, stalk density, plant biomass, stem height, seed weight, filled seed ratios, number of pedicels per stalk, germination rate, and so on. Tracking a combination of metrics over time at both population and plant scales will provide a stronger picture of wild rice growth dynamics and productivity within the waterbody. Plant-specific measures that potentially relate to the presence or absence of sulfate-induced plant stress — outward physical manifestations of impacts, or internal cellular or physiologic changes, for example — may be helpful to study, monitor, and include in an application. The applicant must provide a scientifically defensible rationale for pursuing the metrics chosen and explain why they are appropriate for understanding and characterizing wild rice productivity and/or condition in that specific environmental context. A useful resource to review prior to establishing a sampling plan or beginning data collection efforts is the Wild Rice Monitoring Handbook (Kjerland, 2015), which organizes a set of core wild rice variables and offers a standardized method for monitoring wild rice health (Table 1).

Table 1. Core wild rice variables identified and described in the *Wild Rice Monitoring Handbook* (Kjerland, 2015).

Core Wild Rice Variables		Optional
Biomass & Productivity (Annual Yield)	**Potential Stressors (Field Notes)**	**Plant weight measured directly**
Density (number of stalks per area)	Observed shoreline use	Plant dry weight
Average Stem Height	Observed water use	Number of viable (filled hulls) and non-viable seeds collected
Water depth	Brown spot fungal presence and severity index	Calculate new site-specific biomass equation
Number of potential seeds (# pedicels per stalk)	Animals, birds, pests, pathogens presence	Presence of worm holes in seeds (observed in the lab)
Presence of other plants co-occurring with wild rice (List)	Weather (current and past 2-3 days)	
Estimate of wild rice stand area	Other possible concerns for wild rice growth (i.e. pollutants)	

Long-term annual population data are needed to describe the trajectory of a wild rice population and to demonstrate that the beneficial use is met. A downward trend in spatial extent, stalk density, biomass, or other indicator of population-level productivity raises concerns about the potential for local extirpation of wild rice and negates any claim that the wild rice beneficial use will be supported under a sulfate water quality standard that is less stringent than the 10 mg/L Class 4A WQS. A notable upward trend or strong evidence of a stable population at robust levels of production will support the contention that the beneficial use is met in the waterbody. If, however, long-term monitoring reveals no trend, but the population appears to be substantially diminished relative to historical norms and/or analogous environments, monitoring data should not be interpreted as evidence of a productive population that meets the beneficial use requirement. The wild rice may be merely "hanging on", albeit stably for now, within a portion of its former expanse or at a fraction of its former density within the waterbody.

The MPCA strongly recommends establishing a long-term wild rice monitoring program that facilitates the collection of consecutive annual population data spanning *at least* the most recent ten years or two boom-bust cycles, whichever is shorter. Although boom-bust cycles are often 3-5 years in length, they may be considerably longer or not occur at all (Nyblade, 2022). If an applicant for a SSS chooses to submit population data spanning fewer than ten consecutive years, that data should show an obvious trend or a stable cyclical pattern that encompasses at least two full boom-bust cycles. Examples of a declining trend and stable cyclicity that require long-term monitoring to effectively elucidate can be seen in Figures 2 and 3, respectively.

Figure 2. Box plots indicating wild rice density on Breda Lake (St. Louis County, MN) from 1998 to 2014 (Kjerland, 2015). Long-term monitoring reveals reductions in density that may not have been evident if examining density across a shorter expanse of time.

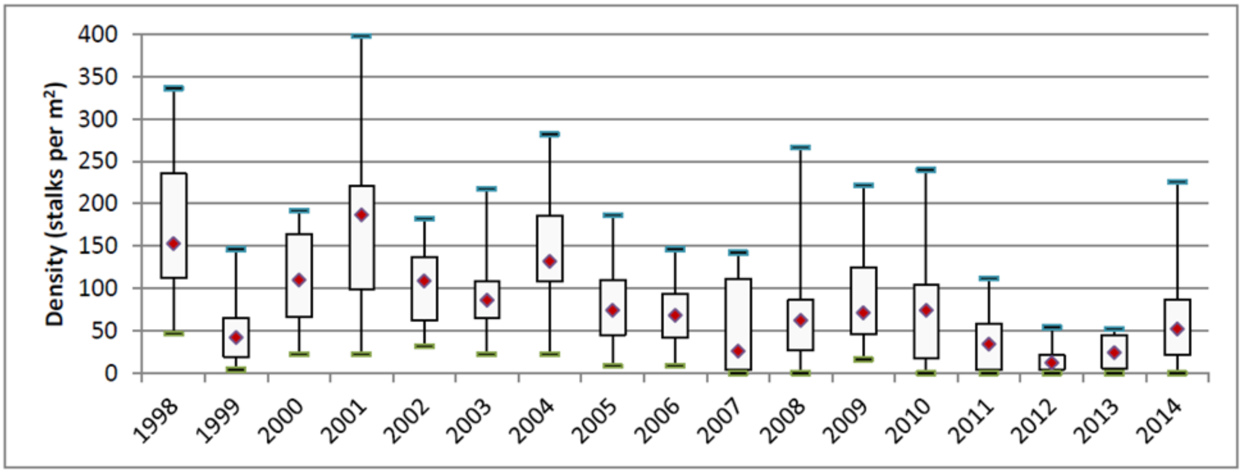
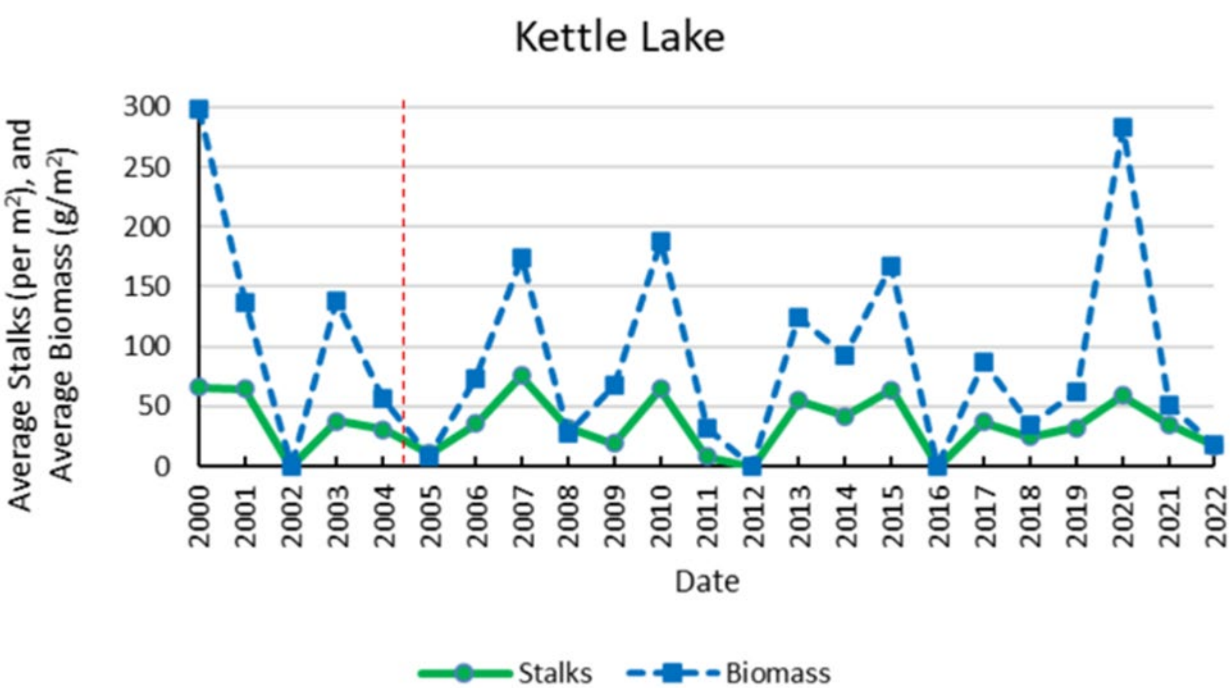


Figure 3. Long-term wild rice monitoring data on Kettle Lake (Carlton County, MN) collected by the 1854 Treaty Authority (Vogt, 2023). The data clearly show wild rice productivity cycles, with boom years following years with little to no production and indicate no statistically significant downward trend in wild rice abundance. The red line at 2005 indicates that the 1854 Treaty Authority changed its sampling methodology in that year.



The MPCA recommends ten years (or two boom-bust cycles) as the default starting point for a wild rice monitoring plan because we expect that this length of time is needed to show a clear population trend, if one exists, under favorable circumstances. The MPCA acknowledges, however, that there may be circumstances in which monitoring over even longer periods is needed to reveal a long-term trend or confirm a possible trend, due to the complexity of natural variability and/or interference from confounding factors. The agency may request additional wild rice monitoring if an application seems generally promising but has not conclusively demonstrated that the beneficial use is met in the waterbody due to ambiguous or abbreviated population data. If it is clear that the beneficial use is not, or will not, be met, the SSS application will be denied without requesting further information. Monitoring should yield enough data to understand whether a year of poor productivity reflects an anomaly, part of normal population cyclicity, or part of a downward trend. Ideally, an application will also contain sufficient monitoring data to examine whether a period of high productivity is part of normal cyclicity, part of an upward trend, or is subdued relative to prior periods of high productivity (which suggests the possibility of long-term population decline).

Example – Mississippi River

The Mississippi River at Pool 8 is a good example of where long-term monitoring can support the evaluation of wild rice productivity and inform a determination on whether the wild rice beneficial use is met. Since 1989, the USGS has monitored wild rice in Pool 8, tracking both wild rice location and relative abundance (Figures 4 and 5). Wild rice within Pool 8 has increased in spatial extent and relative abundance, especially after 2007, and is clearly not in decline. Sulfate concentrations in Pool 8 and nearby stretches of the river consistently measure between 30 and 50 mg/L. Together, these pieces of evidence suggest that wild rice in Pool 8 is not at risk of decline due to current levels of sulfate in the Mississippi River.

Figure 4. USGS data showing wild rice abundance in the Mississippi River Pools 4 and 8 (Minnesota-Wisconsin) and Pool 13 (Iowa) over time (Figure F11 in Houser et al., 2022).

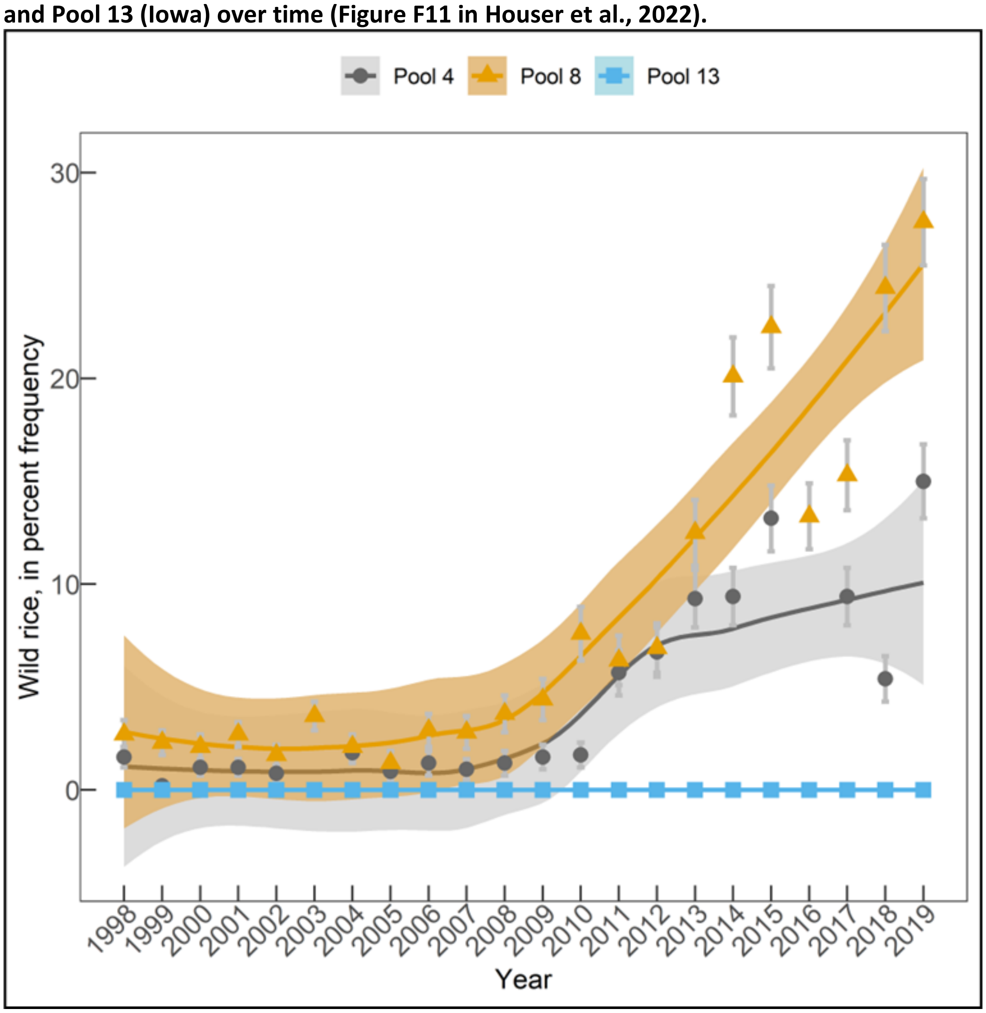
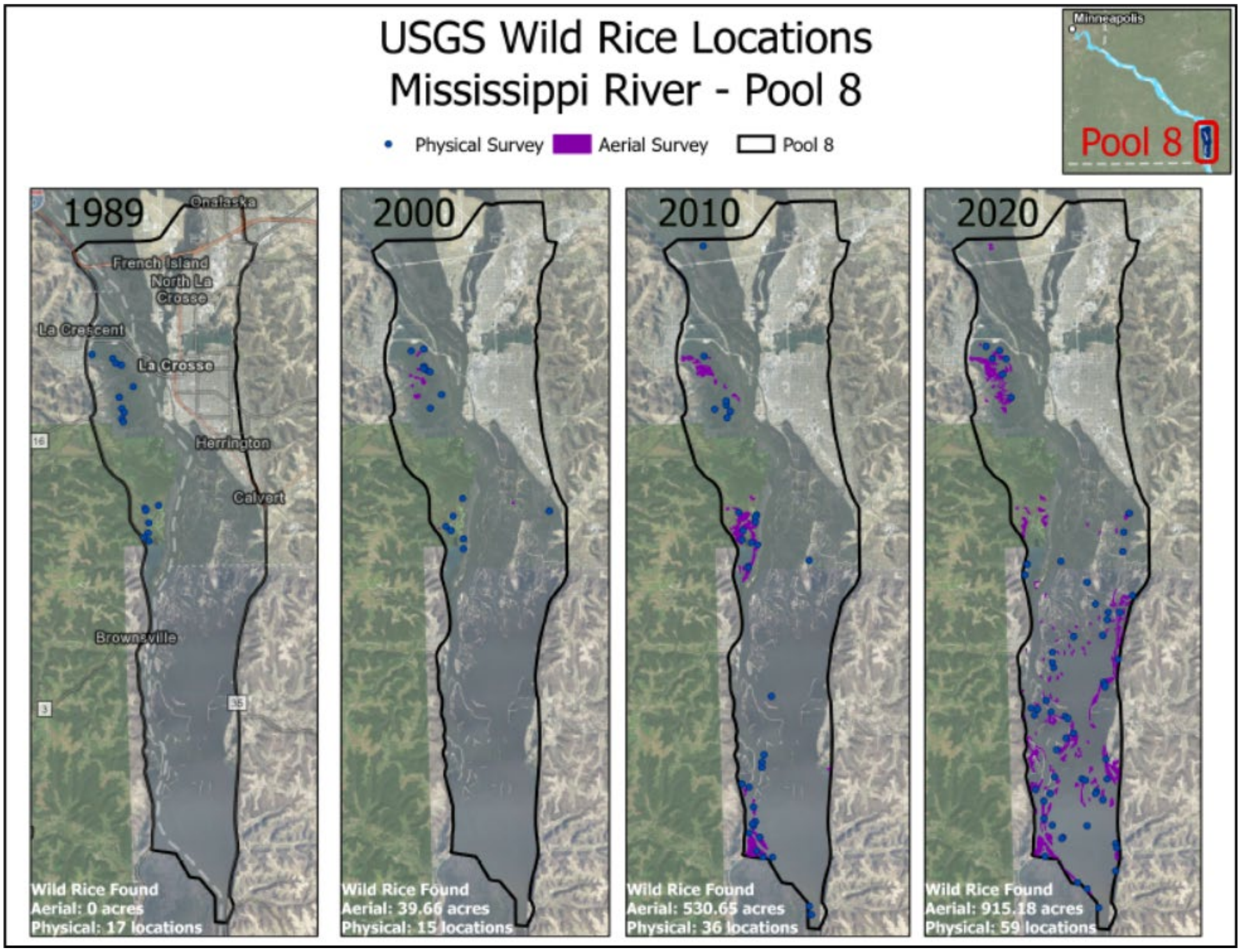


Figure 5. Wild rice locations in Pool 8, as identified by physical and aerial surveying, from 1989 to 2020 (from Houser et al., 2022).



Water quality monitoring

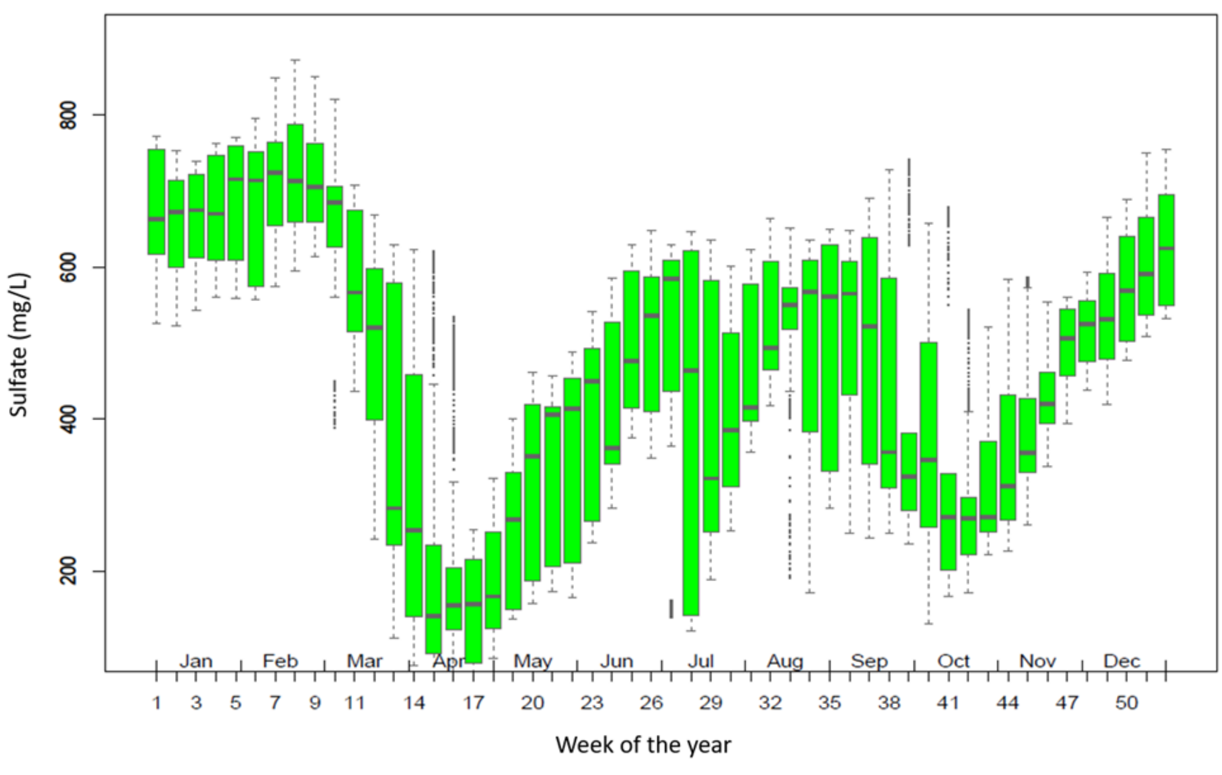
The MPCA expects an applicant for a SSS to perform water quality monitoring in the waterbody of interest. Routine sulfate measurements are an essential part of understanding any relationship between wild rice production and sulfate levels in a specific waterbody. Surface water samples should be collected for sulfate measurement during each of the years that wild rice is monitored by the applicant. In some situations, it may be necessary to rely upon wild rice monitoring data that had been collected prior to initiation of an SSS proposal and that had not been paired with detailed sulfate measurements in all years. However, the applicant should still ensure that sufficient sampling has occurred to adequately describe the local range and variation in sulfate concentration (see further below) and to effectively characterize sulfate concentrations over a recent, multi-year period of wild rice monitoring.

The MPCA also encourages measurement of additional parameters that help to understand biogeochemical conditions in the waterbody that may influence the growth or distribution of wild rice (temperature, dissolved oxygen, nutrients including nitrate-N or total N, specific conductance, suspended solids, etc.). Supplemental measurements on samples collected at various depths in the water column – particularly measurements of sulfate in bottom waters near the sediment-water interface – are also encouraged. Sulfate measurements at multiple depths will help to determine whether any lenses of low-sulfate water occur at the surface (measurements restricted to these lenses would not adequately represent sulfate conditions in the waterbody as a whole) and whether bottom waters differ substantially from surface waters in their composition (sulfate levels in bottom waters may better represent availability of sulfate to bacteria that convert sulfate to toxic sulfide in the sediment porewaters).

Sulfate concentrations should be measured at multiple locations within a waterbody – particularly in large or complex waterbodies with multiple bays, inlets, side channels, or backwaters – where sulfate levels may be persistently elevated or diluted relative to other portions of the waterbody. It is important to observe how sulfate levels vary in relationship to where wild rice grows within the waterbody, as such information may help to inform the determination of a numeric sulfate value that is protective of the wild rice beneficial use. If, for example, wild rice is consistently absent from a bay containing higher levels of sulfate (but that is otherwise characterized by favorable growth conditions), and it thrives in portions of the waterbody containing lower levels of sulfate, the proposed numeric sulfate value for the SSS should be lower than the concentration observed in the bay.

Any proposal for a SSS should account for seasonal variations in sulfate concentration, which are substantial in some environments (Figure 6). Water samples for sulfate measurements should be collected during multiple seasons – perhaps monthly or even at finer frequency until the full range of sulfate concentrations in the waterbody can be adequately captured and understood. Annual measurements that are restricted to a single month or season are insufficient, as they will not show the full range of likely sulfate concentrations. Measurements across multiple years are necessary to capture possible interannual variation resulting from climatic differences (e.g., drought, flood), variable tributary flows, sulfate discharges, or other factors.

Figure 6. Weekly sulfate concentrations predicted for the Sand River (St. Louis County, MN), from 2017 through 2021, based on measurements of specific conductance (Great Lakes Indian Fish & Wildlife Commission, 2022). In this location, a strong relationship between sulfate concentrations and specific conductance enables the use of one parameter to predict the other. Seasonal variation in predicted sulfate is several fold.



The MPCA expects an applicant for a SSS to provide detailed analysis of spatial and temporal variability in sulfate concentrations across the waterbody of interest. Such analysis is an essential part of any SSS application, necessary to characterize current chemical conditions and identify whether they have changed over time, to inform the determination of an appropriate numeric sulfate value, and to understand the waterbody in comparison to others in the same general region. The analysis should include all sulfate data available for the waterbody, produced at any time by any party (including MPCA). Any prior measurements of sulfate should be presented, summarized, and statistically examined. MPCA recommends that the applicant check the following sources for available data:

- The MPCA databases (contact MPCA for assistance in retrieving data)
- Databases maintained, and reports produced, by other agencies that may be performing research or monitoring in the waterbody or within the general geographic area (e.g., Metropolitan Council, USGS, DNR, U.S. Forest Service)
- Academic literature (search Google Scholar or academic databases)
- Tribal water quality monitoring records or reports (contact appropriate tribal representatives or offices to inquire about any pertinent data that is sharable)
- Internal reports or consultant reports that may contain water quality data

Analysis of sediment and porewater chemistry

Because wild rice germinates in, and grows from, the aquatic sediments of a waterbody, it is important to understand the geochemical composition of those sediments and of the sediment porewater in the root zone of the plant. MPCA recommends exploring the following categories of supplementary data, which may provide evidence to support a proposed SSS. Please note, however, that the agency does not support their use as a primary means to derive the magnitude of the numeric standard.

Measuring sulfide concentrations in sediment porewater

- MPCA is interested in understanding the extent to which sulfate in the waterbody is converted into sulfide and the extent to which sulfide accumulates within sediment porewaters.
- Accumulation of sulfide (hydrogen sulfide [H_2S] and bisulfide [HS^-]) in sediment porewater is a primary controlling factor on wild rice occurrence (Myrbo et al., 2017). At elevated levels, sulfide has shown to affect seedlings, causing reductions in emergence and survival (Pastor et al. 2017). Wild rice is also vulnerable to sulfide during later life stages, when nutrient uptake and seed production may be inhibited (Johnson et al., 2019; LaFond-Hudson 2018, 2020).
- The MPCA recommends collecting porewater samples from multiple wild rice stands, specifically within the root zone of existing wild rice plants and then comparing measured porewater sulfide concentrations to potential toxicity effect thresholds that have been explored in the scientific literature, some of which can be found in a previous technical support document published by MPCA (MPCA, 2017a). Collecting samples during the seed production phase of the plant is recommended; collecting additional samples at other times of the year, particularly during the germination phase, is also encouraged. Field sampling suggestions and methodological guidance can be found in the MPCA document "Sampling and Analytical Methods for Wild Rice Waters" (MPCA, 2017b), which was originally prepared as a companion to proposed rulemaking in the same year. Applicants may contact MPCA to obtain this document and to discuss sampling plans.
- Data produced from such efforts will help to understand the extent of spatial and temporal variability in porewater conditions that may affect the production of wild rice in the waterbody and help to evaluate whether the beneficial use is likely to be maintained into the future. If

measured porewater sulfide concentrations are consistently low relative to suspected toxicity thresholds, this lends support to the contention that the wild rice beneficial use is protected under current conditions and that the beneficial use will be maintained in the future if those conditions persist. If sulfide concentrations exceed suspected toxicity thresholds, then greater scrutiny of a SSS proposal based on a “current conditions” method to determining the proposed sulfate magnitude is warranted.

- Any existing porewater sulfide data for the waterbody, produced at any point in time by the applicant or by any other party (if known), should be presented for comparison.

Measuring the chemical composition of bulk sediment

- MPCA recommends collecting short sediment cores from wild rice growth areas for the purpose of measuring total extractable iron and total organic carbon. These variables, along with sulfate concentration in the overlying water, influence variations in porewater sulfide concentration (Pollman et al., 2017), which in turn impacts the health and production of wild rice. Field sampling suggestions and methodological guidance can be found in the MPCA document “Sampling and Analytical Methods for Wild Rice Waters” (MPCA, 2017b), which was originally prepared as a companion to proposed rulemaking in the same year. Applicants may contact MPCA to obtain this document and to discuss sampling plans.
- Bulk sediment data will provide helpful geochemical context and may enhance understanding of the relationship between concentrations of porewater sulfide and surface water sulfate in the waterbody.
- The MPCA may use the data as inputs to a sediment-based equation that was proposed during the 2017 rulemaking attempt (original or revised). The equation predicts a sulfate concentration value associated with a defined porewater sulfide concentration, based on measurements of total extractable iron and total organic carbon in the sediment. If the equation output is greater than the proposed magnitude of the SSS, the result provides some support for the application (i.e., the calculation is consistent with the argument that the wild rice beneficial use will be protected). If the equation output is less than the proposed value, then the equation predicts that wild rice would not be adequately protected at the proposed sulfate concentration, and extra scrutiny of the SSS application is warranted.
  - Some caution is warranted in application of the sediment-based equation because: 1) it can return sulfate concentration values that are thought to be unsupportive of wild rice, at least in some environments, as evidenced by growth experiments in mesocosms (Pastor et al., 2017; Johnson et al., 2019; LaFond-Hudson et al., 2022); 2) it does not directly establish that the beneficial use is attained, but rather predicts a sulfate concentration value that corresponds to a suspected sulfide toxicity threshold at 120 µg/L (or whichever threshold is specified), based on local sediment geochemistry; and 3) concerns have emerged that the degree of protection against sulfide that is afforded by iron may not be as great as originally conceived, or as expressed within the equation, due to the formation of iron sulfide plaques on wild rice roots when porewater sulfide concentrations exceed a certain level. Further investigation into this topic is needed, as it is presently unclear whether iron sulfide plaques are a cause or a symptom (or both) of the deleterious impacts of high sulfide levels on wild rice.
- Any prior measurements of total extractable iron and total organic carbon (paired) performed on sediments collected from the waterbody should be presented for comparison.

Historical context

When considering whether the wild rice beneficial use is presently met in the waterbody of interest, it is important to review all relevant historical data and information concerning its wild rice population and the local water chemistry. Much can be gleaned from historical documentation that extends beyond the reach of modern data collection. It is also important to gather and evaluate information regarding historical changes in surrounding land use; local hydrology, water management, and waterbody use; pollutant discharges, restoration efforts, and wild rice harvesting.

MPCA expects an applicant for a SSS to gather, describe, and evaluate all historical context that is knowable and relevant, including:

- Any and all known data and information concerning changes in sulfate loading or transport to the waterbody of interest.
- Any and all known data and information concerning wild rice production, productivity, or harvest in the waterbody (These include lake survey reports, technical memoranda, harvest records, on-site photographs, and interpreted aerial and satellite imagery. The applicant may wish to contact experts at the Minnesota DNR, University of Minnesota, or elsewhere for input on how to use aerial and satellite imagery to identify historical presence and extent of wild rice.)
- Any prior analysis concerning sulfate impacts upon wild rice in the waterbody.
- Detailed explanation of any modification to the local environment undertaken by the applicant, or water management decision rendered by the applicant, that potentially affects the health or productivity of wild rice in the waterbody.

The MPCA encourages the applicant to thoroughly examine any archived reports or waterbody surveys produced by the Minnesota DNR (see Figure 7 for example), U.S. Fish & Wildlife Service, or other sources that describe the waterbody or its surroundings. The agency additionally encourages the applicant to seek and consider traditional ecological knowledges (TEK), if available and sharable by appropriate tribal representatives, that may provide invaluable insight into historical wild rice abundance, extent of ricing activity, or ecological conditions at a given location.

Figure 7. Historical documentation of wild rice conditions on Sandy Lake, extracted from an aquatic vegetation survey report prepared by the predecessor to the Minnesota DNR (Minnesota Division of Game and Fish, 1966).

LAKE Sandy
COUNTY(IES) St. Louis

V. BIOLOGICAL CHARACTERISTICS OF LAKE

OBSERVATION DATE (PLANTS) Sept. 3, 1966

AQUATIC PLANTS (SEE PAGES 18 AND 19 - MANUAL OF INSTRUCTIONS FOR GAME LAKE SURVEYS)

SPECIES OF EMERGENT AQUATIC PLANTS

ABOUT 80% PERCENT OF THE PRESENT LAKE WATER AREA IS COVERED BY STANDING EMERGENT VEGETATION.

COMMON NAME	SCIENTIFIC NAME	*RELATIVE ABUNDANCE	DISTRIBUTION	**FOOD VALUE TO WATERFOWL
Wild Rice	Zizania aquatica	Common	general	E
Pickerelweed	Pontederia cordata	Occasional	N.E. part of lake	-
Stiff Wapato	Sagittaria rigida	Occasional	N.E. part of lake	-
Greenfruited burreed	Sparganium chlorocarpum	Rare	Outlet only	F
Needlerush	Eleocharis acicularis	Rare	Outlet only	F-G

DESCRIPTION AND LOCATION OF EMERGENT PLANT DISTRIBUTION (OUTLINE EMERGENT PLANT AREAS ON MAP)
Wild Rice stand in excellent condition over entire lake.

LAKE Sandy
COUNTY(IES) St. Louis

WILD RICE

LOCATION OF WILD RICE STANDS IF PRESENT (OUTLINE ON MAP)
general throughout lake.

DENSITY AND CONDITION OF WILD RICE STANDS IF PRESENT
The stand was generally very dense and in good condition. Several boats were ricing on the lake.

HISTORY OF WILD RICE HARVESTS
The lake is apparently riced whenever there is a sufficient stand.

Monitoring reports produced by the 1854 Treaty Authority for Sandy Lake and Little Sandy Lake, located north of Virginia, Minnesota, serve as excellent examples of using historical analysis in combination with recent surveying to identify major changes in wild rice production that have occurred over time (see: Vogt, 2022). Wild rice populations had once flourished in these waterbodies but today are greatly diminished, likely due to seepage of high-sulfate waters from an upstream iron-ore tailings basin constructed by U.S. Steel beginning in 1966.

If analysis of historical data and information relating to wild rice production indicates that a population exists in a substantially degraded state – a suppressed condition caused by any stressor or combination of stressors, not necessarily including sulfate – then the wild rice population should not be considered productive, and the beneficial use should not be regarded as met. MPCA does not intend to approve an application for a SSS that is less stringent than the statewide sulfate standard when wild rice is substantially diminished relative to historical norms for the waterbody, even if evidence is supplied that wild rice can likely tolerate sulfate concentrations greater than 10 mg/L.

Literature and data review

It is important to evaluate all relevant chemical, hydrological, and biological data – not only those generated from on-site monitoring and sampling, but also those published in recent studies – to demonstrate that arguments supplied in the SSS application are consistent with current scientific knowledge. Minnesota's tribal communities and the Minnesota DNR have collected important data that are publicly available on their websites. Additionally, it is important to evaluate data uncertainties and acknowledge statistical uncertainties, as the growth and expression of wild rice is inherently variable, as may be the relationship between ambient sulfate and wild rice production. Consider the application of statistical concepts such as confidence limits, Type I/II error analyses, and sampling errors where appropriate, to describe and justify a protective site-specific standard or the data which underpin it.

Regional analysis and comparison of ambient sulfate concentrations

Sulfate levels measured within the waterbody of interest should also be examined within a larger geographic context. Surface water sulfate concentrations vary widely across Minnesota, ranging from less than 1 mg/L near the Boundary Waters to upwards of 5000 mg/L along the South Dakota border. Sulfate concentrations in the Northern Lakes and Forest ecoregion are nearly always below 10 mg/L, except for waters flowing from the Iron Range, where taconite mines and tailings basins contribute substantial sulfate loads. Many wild rice waters in the southern and western regions of the state contain levels of sulfate elevated well above the 10 mg/L Class 4A statewide sulfate standard, due to a combination of natural (geologic) and anthropogenic (largely non-point agricultural) sources. MPCA encourages applicants to consider how sulfate concentrations in the waterbody of interest compare to ambient sulfate levels in nearby waterbodies – particularly those with analogous characteristics – as well as to concentration ranges observed across the region (e.g., ecoregion, county, watershed, area of similar land use). Analogous waterbodies are those with similar basic physical, hydrologic, and biological characteristics. The applicant may wish to consider likenesses of substrate, hydrology (degree of groundwater influence, lentic vs. lotic character, extent of connectedness to other waterbodies, water depth), biology (composition of aquatic vegetation, extent of herbivory or animal interference), soil and land use characteristics in the immediate watershed, morphometry (size, bathymetry, slope), shoreline character, and/or other conditions of the waterbodies and their surroundings.)

The following questions may be helpful to consider:

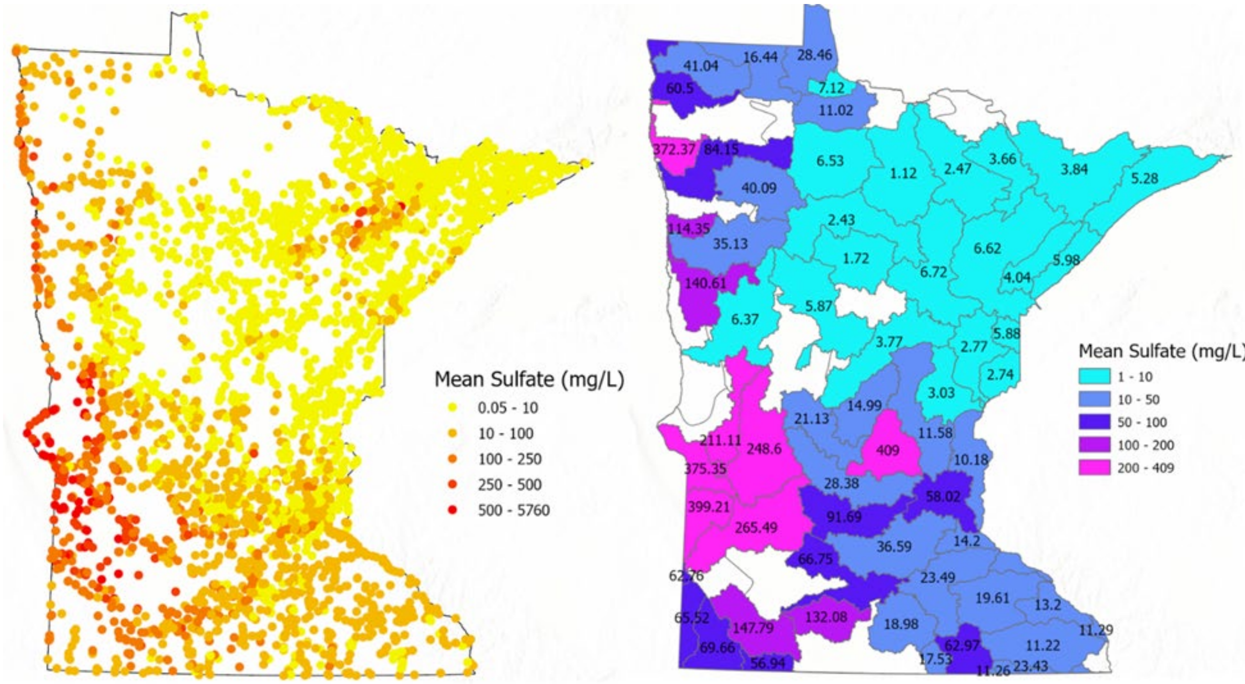
- Within a defined spatial boundary (local or regional extent), what are typical ambient sulfate concentrations in waterbodies that appear to contain productive and healthy wild rice populations? How do sulfate concentrations in those environments compare to those in the waterbody of interest?
- Within that same spatial boundary, are there waterbodies in which wild rice appears to be consistently sparse, unproductive, or unhealthy? Is elevated sulfate a possible reason why wild

rice is not productive in those locations (or are confounding factors or unsuitable growth conditions more likely determinant)? How do sulfate concentrations in those waterbodies compare to sulfate concentrations in waterbodies with productive and healthy wild rice populations? How to they compare to sulfate concentrations in the waterbody of interest?

  - MPCA also encourages documenting, and then contrasting, sulfate concentrations that have been recorded for waterbodies containing wild rice and waterbodies containing no wild rice (within the spatial boundary). Significant differences may emerge that provide additional insight into the typical sulfate concentration ranges that locally support (or prevent) wild rice growth.

- What is a “normal” sulfate concentration range for the local or regional environment?
  - Consider obtaining (existing data stored in MPCA databases or available through other parties) or measuring (new field collection effort) sulfate concentrations in 1) waterbodies receiving point-source discharges of sulfate-containing effluent; 2) waterbodies receiving sulfate loads from non-point agricultural sources or other anthropogenic non-point sources on the landscape; 3) waterbodies unaffected (or nearly so) by anthropogenic additions of sulfate (other than aerial deposition).
  - Comparison of sulfate concentrations and ranges across these environments may help to estimate “natural background” conditions (absent anthropogenic sources) or “regional baseline” conditions (absent only point sources, but typical for the dominant land use in the area; Figure 8). Knowledge of these conditions may, in turn, help to evaluate the appropriateness of the proposed numeric sulfate value in a SSS application.
  - MPCA recommends reporting the full distribution of data, determining whether the waterbodies are likely impacted or unimpacted by sulfur-containing discharges to local surface water or groundwater, and attempting to identify a sulfate concentration value that would be reasonably expected to support productive wild rice. The value should be statistically and scientifically justifiable (e.g., median of sulfate concentrations recorded in waterbodies containing productive and healthy wild rice in the same watershed). If the value is similar to, or greater than the proposed magnitude of the SSS, the finding provides some support for the SSS application (i.e., the finding is consistent with the argument that the wild rice beneficial use will be protected). If the finding is notably less than the proposed value, then additional scrutiny of the SSS application may be warranted.

Figure 8. Mean ambient sulfate concentrations in surface waters (left, visualized by sample location) and predicted mean sulfate concentration after subtraction of point-source discharges of sulfate (right, summarized by major watershed).

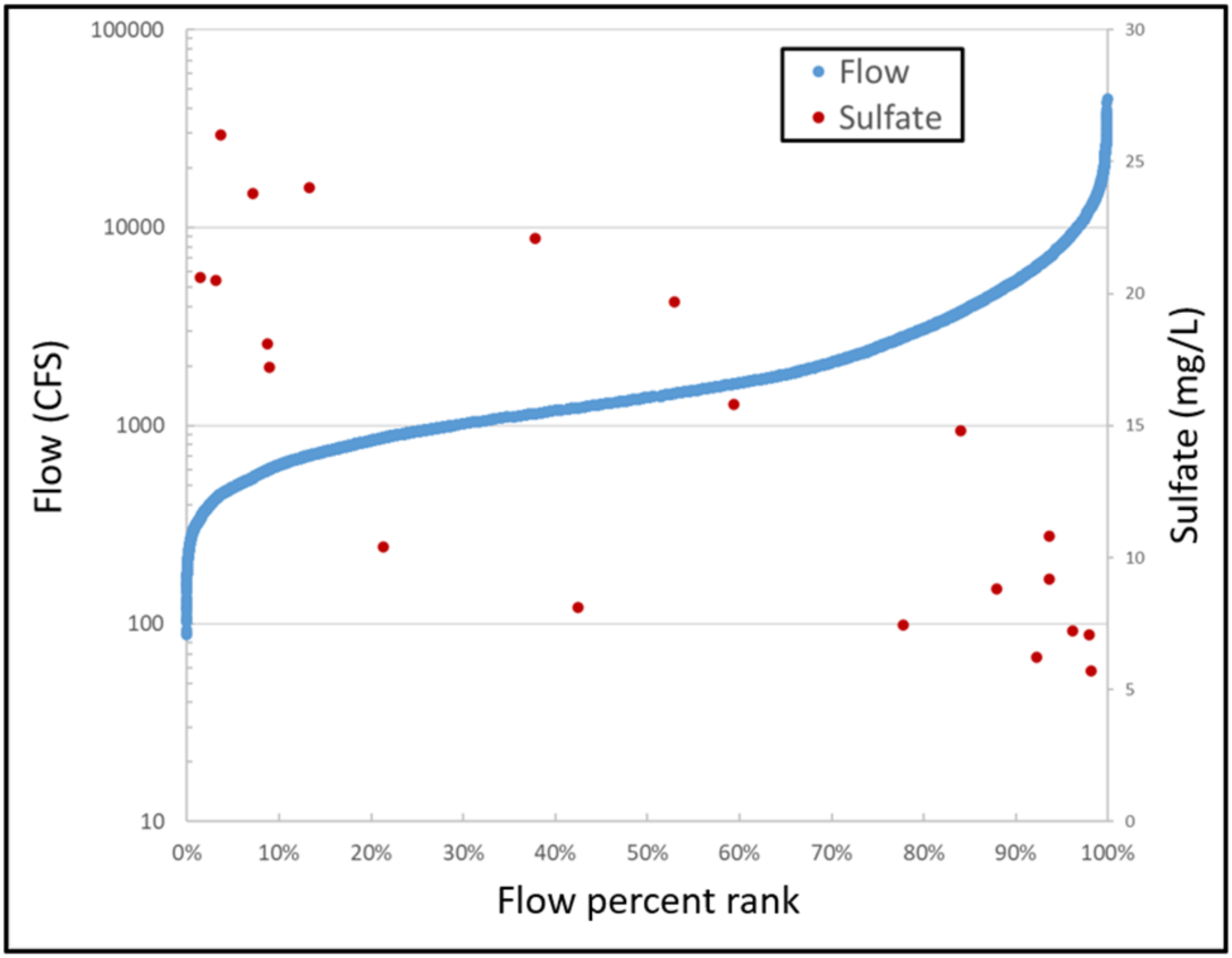


Example – St. Louis River Estuary

The St. Louis River Estuary, an impaired water used for the production of wild rice, is located in the Northern Lakes and Forest ecoregion, where regional baseline concentrations of sulfate are less than 10 mg/L. Sulfate in the St. Louis River Estuary is dominated by loading from mining-influenced water, with upwards of 95% of sulfate loading to the estuary coming from areas containing the mining activity. There are municipal wastewater dischargers in this watershed, but their cumulative effect on sulfate loading is small, making up less than 2% of the total sulfate load. In this watershed, if all loading from point sources was eliminated, the estuary would have a sulfate level of less than 10 mg/L, approximately in alignment with regional baseline sulfate levels.

The St. Louis River at Scanlon, Minnesota, located several miles upstream from the estuary, is a good physical location at which to determine cumulative sulfate loading into the estuary. Here, a river gauge enables estimation of daily river flow, which can be paired with sulfate concentration data recorded for samples collected nearby. A load duration curve (Figure 9), relating sulfate concentration to river flow, indicates that sulfate concentrations increase at low flows (when precipitation-driven contributions of sulfate are lower) and decrease at high flows (when precipitation-driven contributions are greater) – a clear sign that point sources dominate sulfate loading. Construction and evaluation of load duration curves can help to understand the sources of sulfate to a waterbody, provided that sufficient data is available.

Figure 9. Sulfate load duration curve for the St. Louis River at Scanlon, MN.



Confounding factors

Protecting wild rice from the deleterious effects of excess sulfate is the primary focus of this document and an imperative condition for the approval of any proposal for a site-specific modification of the Class 4A statewide sulfate water quality standard. The MPCA also acknowledges that other, non-sulfate stressors – confounding factors that are both natural and anthropogenic in origin – may hinder the wild rice population in a waterbody by interfering with plant growth requirements (appropriate water depth, sufficient available nutrients, adequate light penetration, quiescent cold period prior to seed germination, etc.). These confounding factors include, but are not limited to:

- Modified hydrology (ditching or other artificial drainage, channelization, impoundment, actions or events that drain or inundate a wild rice bed, actions or events that alter the rate or extent of water level fluctuation). Abrupt changes in water level may injure or uproot wild rice during the floating leaf stage of its life cycle. During this and other stages, substantial changes in water level may also impede plant growth via diminished light penetration, loss of physical support (water level decline causing plants to fall over), or other forms of impact.
- Aquatic invasive species and competing vegetation (physical disruption, changes in light penetration due to sediment agitation, displacement by competition). Non-native carp, for example, have habits that disturb sediments and that may uproot plants, increase turbidity, reduce light penetration, and release phosphorus that exacerbates eutrophication. Competition from other plants for growth resources (e.g., light, nutrients, space) is an important factor in the

ability of wild rice to establish and maintain a population. Perennial aquatic plants like pickerelweed, water lily, and cattail, along with introduced aquatic plants like flowering rush and common reed, may establish populations that exclude wild rice. Perennial plants typically gain a competitive advantage over annual plants (like wild rice) where critical physical and chemical needs are consistently available. Reductions in natural hydrologic variation via damming by humans or beavers can favor perennial plants.

- Shoreline development or other land uses (physical removal; effects on sedimentation, light penetration, or fluxes of nutrients or contaminants)
- Boat traffic (physical damage by direct contact or wake effects)
- Pests and disease (e.g., fungal damage)
- Grazing/herbivory by waterfowl or other aquatic animals. Impacts from grazing by Canada geese are widely documented, and control measures to reduce the local presence of geese are sometimes needed to aid in the restoration of wild rice
- Eutrophication (delivery of excess nutrients may induce high levels of algal growth, with concomitant reduction in light penetration that disfavors growth of aquatic plants)
- Climate change (modulation or exacerbation of other stressors, possible reduction in extent or intensity of pre-germination cold period)

Additional discussion of these and other confounding factors that may affect wild rice can be found in MDNR (2008), Moyle (1944), Pillsbury and McGuire (2009), and other sources.

Monitoring and documenting the confounding factors operating within a waterbody may provide important context for evaluating whether wild rice is healthy, robust, and self-sustaining – and therefore whether existing conditions are protective of the wild rice beneficial use. Additionally, monitoring and documenting confounding factors may help to explain trends and anomalies (or the absence of them) in wild rice population data. A thoughtful consideration of potential confounding factors should be included in supporting documentation for a SSS proposal, particularly if the applicant believes that such factors have suppressed wild rice production at any point during the period of wild rice monitoring. If it is determined that non-sulfate confounding factors exert a sustained negative effect on wild rice in the waterbody of interest, such a determination cannot serve as a basis for approving a SSS application. If the local wild rice population is consistently stressed and suppressed due to any reason or reasons, a SSS that is less stringent than the existing statewide standard is not appropriate. In this situation, the applicant cannot reasonably conclude that local conditions will sustain a productive population of wild rice into the future and that the beneficial use will be protected.

Seeking a site-specific standard that is more stringent

Much of the information and discussion contained in this framework assumes that an applicant for a SSS is seeking a higher (less-stringent) numeric standard for the waterbod(ies) of interest, yet the MPCA may develop, and an external party may request, a SSS that is more stringent than the existing Class 4A statewide sulfate standard. Presumably, an application for a more stringent standard would pertain to an environment in which the beneficial use is not currently being met (which the applicant hopes to rectify), as evidenced by a sustained decline in the local wild rice population, low levels of productivity relative to historical norms, and/or presence of only sparse wild rice that raises doubts about the population's ability to sustain itself. In this situation, the applicant, after documenting that the beneficial use is not being attained, should seek to establish that excess sulfate is a primary cause of non-attainment. If excess sulfate is not a primary cause of non-attainment, then one cannot reasonably expect the beneficial use to be attained in the future under a more-stringent sulfate standard. The applicant should therefore also seek to rule out, to the extent possible, other stressors and confounding factors as major contributors to poor productivity or instability in the wild rice population.

After establishing that the beneficial use is not attained in the waterbody and that excess sulfate is the reason (or one of multiple contributing reasons) for non-attainment, the applicant will need to consider how to construct the SSS proposal, namely what method to use to determine an appropriate sulfate numeric value (magnitude) for the proposed SSS. Clearly, the "current condition" method (i.e., applying the current ambient sulfate concentration in the waterbody), as described earlier in the framework, would not be appropriate because the current sulfate concentration does not, in this scenario, protect the wild rice beneficial use.

As with proposals for a less-stringent standard, proposals for a more-stringent standard must demonstrate that a "site-specific modification is more appropriate" than the existing statewide standard. The applicant should explain why a lower numeric sulfate value is more appropriate than 10 mg/L and why its implementation would achieve protection of the wild rice beneficial use. The proposed numeric sulfate value must not be zero. Since sulfate will be naturally present in the environment in some amount, achieving zero sulfate in the water (or zero sulfide in sediment porewaters) would not be a realistic goal. If the existing Class 4A statewide sulfate standard is not sufficiently stringent to ensure the protection of wild rice from harm due to excess sulfate in a given water body, then a site-specific modification of that standard *must* be adopted, as federal regulations at 40 C.F.R. §§ 131.6(c) and 131.11(a) require states to adopt water quality standards that protect the designated use.

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