BUREAU OF WATER QUALITY
PROGRAM GUIDANCE

Wastewater Policy and Management Team

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Calculating Ammonia Nitrogen Effluent Limitations for Surface Water Discharges

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This document is intended solely as guidance and does not contain any mandatory requirements except where requirements found in statute or administrative rule are referenced. Any regulatory decisions made by the Department of Natural Resources in any matter addressed by this guidance will be made by applying the governing statutes and administrative rules to the relevant facts.

APPROVED:

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1/14/2020
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Summary

In 1999, the United States Environmental Protection Agency (EPA) provided an update to the recommended acute and chronic toxicity criteria for ammonia nitrogen in surface waters. These federal updates were adapted into administrative code ch. NR 105, Wis. Adm. Code, in February of 2004. The criteria for salmonid and non-salmonid waters that were developed by EPA correspond to Wisconsin's criteria for coldwater and warmwater sportfish communities, respectively. Procedures for calculating ammonia limits for discharges to surface water based on these criteria are found in ch. NR 106, Wis. Adm. Code.

The intent of this document is to provide guidance primarily to Wisconsin Department of Natural Resources (DNR) limit calculating staff on standard procedures for determining the applicable criteria equations and calculating ammonia limits for surface water discharges covered under Wisconsin Pollutant Discharge Elimination System (WPDES) wastewater discharge permits. This guidance document may also be useful to WPDES permittees and their associates in understanding how to implement the procedures in chs. NR 105 and NR 106, Wis. Adm. Code, to ensure the protection of surface waters receiving wastewater discharges containing ammonia nitrogen.

This document is intended solely to provide guidance for procedures in chs. NR 105 and NR 106, Wis. Adm. Code according to the authority in s. 283.31(3)(d)1 Wis. Stats. Any decisions made regarding ammonia criteria or limits maybe guided by the use of this document as a reference, but ultimately decisions should be made by applying the applicable statues and administrative code with the relevant facts.

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Abbreviations and Definitions

This list contains the most common abbreviations used in this document as well as definitions of frequently used terms.

Acute toxicity	The ability of a substance to cause mortality or an adverse effect in an organism which results from a single or short-term exposure to the substance (s. NR 105.03(1), Wis. Adm. Code).
Acute toxicity criteria (ATC)	The maximum daily concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the acute toxicity of that substance and will adequately protect the designated fish and aquatic life use of the surface water if not exceeded more than once every 3 years. If the available data indicate that one or more life stages of a particular species are more sensitive to a substance than other life stages of the same species, the ATC shall represent the acute toxicity of the most sensitive life stage. (s. NR 105.03(2), Wis. Adm. Code).
Ammonia	As used in this document, ammonia refers to the combination of the unionized (NH_3) and ionized (NH_4^+) fractions of ammonia which is measured in terms of the nitrogen portion, aka ammonia as nitrogen (NH_3-N).
Categorical Limits	Technology-based effluent limits which apply to a group of permittees because of similar manufacturing processes, treatment processes, raw materials, or products.
cfs	cubic feet per second
Chronic toxicity	The ability of a substance to cause an adverse effect in an organism which results from exposure to the substance for a time period representing a substantial portion of the natural life expectancy of that organism (s. NR 105.03(14), Wis. Adm. Code).
Chronic toxicity criteria (CTC)	The maximum 4−day concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the chronic toxicity of that substance and will adequately protect the designated fish and aquatic use of the surface water if not exceeded more than once every 3 years. (s. NR 105.03(15), Wis. Adm. Code).
C_s	Background concentration of the substance (in units of mass per unit volume) as specified in s. NR 106.06(4)(e), Wis. Adm. Code.
Dilution	The process whereby the concentration of the discharged substance is reduced because of the lower concentration of that substance in the receiving system; can be expressed as a simple mass balance. Dilution is related to the receiving water flow and the size of the discharge. The lower the available dilution, the greater the potential for toxic effects.
DNR	Wisconsin Department of Natural Resources
Early life stages (ELS)	The fish life cycle stages beginning at spawning through the end of the larval period, which are demonstrated to be more sensitive to ammonia than adult fish; ELS includes the pre−hatch embryonic period, post−hatch

	free embryo or yolk−sac fry, and the larval period, during which the fish feeds. Juvenile fish, which are anatomically similar to adults, are not considered an early life stage. The duration of the early life stage extends from the beginning of spawning through the end of the larval period (s. NR 106.31(3), Wis. Adm. Code)
Effluent flows (Q_e)	The flow rate in million gallons per day, that represents the expected effluent discharge rate for limit calculation purposes. For continuous dischargers subject to ch. NR 210, Wis. Adm. Code, Q_e typically equals the annual average design flow rate. For all other dischargers not subject to ch. NR 210, Wis. Adm. Code, Q_e typically equals the maximum average annual flow rate. For seasonal discharges, discharges proportional to stream flow, and other unusual discharge situations, Q_e is determined on a case-by-case basis. (s. NR 106.06(4)(d), Wis. Adm. Code).
EPA	United States Environmental Protection Agency
Industrial discharge	Wastewater discharges from industries, any non-municipal wastewater discharge.
Limit of detection (LOD)	The lowest concentration level that can be determined to be significantly different from a blank for that analytical test method and sample matrix.
Limit of quantitation (LOQ)	The concentration of an analyte at which one can state with a degree of confidence for that analytical test method and sample matrix that an analyte is present at a specific concentration on the sample tested.
mg/L	milligrams per liter
Mixing zone	An area where an effluent discharge undergoes initial dilution and is extended to cover the secondary mixing in the ambient waterbody. A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented.
Municipal discharge	Referring to a wastewater treatment facility that treats domestic or mostly residential wastewater. Most commonly (but not always) these facilities are publicly owned treatment works and are subject to ch. NR 210, Wis. Adm. Code.
P_{99}	The upper 99th percentile of a lognormally distributed dataset as calculated in s. NR 106.05(5), Wis. Adm. Code.
Q_s	Stream flow rate used in limit calculations (in units of volume per unit time).
<u>Streamflow Statistics:</u>	
1-Q_{10}	the lowest one-day flow which occurs once in 10 years
7-Q_2	the lowest seven-day average flow which occurs once in two years
7-Q_{10}	the lowest seven-day average flow that occurs once in 10 years
30-Q_5	the lowest 30-day average flow which occurs once in five years

$4\text{-}B_3$	a biologically based design flow; the lowest 4-day average flow which occurs once in 3 years.
<u>Stream Classifications:</u>	Fish and aquatic life designated uses as described in s. NR 102.04(3) Wis. Adm. Code:
LAL	Limited aquatic life system pursuant to ch. NR 104, Wis. Adm. Code
LFF	Limited forage fish community pursuant to ch. NR 104, Wis. Adm. Code
WWSF	Warm water sport fish community
WWFF	Warm water forage fish community
CW	Cold water community
Surface waters	All natural and artificial named and unnamed lakes and all naturally flowing streams within the boundaries of the state, but not including cooling lakes, farm ponds, and facilities constructed for the treatment of wastewaters (s. NR 102.03(7), Wis. Adm. Code).
Toxic substance	A substance or mixture of substances which through sufficient exposure, or ingestion, inhalation or assimilation by an organism, either directly from the environment or indirectly by ingestion through the food chain, will cause death, disease, behavioral or immunological abnormalities, cancer, genetic mutations, or developmental or physiological malfunctions, including malfunctions in reproduction or physical deformations, in such organisms or their offspring (s. NR 105.03(27), Wis. Adm. Code).
USGS	United States Geological Survey
Water quality parameter	One of the indicators available for describing the distinctive quality of water. Those indicators may include hardness, pH, or temperature (s. NR 105.03(30), Wis. Adm. Code).
Water quality criteria	Numeric or narrative standards for protection of a water's designated uses. Numeric criteria are scientifically derived ambient concentrations developed by the State for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal.
Water quality-based effluent limits (WQBEL)	Limits calculated under s. 283.13(5), Wis. Stats., for toxic and organoleptic substances and whole effluent toxicity. These limitations are necessary to assure attainment and maintenance of surface water quality standards as established in accordance with s. 281.15, Wis. Stats., and as set forth in chs. NR 102 to 106, Wis. Adm. Code.
WPDES	Wisconsin Pollutant Discharge Elimination System

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Chapter 1 - Introduction to Ammonia

This chapter is intended to provide a brief introduction to ammonia chemistry, ammonia's presence in wastewater, and the history of policy and code relating to ammonia criteria and permit limits.

Section 1.01: Ammonia Chemistry, Wastewater Occurrence and Background

Ammonia enters surface waters directly via municipal effluent discharges or animal waste, and indirect means such as nitrogen fixation, air deposition, and storm water and agricultural runoff. This pollutant is regulated due to its toxic effects on aquatic life. If elevated levels of ammonia are present in water, aquatic organisms can have difficulty sufficiently excreting the toxicant, which causes toxic buildup in internal tissues and blood, potentially leading to death. Several environmental factors including pH and temperature affect ammonia toxicity to aquatic organisms (Environmental Protection Agency [EPA], 2013).

Although the criteria discussed in this document are commonly referred to as for "ammonia," it is more accurate to refer to the regulated pollutant as "ammonia as nitrogen," since the nitrogen portion of the ammonia is actually what is being measured, reported, and evaluated for compliance rather than ammonia itself. Also, this measurement includes both the unionized and ionized forms of the compound, ammonia (NH_3) and ammonium (NH_4^+), respectively. These two chemical forms are in an equilibrium with one another and are dependent on the pH of the solution. In this document, the term "ammonia" refers to the sum of ammonia and ammonium, which is measured for monitoring and compliance purposes as ammonia-nitrogen (mg/L of nitrogen).

A summary of the nitrogen cycle is provided below. The portions of this cycle that are particularly relevant to wastewater treatment are ammonification, nitrification, and denitrification.

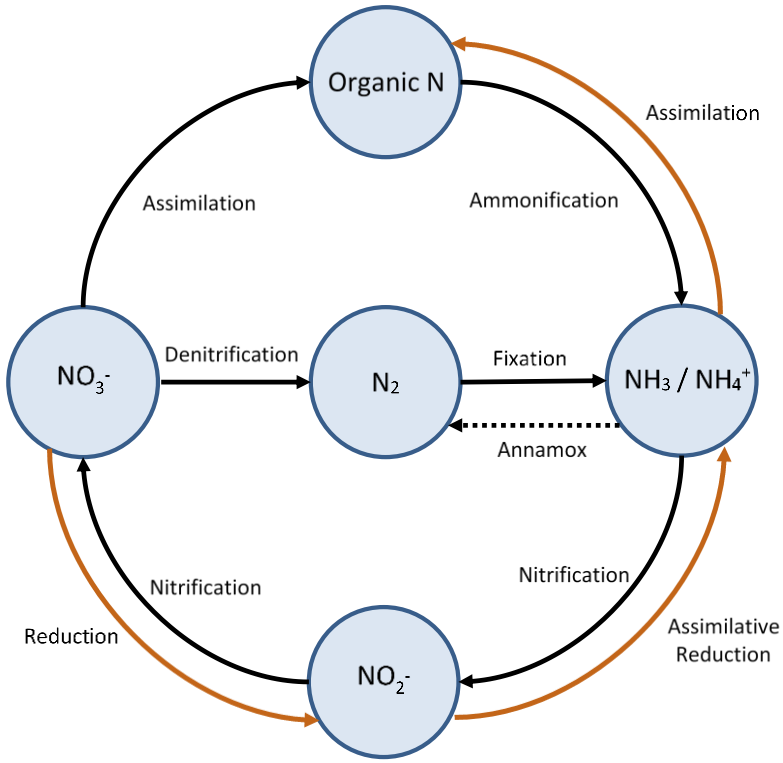

FIGURE 1: NITROGEN CYCLE SUMMARY

Municipal Dischargers:
Nitrogen enters municipal collection systems mostly in the form of organic nitrogen (urea and amino acids). Ammonification naturally occurs in the collection system so that much of the organic nitrogen is converted to ammonia or ammonium by the time it reaches the head works of a wastewater treatment facility.

Biological nitrification is the process of oxidizing ammonia in wastewater to nitrate in a two-step process by two types of aerobic autotrophic bacteria (Nitrosomonas and Nitrobacter). Both types of bacteria require sufficient levels of dissolved oxygen as well as specific environmental conditions relating to temperature, pH, and alkalinity. Where conditions are right, biological denitrification may also take place. Bacteria including Pseudomonas, Alcaligenes, and Paracoccus metabolize nitrates and nitrites, which removes nitrogen from the wastewater in the form of nitrogen gas.

Industrial Dischargers:
While ammonia is most commonly a concern in treatment of municipal wastewater, some types of industrial dischargers can also contain significant levels of ammonia, as follows:

- Dairy Processing – Cheese making and whey processing operations produce several types of process wastewaters including COW water (condensate of whey) and permeate from using reverse osmosis to concentrate a milk or whey product. These waste streams usually go through a treatment system prior to discharge. Dairy processing facilities also commonly discharge lower strength wastewaters such as noncontact cooling water or water softener backwash, which are unlikely to contain ammonia. A surface water discharge from a dairy processing facility often contains a mix of these types of discharges. As a result of this mixture, it is often difficult to estimate expected ammonia concentrations from dairy discharges since they can vary greatly based on the types of waste streams discharged, their relative contributions, and the treatment system utilized. However, in general, the effluent ammonia levels in discharges from dairy processing are often high enough to trigger permit limitations.

- Vegetable Processing – Discharges from vegetable processing, freezing, or canning operations may contain can cooling water, washing water, or cooking water. These waste streams have come into contact with food products and can often trigger ammonia limits. Where biological treatment is utilized to treat the waste streams, lagoons are the most commonly employed treatment system. Discharges may also include wastewater associated with a cooling system such as reverse osmosis reject from source water polishing, noncontact cooling water, cooling tower blowdown, and boiler blowdown. Such discharges are generally not expected to contain significant levels of ammonia and typically do not receive treatment. Similar to dairy processing facilities, a vegetable processing facility may discharge wastewater from both of the aforementioned categories and possibly comingle them prior to discharge.

- Paper Mills – Untreated paper mill process wastewater should not contain high levels of ammonia or any form of nitrogen. In fact, these facilities often add a chemical source of nitrogen to aid in biological treatment. Effluent ammonia levels from paper mill discharges would likely only be a concern if the facility is over-dosing nutrient additions to their treatment process.

Other types of discharges known to be possible sources of ammonia include: other types of food processors, ethanol plants, animal slaughtering facilities, and fish hatcheries.

Ammonia WQBEL Calculation Process Summary:

The ammonia limit calculating process could be broken down into the following steps:

1. Determine the designated use of the receiving water and any applicable downstream uses.
2. Select seasonal ranges for limit calculation.
3. Determine background temperature, pH, and ammonia concentration values for each seasonal range.

   (Steps 2 and 3 can potentially be an iterative process.)
4. Determine a reasonable maximum effluent pH.
5. Calculate acute and chronic ammonia criteria.
6. Calculate acute and chronic ammonia limits.
7. Determine the need for limits based on comparison with effluent ammonia data.
8. Check if the limits meet requirements for antidegradation, antibacksliding, and expression of limits and add any additional required limits.

Section 1.02: Ammonia Code and Policy History

Ammonia Criteria History and Discussion:

As mentioned in the previous section, acute and chronic toxicity criteria for ammonia are based on the 1999 EPA updates, as adapted into ch. NR 105, Wis. Adm. Code, in February of 2004 (EPA 1999). The criteria for salmonid and non-salmonid waters that were developed by EPA correspond to Wisconsin's criteria for coldwater and warmwater sportfish communities, respectively. Unlike other criteria in ch. NR 105, Wis. Adm. Code, two sets of chronic criteria are available for ammonia. EPA and DNR both deemed 4-day and 30-day chronic criteria as appropriate based on the short and long-term response of aquatic life to ammonia exposure. Below is a figure depicting the timeline associated key ammonia criteria updates.

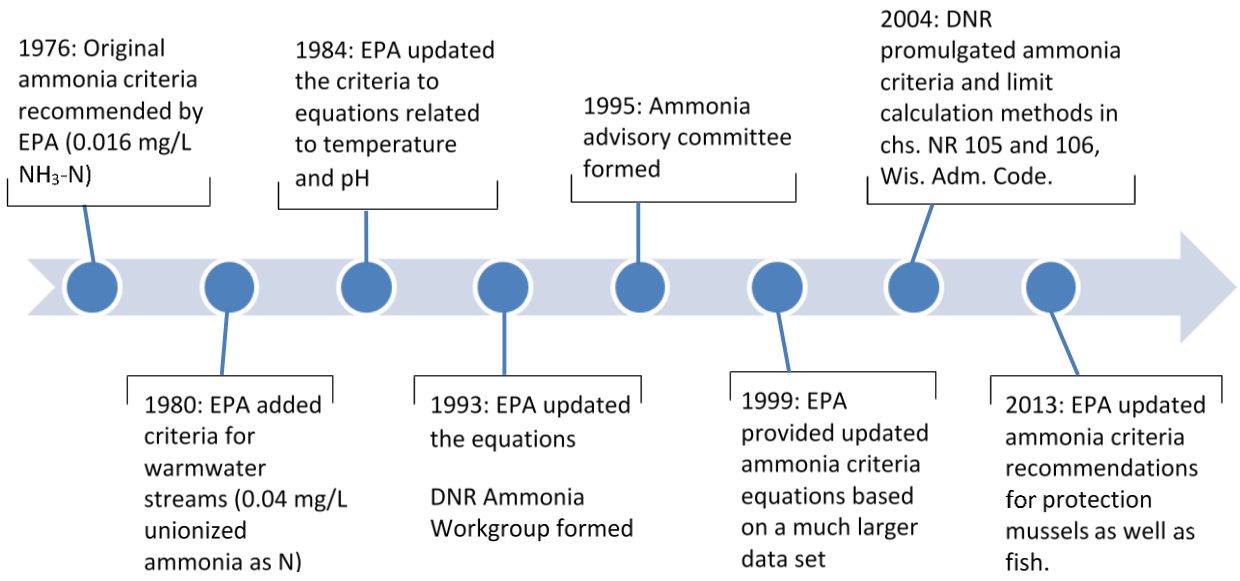

FIGURE 2: AMMONIA CRITERIA TIMELINE

Previous versions of EPA recommendations provided criteria for the unionized form of ammonia (NH_3), which were converted to total ammonia criteria based on the pH and temperature of the water. However, EPA's database used to develop the 1999 recommended criteria demonstrated that the relationship between unionized and total ammonia criteria was offset by the temperature conversion. Also, EPA found that while NH_3 is certainly more toxic to aquatic organisms than NH_4, the ammonium ion can also contribute to the toxic effect. As a result, the 1999 recommended criteria were expressed as total ammonia (as N) rather than unionized ammonia.

Also, as part of the 1999 update, EPA reexamined the pH and temperature dependence of ammonia toxicity. It was found that both factors influence ammonia toxicity. Thus, the 1999 criteria are in the form of equations relating ammonia toxicity to pH and temperature.

The 1999 update provided criteria for warm waters and cold waters (based on salmonid presence or absence). DNR adapted these into more specific criteria based on the presence of species found in Wisconsin waters. Less stringent criteria equations were developed for limited forage fish and limited aquatic life waters based on the expected species. The cold water criteria was subdivided into five categories since not all cold waters contain the full range of cold water species.

20/40 Cutoff for Municipal Discharges:
Prior to September 1, 2016, ammonia limits were not required in WPDES permits for municipal facilities if the calculated limits were greater than or equal to 20 mg/L for the period of May through October or greater than or equal to 40 mg/L for the period of November through April. This was based on the expectation that a typical well-operated secondary treatment plant would be able to meet such limitations without any additional treatment. This provision from code was removed on September 1, 2016 and is no longer applicable. The same reasonable potential procedures must be performed on all calculated limits regardless of their value, as required in s. NR 106.33, Wis. Adm. Code.

In previously issued permits with a table of daily maximum ammonia limits based on effluent pH, the table may have been cut-off where limits exceeded the 20/40 thresholds. In these cases, the table should be expanded to cover the permittee's full allowable pH range as permits are reissued.

Changes to Daily Maximum Ammonia Limits:
On September 1, 2016, DNR revised ch. NR 106, Wis. Adm. Code, to require daily maximum limits based on acute criteria to be calculated using the same mass balance equation as used for other criteria using a 1-Q_{10} receiving water low flow if necessary, in order to be sufficiently protective of fish and aquatic life. Previously, all daily maximum limits for ammonia were calculated as two times the acute toxicity criteria (ATC) regardless of the amount of dilution available in the receiving water. Following the code change, two times the acute criteria is the maximum limit level, but limits may be lower if these limits "are not sufficiently protective of fish and aquatic life" (s. NR 106.32(2)(e)). Generally, this is considered to be the case if the limits based on the available dilution are more restrictive. Because of this change, new calculated daily maximum limits may be significantly more restrictive than those included in current permits.

Mass Limits:
In accordance with s. NR 106.32(5)(b), Wis. Adm. Code, mass limits are not required except where assimilative capacity has been allocated between two nearby discharges or the discharge is to an outstanding or exceptional resource water. Some permits may include mass limits for ammonia as a remnant of previous requirements from prior to the code revision, and these mass limits can be removed from the permit.

Expression of Limits:
Following revisions to ch. NR 106, Wis. Adm. Code, effective September 1, 2016, the following concentration limits are required in WPDES permits whenever ammonia limits are determined necessary:

- Weekly average and monthly average limits for municipal dischargers
- Daily maximum and monthly average limits for industrial dischargers

Procedures for determining these limits are given in ss. NR 106.07(3) and (4), Wis. Adm. Code, and are summarized in Section 5.02 of this guidance.

Chapter 2 - Determining Appropriate Input Parameters

In order to calculate criteria and limits for ammonia according to s. NR 106.33, Wis. Adm. Code, several factors need to be determined. These include:

- The designated use of the receiving water
- For acute criteria:
  - The reasonable maximum effluent pH
- For chronic criteria:
  - Appropriate seasonal ranges to use in calculating chronic limits
  - Receiving water background ammonia concentration
  - The reasonable maximum effluent pH
- For the calculation of chronic limits:
  - Receiving water background ammonia concentration

This chapter is designed to provide guidance on selecting these parameters. Default selections that are appropriate in most cases are provided as well as recommendations for cases where alternative values may be more appropriate and site-specific information is available.

Section 2.01: Receiving Water Designated Use

The sensitivity of aquatic life to ammonia varies based on species and life stage, and the equations for calculating ammonia criteria are broken down accordingly to ensure that the species and life stages present at each designated use are protected.

Acute:
Chapter NR 105, Wis. Adm. Code, includes four different equations for acute ammonia criteria based on the following classifications dependent on the maximum effluent pH level:

- Cold Water Category 1 and 4
- Cold Water Category 2 and 3 (Lakes)
- Warmwater/Limited Forage Fish/Cold Water Category 5
- Limited Aquatic Life

Chronic:
Five equations are presented in ch. NR 105, Wis. Adm. Code, for calculating chronic criteria. The equations take into account both the designated use and protection of early life stages (ELS) in warm waters and limited forage fish waters. Separate equations are available for the protection of early life stages when they are present and less restrictive criteria for portions of the year when they are absent. The classifications for each equation are:

- Cold Water (All Categories) and Warmwater-ELS present
- Warmwater-ELS absent
- Limited Forage Fish-ELS present
- Limited Forage Fish-ELS absent
- Limited Aquatic Life

The same input parameters are used in the equations for each designated use.

Acute and chronic criteria are based on two different set of designated uses so there are many different possible criteria combinations that may apply to a receiving water. Figure 3 visually summarizes all the criteria equation combinations that might apply to a single designated use:

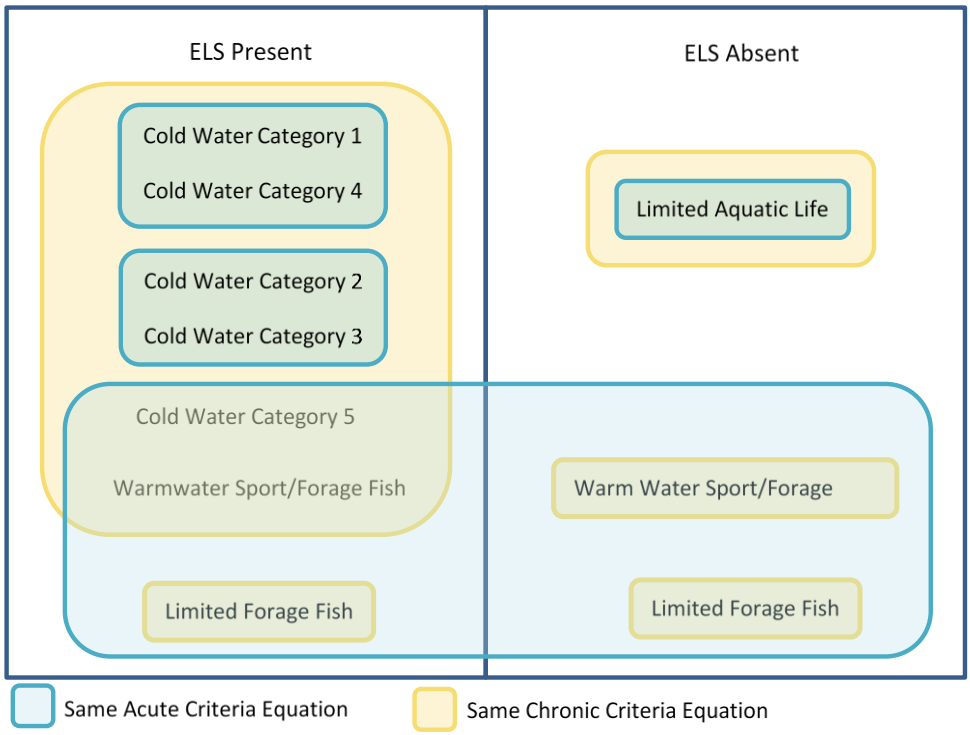

FIGURE 3: CRITERIA EQUATIONS FOR DESIGNATED USES

Cold Water Categories from Table 2C in ch. NR 105, Wis. Adm. Code:

CW Category 1 = Default category of cold water classification. This category includes all fish. [Note: CW Category 1 is always applicable in Lake Superior, Lake Michigan, and Green Bay north of 44° 32' 30" north latitude.]

CW Category 2 = Inland lakes with populations of cisco, lake trout, brook trout or brown trout, but no other trout or salmonid species. This category excludes data on genus Onchorhynchus.

CW Category 3 = Inland lakes with populations of cisco, but no trout or salmonid species. This category excludes data on genera Onchorhynchus, Salmo, and Salvelinus.

CW Category 4 = Inland trout waters with brook, brown, or rainbow trout, but no whitefish or cisco. This category excludes data on genus Prosopium.

CW Category 5 = Inland trout waters with brook and brown trout, but no whitefish, cisco, or other trout or salmonid species. This category excludes data on genera Prosopium and Onchorhynchus.

Currently, there are no known point source discharges to a cold water lake in category 2 or 3. Generally, most cold waters with a discharge will fit into either category 1, 4, or 5. The following decision procedure could be followed in most cases:

Is the receiving water a Great Lakes waterbody?

Yes → *Category 1*

No → Are rainbow trout present in the receiving water?

Yes → *Category 4*

No → *Category 5*

Information on the species present in a receiving water can be obtained from the DNR fisheries database or by consulting with the regional DNR fisheries biologist.

Section 2.02: Seasonal Breakdown of Chronic Effluent Limits

Unlike criteria for most other pollutants, chronic ammonia criteria in Table 4B of ch. NR 105, Wis. Adm. Code, and corresponding limits vary with several factors dependent on the season. The receiving water pH, temperature, and the presence or absence of the fish early life stages (ELS) impact ammonia criteria, and the ambient ammonia concentration and amount of available dilution impact ammonia limits. For this reason, it is typically not appropriate to apply one set of weekly and monthly average limits year-round. Instead, the limit calculation should be broken down into appropriate seasonal ranges based on periods when these factors are fairly similar.

The seasonal breakdown can be as simple as a two-season approach or as complex as individual limits for each month, or some variation in between. Using a larger seasonal range requires more broad and conservative assumptions. Because of this, generally the more detailed the approach, the less restrictive the limits will be (illustrated in Figure 4). When selecting an approach, consideration should be given to the following factors:

- The volume of season-specific data available
- The amount of seasonal variation in the available data
- The impact different seasonal ranges have on the calculated limits
- How close effluent levels are to the calculated limits
- The permitee's interest in limit restrictiveness versus limit simplicity
- The availability of receiving water flows by season or month.
- The current permit limits (and current effluent concentrations) as any increase from the current permit limits would require an antidegradation demonstration under ch. NR 207, Wis. Adm Code.

Default Seasonal Ranges:
Historically the development of more complex WQBEL scenarios have been done primarily for the benefit of the individual permittee. Because of this, the seasonal breakdowns should be kept as simple as practicable, and the burden and responsibility for data gathering and analysis to pursue more complex approaches rests with the permitee.

The simplest recommended approach for seasonal breakdowns is given in Table 1. These ranges are set to maintain appropriate ELS periods and to also group together months of the year when receiving water background conditions are expected to be reasonably similar. This method should yield conservative results that will allow the limit calculator to determine if ammonia limits are necessary based on a reasonable potential determination pursuant to s. NR 106.33, Wis. Adm. Code, and described in Section 5.01 of this guidance. For cold water streams the ELS present criteria are used year-round. For fish and aquatic life waters with burbot, the ELS absent criteria should be used for the months of October through December and the ELS present criteria should be used for January through April. (s. NR 106.32(3), Wis. Adm. Code.)

Table 1: Default Seasonal Ranges

	April	May	June	July	August	September	October	November	December	January	February	March
Coldwater communities	Spring		Summer				Winter					
Warmwater sport/forage fish communities **without burbot**	Spring		Summer				Winter					
Warmwater sport/forage fish communities **with burbot**	Spring		Summer				Fall			Winter		
Limited Forage Fish	Spring	Summer					Winter					
Limited Aquatic Life	Spring		Summer				Winter					

ELS present specified in code
ELS present recommended
ELS absent specified in code
ELS absent recommended

Where it is clear that there is no reasonable potential to exceed ammonia limits or limits are readily attainable, default seasons and background values are appropriate. However, where reasonable potential is shown for the first time limits are changing, or its known that conditions change significantly based on season, it may be worthwhile to perform a more detailed assessment.

Alternative Approaches: There are many possible reasons to deviate from the default seasons in the table above. If based on the standard approach outlined above limits would be required in the reissued permit, staff could explore the appropriateness of alternate ammonia limits based on more complex seasonal breakdowns. These breakdowns could be as simple as breaking out some of the transitional spring and fall months based on temperature alone or as complex as monthly limits with different pH, temperature, and low flow values for each month.

Where permittees already have ammonia limits that have taken effect, considerations should be given to continuing the current seasonal breakdown to avoid unnecessarily complicating the limit calculation process as long as that seasonal breakdown is considered still to be protective. For sites where existing seasonal stream flow data are available, the receiving water background data and effluent data can be broken-down to coincide with the seasonal flow data. The permittee can request and pay USGS to calculate low flows on a seasonal basis. Alternatively, where monthly low flows are available, the minimum low flow from a season can be used as a conservative estimate.

Where default values or general assumptions are used, these assumptions are made more conservatively to be protective of water quality. Because of this, when more detailed or site-specific information is used fewer conservative assumptions may need to be made and limits are typically less

restrictive. This spectrum of detail versus conservatism is represented in Figure 4. Given the number of possible permutations, more complex limits should only be pursued if the facility may not be able to meet limits obtained from more simple approaches. The permitee is ultimately responsible for providing additional monitoring data if needed for more detailed approaches.

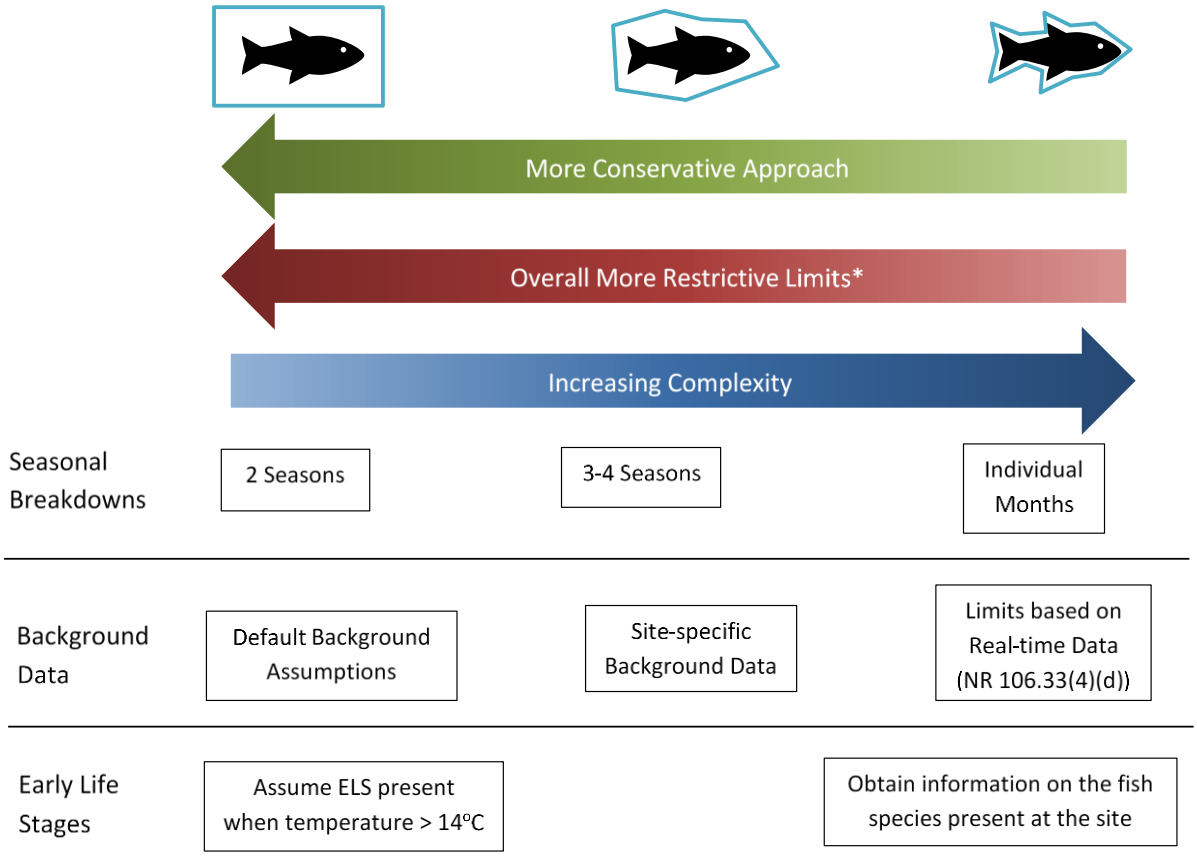

FIGURE 4: VISUAL REPRESENTATION OF MORE DETAILED APPROACH VS. MORE CONSERVATIVE APPROACH WITH EXAMPLES

*This is generally the case, but sometimes a more detailed look at limits and background assumptions can result in more restrictive limits.

Section 2.03: Background Conditions and Water Quality Parameters

It is necessary to determine the appropriate background pH and temperature to calculate ammonia limits because these parameters impact criteria. The best way to determine stream background conditions is to use data collected near the proposed discharge site. Where site-specific background data are not available, default values for each water quality parameter should be used (s. NR 106.06(4)(e), Wis. Adm. Code).

The three aforementioned water quality parameters each have varying levels of impact on the calculated limits. The pH value used has the largest impact on the calculated limits as the chronic toxicity criteria equations are heavily dependent on the pH value. Temperature has an influence on the calculation of the ammonia criteria as well, but mostly at higher temperatures. Measured background ammonia does not impact the criteria, but it can have a minor impact on the calculated limits due to reducing the amount of assimilative capacity available for the discharger. Appendix D includes graphs showing the impact of each parameter on the water quality criteria.

When data is not available at the proposed discharge site, data from other locations on the same stream or from other, similar streams can be used. However, s. NR 106.06(4)(e), Wis. Adm. Code, does not allow the use of data from sites under the direct influence of a point source. In determining whether a monitoring point could be influenced by an upstream point source discharge, hydrologic changes between the discharge and the downstream monitoring point should be considered. Hydrologic changes include additional flows from tributaries and the presence of impoundments. DNR has found that discharges of ammonia can generally be assimilated by a stream within a few miles during the summer but may persist 10 miles or more during winter.

"Default" values are suggested below, but background data from comparable sites are preferred to any default values. Data from nearby streams may be used for informational purposes as a means to check whether the default values are appropriate. However, the ideal situation is to use data upstream of the actual discharge site being evaluated.

Background pH:
In 1994, DNR's Ammonia Workgroup generated default values which are summarized in the Final Report of the Ammonia Workgroup. In 2010, DNR updated these default values as summarized in Table 2. Ambient pH information from around the state was averaged based on the following facts:

- pH is naturally lower in softer water such as that found in northern and western Wisconsin;
- pH is lower in winter months than during summer; and
- pH is higher within and immediately downstream of impoundments due to the presence of algae and other plant growth.

Table 2: Default pH for Wisconsin Streams and Lakes							
	Streams and Non-Impounded Waters						
Hardness (mg/L as $CaCO_3$)	Annual	May-Oct.	Nov.-April	April-June	July-Sept.	Oct.-Dec.	Jan.-Mar.
30 and less	6.27	6.11	6.44	6.11	6.37	6.13	6.50
31 – 50	7.29	7.35	7.19	7.26	7.42	7.18	7.19
51 – 100	7.67	7.73	7.57	7.69	7.75	7.63	7.55
101 – 150	7.85	7.90	7.75	7.85	7.90	7.90	7.77
151 and greater	8.05	8.08	7.99	8.09	8.08	8.06	7.90
	Lakes and Impounded Waters						
30 and less	7.07	7.05	7.09	7.11	7.02	7.05	6.96
31 – 50	7.70	7.76	7.51	7.66	7.84	7.50	7.43
51 – 100	7.98	8.05	7.79	7.92	8.13	7.88	7.64
100 and greater	8.19	8.24	8.05	8.21	8.26	8.18	7.86

For lakes, the "impounded" values should be used unless specific information is available on the lake in question. Unlike other water quality parameters, s. NR 106.32(4)(a), Wis. Adm. Code, specifies the use of an arithmetic mean for averaging background pH data.

Mix pH values may be used to calculate chronic toxicity criteria (s. NR 106.32(4)(a), Wis. Adm. Code), but this requires a demonstration by the discharger that the pH of the receiving water after mixing with the effluent will actually approach the mix pH value. If a demonstration shows a pH other than background will be expected in the receiving water after mixing, that pH value may be used to calculate the chronic criteria and the resulting limits. This is discussed further in the Section 2.03.01.

For streams with zero low flow, there are several possible options for determining an appropriate pH for chronic criteria calculations:

- use effluent pH in place of receiving water pH, assuming that the receiving water is effluent dominated;
- use receiving water pH (or estimated pH based on receiving stream hardness) assuming that pH will likely revert to this value soon after discharge; or
- use ambient pH information from a similar, nearby waterbody if receiving water data is not available.

When receiving water low flows are zero, effluent water quality parameters are typically substituted for receiving water values. However, DNR has generally found that streams tend to have a strong "buffering capacity" and the mix pH tends reverts back to the receiving water pH soon after discharge. Therefore, this same assumption might not be appropriate for pH. A single approach is not recommended in this guidance since the appropriate choice will be dependent on site-specific conditions and the available data.

Background Temperature:

The relationship between toxicity and temperature is especially important with regard to ammonia. A lower temperature produces a lower fraction of the more toxic unionized form and, therefore, more

total ammonia can be discharged without increasing the toxicity. Conversely, ammonia also decays more rapidly at higher temperatures.

The following (Table 3) default ambient temperatures from ch. NR 102, Wis. Adm. Code, can generally be applied where site-specific data is not available.

Table 3: Ambient Temperatures from ch. NR 102 Tables 2, 3, 4 and 5 (°F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cold Water Streams	35	36	39	47	56	62	64	63	57	49	41	37
Large Warm Water Streams ($7\text{-}Q_{10} \geq 200$ cfs)	33	33	36	46	60	71	75	74	65	52	39	33
Small Warm Water Streams ($7\text{-}Q_{10} < 200$ cfs)	33	34	38	48	58	66	69	67	60	50	40	35
Limited Forage Fish	37	39	43	50	59	64	69	68	63	55	46	40
Lower Fox River (below L. Winnebago outlet)	34	34	41	49	66	75	78	76	68	50	40	32
Mississippi River	34	33	38	48	63	74	75	76	65	48	38	34
Rock River (below L. Koshkonong)	34	34	38	52	66	74	77	76	68	54	42	32
Wisconsin River (below Hat Rapids Dam)	34	34	36	53	68	76	77	74	64	46	38	32
Northern Lakes (north of highway 10)	32	32	34	42	57	74	75	71	65	53	37	32
Southern Lakes (south of highway 10)	32	32	38	49	61	74	80	77	69	55	43	32
Northern Lake Michigan (north of Milw/Ozaukee CL)	34	34	35	40	45	47	52	53	50	49	42	37
Southern Lake Michigan (south of Milw/Ozaukee CL)	34	34	35	42	49	55	60	59	57	51	44	37
Northern Green Bay (north of Brown Co. Line)	35	35	35	39	48	55	62	62	58	52	42	36
Southern Green Bay (south of Brown Co. Line)	34	34	38	49	61	66	70	69	66	53	43	34
Lake Superior (except for Chequam. Bay)	35	34	34	36	44	51	58	62	56	49	42	39
Chequamegon Bay	33	33	33	37	51	60	63	67	60	49	38	36

For all stream classifications, the chronic ammonia criteria are the same at temperatures of 7°C and lower. Some of the criteria are also constant at temperatures above 7°C, and that fact will be addressed in the criteria and limit calculations for specific locations and receiving water classifications. Note: Using the equation currently listed in code, LAL criteria continue to increase as temperatures drop below 7°C, but this is an error in the code (March 1, 2004 version) and will be corrected with the next revision to ch. NR 105, Wis. Adm. Code. Currently, calculated LAL criteria are “capped” at a minimum temperature of 7°C.

When consecutive months have similar temperatures, they can be grouped together into a seasonal temperature. In order to be protective of critical receiving water conditions, the maximum temperature from the range should be selected for criteria calculation and the average should be selected to determine the percent stream mixing that is allowed. Selecting seasonal ranges also requires consideration of the background pH, background ammonia values, temperature, available low flow values, and the presence or absence of ELS.

Not every stream should necessarily be handled the same way in terms of background temperature. Some site-specific considerations can be made based on the default guidance, and any available background data, even if fairly limited in scope, can be used as part of this decision process.

Both instream pH and temperature experience significant diurnal fluctuation. Because of this, daily average values are recommended where available for developing chronic ammonia toxicity criteria. Temperature and pH may also be inversely related to stream flow, so the highest (most conservative) background values often occur as stream flow approaches 7-Q_{10} within a season. Thus, the ideal value for background conditions would be a mean from continuous recorded data collected during a drought. Since this data is rarely available, alternatives are commonly used. Techniques are available for adjusting grab sample data to approximate daily mean values, but knowledge of the stream's daily pattern is needed.

Background Ammonia:

Since ammonia shows significant seasonal variation in Wisconsin streams, it is appropriate to group data averages by season. Flow correlation as described below may also be appropriate where sufficient data is available. Averages should be made with a geometric mean in accordance with s. NR 106.32(3)(e), Wis. Adm. Code. Values below an acceptable limit of detection (LOD, usually around 0.0075 mg/L) should be substituted with half of the LOD value in this calculation.

The exact background ammonia concentration is not typically important since the typical background values for ammonia are far below criteria. As part of the mass balance calculation of limits, background ammonia does factor into the equation, even if its impact is small. However, if criteria are very low, a more detailed evaluation of background ammonia levels may be warranted since this data will have a greater impact on limits. Background ammonia values do not affect ammonia limits and do not need to be determined if the receiving water flow is zero.

Table 4 summarizes instream ammonia geomean values from each major drainage basin based on data collected from January 2000 to September 2019 and stored in the Surface Water Integrated Monitoring System (SWIMS) database. Measurements below the LOD value were substituted with one half of the LOD. Each seasonal geomean is based off a minimum of 8 monitoring results. Where sufficient data was available, monthly ammonia values were also calculated and are provided in Appendix C.

Table 4: Ambient Ammonia Concentrations (mg/L)

	Seasons for CW, WW, and LFF			Additional Seasons for LAL		Additional Seasons for WW with Burbot	
	April-May	June-Sept	Oct-Mar	April	May-Sept	Oct-Dec	Jan-Mar
Bad Axe - La Crosse	0.026	0.030	0.045	0.043	0.027	0.024	0.087
Black River	0.046	0.016	0.052	0.16	0.017	0.021	0.13
Buffalo - Trempealeau	0.078	0.019	0.068	0.13	0.022	0.024	0.22
Central Wisconsin	0.047	0.030	0.051	0.055	0.031	0.025	0.11
Fox (IL)	0.035	0.034	0.041	0.034	0.035	0.035	0.053
Grant - Platte	0.020	0.041	0.037	0.014	0.040	0.016	0.11
Green Bay	0.019	0.013	0.023	0.029	0.013	0.012	0.044
Lake Superior	0.011	0.015	0.011	0.010	0.015	0.0085	0.015
Lower Chippewa	0.035	0.033	0.052	0.088	0.027	0.027	0.092
Lower Fox	0.051	0.054	0.088	0.038	0.056	0.079	0.097
Lower Rock	0.041	0.037	0.050	0.042	0.038	0.038	0.061
Lower Wisconsin	0.037	0.024	0.062	0.047	0.025	0.028	0.12
Manitowoc	0.019	0.025	0.025	0.018	0.024	0.016	0.083
Sheboygan/Milwaukee	0.029	0.022	0.037	0.030	0.023	0.023	0.062
Southeast	0.019	0.022	0.037	0.030	0.019	0.019	0.075
St. Croix	0.015	0.017	0.018	0.015	0.017	0.0084	0.043
Sugar - Pecatonica	0.047	0.035	0.034	0.078	0.034	0.021	0.049
Twin - Door - Kewaunee	0.042	0.038	0.051	0.044	0.038	0.055	0.042
Upper Chippewa/Upper Wisconsin	0.023	0.042	0.028	0.029	0.035	0.014	0.058
Upper Fox	0.024	0.041	0.046	0.028	0.036	0.034	0.063
Upper Rock	0.034	0.029	0.055	0.044	0.029	0.022	0.11
Wolf River	0.023	0.019	0.028	0.021	0.020	0.015	0.057

It should be noted that the majority of the available instream ammonia data utilized in the basin-wide values is from rivers. As of 2019, there is too little data available from lakes, smaller streams, and wetlands in order to assess if there is a significant difference in their background ammonia concentrations which would warrant separate default values. This should be considered when assessing the need for and reliability of site-specific ambient ammonia data. For this reason, special consideration should be given to obtaining ambient data for discharges to lakes, small streams, and wetlands.

Seasonal Averaging of Background Data:

Chapter NR 106, Wis. Adm. Code, allows for seasonal calculations of both the water quality parameters related to toxicity (s. NR 106.06 (5)(a)2., Wis. Adm. Code) and the pollutant itself (s. NR 106.06(4)(e)2., Wis. Adm. Code). Instream ammonia, pH, and temperature all have seasonal variability and should be grouped together accordingly. Data for these parameters should not be averaged into a single year-round value.

The most detailed and accurate way to account for all these variables is to develop separate limits using separate values for water quality parameters and monthly 7-Q_{10} values for each month of the year. However, this requires monthly low flow data and at least three data points for each month. Since there is often an insufficient amount of data to do this over an entire year, an alternative procedure is to group stream sample data into logical seasons. When selecting a period for seasonal limits, stream biology and hydrology should be considered. Note that summer biological activity can cause changes in water quality parameters that do not occur at other times of the year.

Low Flow Adjustment of Background Conditions:

Ambient ammonia, pH, and stream temperature can be either directly or inversely correlated with stream flow. In the uncommon case, where a large amount of data is available for these parameters, an attempt should be made to correlate the data with stream flow. This will allow the limit calculator to select a background condition that best reflects the low flow conditions which the limit calculation is intended to model.

A correlation between stream flow and the parameter of interest can be determined using a regression analysis. A minimum of at least 8 paired data points for both flow and the parameter of interest per season (over at least two years) is needed for this analysis. A simple flow correlation analysis can be conducted using the following process:

1. Plot the data from each season of interest against flow to see if a relationship exists.
   If no trend is apparent → No flow correlation is needed. Use the mean of all representative data.
   If a trend is apparent, then proceed to step two below.
2. Try to fit the regression with an equation. The R^2 value from the regression should be above 0.7 (0 to 1 scale) and the relationship should be significant at the 95% level to be a good fit.
   If the relationship can be described with a straight or curved line → Use the regression analysis to predict the water quality value at the 7-Q_{10} conditions for each season.

   Caution should be taken if no data is available at flows close to the 7-Q_{10}. To avoid over-extrapolating the regression equation, use the approach in point 3 below.

   If there is no fit equation with a high enough significance, but a trend is apparent, there should still be some kind of flow adjustment of the parameter. Proceed to step 3.
3. To estimate a value at the low flow condition, use the mean of the values associated with the lowest 10% of flow values. For example, if the sample size is 80, use the data associated with the 8 lowest flows. Do this for each seasonal range separately.

Summary:

In cases where a facility can meet limits based on default approaches and background values, these values may be used. Where a facility cannot meet limits based on these approaches, a more detailed assessment is warranted and options to obtain more precise background values should be considered.

See Figure 4 for a visual representation of this. The approaches and methods on a spectrum of simple/default to complex/precise is summarized below.

a. The possible sources of data in order from simple/default to complex/precise are:
    1. Default regional or statewide values
    2. Similar-site stream data that's readily available
    3. Site-specific stream data (SWIMS or permittee-collected)
b. The methods for averaging data in order from simple/default to complex/precise are:
    1. Averages for each season
    2. Averages for each month
    3. Low flow adjusted values

When averaging data, an arithmetic mean should be used for pH and geometric means should be used for temperature and background ammonia concentrations. To calculate a geometric mean with a dataset which contains non-detect values, substitute one half of the LOD value.

If available, daily mean values for temperature and pH are preferred over grab samples.

Section 2.03.01: Site-specific Ambient Monitoring Recommendations

The previous section dealt with default values and suggestions as to what to use if site-specific information is not available. This section discusses the procedures for collecting site-specific information for cases where a facility may opt to collect site-specific information.

Between the parameters of temperature, pH, and ammonia, site-specific monitoring of pH typically has the most significant impact on the calculated limits. Monitoring recommendations for each parameter are discussed below.

Temperature:
Because the ambient temperature values in s. NR 102.25, Wis. Adm. Code, are based on Wisconsin stream data, site-specific temperature is not expected to vary greatly from these values. Site-specific temperatures are most likely to be useful in the spring and fall months, because the default values vary greatly at those times of year.

Section NR 102.26, Wis. Adm. Code, allows the owner or operator of a facility to submit a request for determination of a site-specific ambient temperature and includes data requirements in order for these determinations to be made. Preferably, site-specific temperature should reflect continuous sampling during low flow conditions, since the criteria are based on long-term (chronic) impacts and limits are calculated using 7-Q_{10} or 30-Q_5 low flows. If continuous sampling cannot be performed, the best estimate of a daily average temperature is likely to occur using samples from mid-to-late morning and/or late afternoon. This may serve as a good midway point between cooler temperatures in evening and warmer temperatures in mid-day. It is just as important to try and do this sampling during times that are as close to low flow as possible, which can be challenging to implement.

Ammonia:
Ammonia concentrations are usually far below criteria and generally do not have a large impact on the calculated limits. However, background ammonia monitoring has the potential to significantly impact limits if the criteria are very low due to high pH conditions or in multiple discharge situations where a more specific and detailed allocation is necessary. The default basin values summarized earlier are typically at or below 0.1 mg/L. Consideration should be given to the significance of different background ammonia values on the final limits before recommending site-specific monitoring.

pH:
Site-specific information on pH can be particularly significant for the final ammonia limits for two reasons:

- Chronic ammonia criteria vary greatly with background pH
- Upstream pH is used to calculate ammonia limits, but this might not reflect the real-world conditions in cases where effluent pH significantly influences the downstream pH.

By default, the background or upstream pH is used to calculate chronic criteria, even though the area where the criteria are being considered is downstream from the outfall. DNR has generally found that even if the effluent pH is much different than the background, in the mixing zone below the outfall, pH values tend to revert back to the background levels, especially in hard water areas such as those in southern Wisconsin. There may be a benefit in making a demonstration that the stream pH below the outfall is significantly different than above the outfall. Considering this, two different site-specific monitoring strategies, as discussed below, are possible.

First, additional data on background pH could be collected upstream of the discharge. Preferably, this would be done during dry-weather periods since the limits are calculated using low flows. The data could initially be compared to background to see if values are significantly different than the default, and if that is the case, a more intensive monitoring program could be considered to account for longer periods of time. A handful of values during one year is not preferable in such situations. A long-term monitoring program should be in place to justify site-specific values, especially if seasonal or month-to-month limits are considered.

Second, a combination of upstream and downstream monitoring could be done (in conjunction with the effluent pH monitoring) to determine the site-specific validity of the assumption that downstream pH values revert to background. Rather than a "mix calculation," this type of assessment empirically determines the overall effect of the effluent pH on ambient stream conditions, again, preferably during low flow periods. If long-term monitoring suggests downstream pH is not equal to background, the downstream pH could be used to calculate chronic ammonia criteria since the criteria are imposed after mixing of the effluent and receiving water.

Real-Time data:

Unlike the limit calculations for other toxic substances, s. NR 106.32(4)(d), Wis. Adm. Code, allows flexibility and use of real-time data in the background values used in calculating ammonia limits. Permittees may be interested in performing site-specific monitoring if it is believed that the default values might not accurately reflect representative conditions at the site.

Section 2.04: Effluent pH Analysis for Daily Maximum Limit Calculations

The measurement of "ammonia as N" includes both the unionized form, ammonia (NH_3), and ionized form, ammonium (NH_4^+). Almost all toxic effects are due to the ammonia (NH_3) portion. Because the balance between ammonia and ammonium is dependent on pH, the pH levels of the discharge determine the daily maximum pH criteria. The relationship is given below:

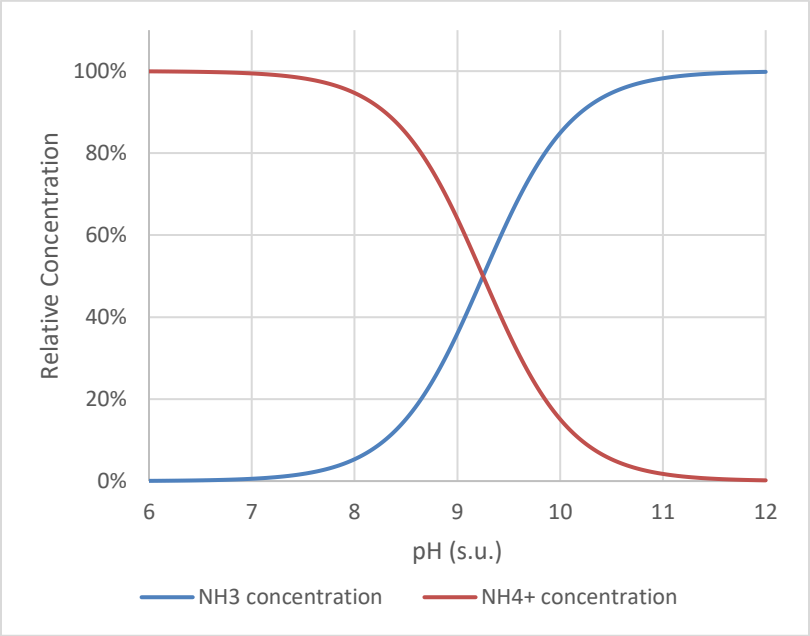

FIGURE 5: RELATIONSHIP BETWEEN AMMONIA/AMMONIUM BALANCE AND PH

In order to calculate acute ammonia criteria, a maximum expected effluent pH must be selected. As the only parameter that affects the acute ammonia criteria, the choice of a maximum pH value to use can make a significant difference to the resulting limit. A pH difference of 0.1 s.u. can represent a 15-20% change in the corresponding daily maximum ammonia limit.

Effluent monitoring for pH is a common WPDES permit requirement, and most wastewater dischargers monitor effluent pH several times a week, daily, or for some industries, continuously. As a result, hundreds or thousands of effluent pH values are typically available from a permit term, and the maximum pH measurement may be from an upset or an unreliable measurement and not represent a maximum pH value that would be present under normal effluent conditions. Therefore, staff should select a "reasonable maximum" pH which reflects the maximum expected pH value at the facility without picking a value that is not protective of water quality. This value should be rarely, if ever, exceeded by the discharge in order to be conservatively protective of the receiving water.

There are several ways of determining the reasonable maximum pH. Possible methods and their advantages and disadvantages are presented in Table 5.

Table 5: Comparisons of methods for determining the reasonable maximum effluent pH

Method	Advantages	Disadvantages
Use recorded maximum pH after removing clear "outliers"	Can eliminate unrepresentative data that should not be considered in a statistical evaluation	Can be very subjective, may not be predictive if there is relatively little data
1-day P_{99} of data set	Similar to other types of WQBEL calculations, predictive capability	May not be representative of the upper 99th percentile of a normal distribution of values
Arithmetic mean plus three standard deviations	Predictive capability	May not be representative of the upper 99th percentile for a distribution that is not normal.
99th percentile	Indicates value that is greater than or equal to 99% of the available data.	No assumptions made of distribution of data, may not be predictive if there is relatively little data

No one procedure is recommended over another, as the decision on which procedure to use will depend on the characteristics of the individual data set and the best professional judgment of limit calculator staff. Staff should remember that the selected reasonable maximum pH should not exceed a pH limit in the permit.

Alternative Daily Maximum Limits:
While the default approach is to use a single year-round daily maximum limit, alternative approaches may be used in some cases, including the following.

<u>Variable Daily Maximum Limits</u>
Section NR 106.32(4)(d), Wis. Adm. Code, allows a facility to request effluent limits based on real-time data. Instead of a single daily maximum ammonia limit, some permits include a table of daily maximum ammonia limits based on the measured effluent pH on that day. This option is particularly useful in cases where the "reasonable maximum" pH is very different than the typical effluent pH. This approach also is recommended where effluent pH data is unavailable or there are significant concerns about much of the recent data's reliability.

Although there may be some situations where use of a table is appropriate, a table for daily maximum ammonia limits adds considerable complexity to the determination of limits and to tracking of compliance. Due to limitations of the SWAMP system, these types of limits cannot be coded in the electronic discharge monitoring report, so the permittee would be required to report the 'calculated variable limit' based on that day's pH measurement. Therefore, this option is not recommended as a default or standard if it is not requested by the facility or does not seem necessary for limit compliance.

Switching the limit format from a single daily maximum to a table based on pH or vice versa is not considered degradation or backsliding which would require a review under ch. NR 207, Wis. Adm. Code.

Daily Maximum Ammonia Limits with pH Limits

If a permittee is facing difficulty in meeting a daily maximum ammonia limit, they may have an easier time controlling their effluent pH level. In these cases, consideration should be given to a daily maximum limit based on a lower effluent pH and a corresponding maximum pH limit. Section NR 106.32(2)(d), Wis. Adm. Code, allows permittees to adjust their pH levels for ammonia limit compliance if approved by the department and allows the department to include a pH limit in the permit alongside a daily maximum ammonia limit. If the permittee proposes to control the effluent pH to meet a certain value, such as by effluent acidification, then the selected pH should be included as a maximum limit in the permit along with the ammonia limit based on that pH.

This approach can lead to situations where the pH limit is exceeded but the ammonia limit is met. In these cases, water quality standards may still be met, but the violation is a result of setting permit limits based on a conservative assumption when discharge conditions are actually more variable. The "Variable Daily Maximum Limits" approach described above avoids this issue. Therefore, consideration should be given to a permittee's ability to maintain a constant pH before utilizing this approach.

Seasonal Daily Maximum Limits

Some types of wastewater treatment systems experience seasonal fluctuations of pH. It is suggested that a single maximum pH be used as a default, but if there appears to be a bias of pH values as well as ammonia values based on seasons, seasonal maximum pH values and corresponding limits could be considered.

Chapter 3 - Calculation of Ammonia Water Quality Criteria

This chapter includes the equations for calculating acute and chronic ammonia criteria for all classifications and for periods of the year when early life stages (ELS) are present or absent. A discussion on determining what parts of the year when ELS are present is also included.

Section 3.01: Ammonia Criteria Equations

Acute and chronic toxicity criteria are available for ammonia in Tables 2C and 4B of ch. NR 105, Wis. Adm. Code. The acute criteria (related to exposures of 96 hours or less), 4-day chronic criteria (for exposures of 96 hours to 30 days) and 30-day chronic criteria (for exposures of 30 days or more) are used to calculate daily maximum, weekly average, and monthly average effluent limits, respectively, based on the procedures in Subchapter IV of NR 106, Wis. Adm. Code. Discussion on the appropriate background data to use in calculating limits is discussed in Section 2.03.

In order to establish ammonia nitrogen limitations, a receiving water use designation has to be determined (more information on this is given in Section 2.01). Acute criteria are dependent on effluent pH (Table 2C of ch. NR 106, Wis. Adm. Code) and chronic criteria are depended on receiving water pH and temperature (Table 4B of ch. NR 106, Wis. Adm. Code). This is based on the assumption that short term (acute) impacts are more effected by effluent conditions since little mixing has occurred, and long term (chronic) impacts are more effected by instream conditions.

In addition, EPA in its 1999 recommendations report found that ELS of some fish species are more sensitive to chronic impacts than adults. Because of this, separate chronic criteria formulas are available in ch. NR 105, Wis. Adm. Code, for when ELS of fish are present and absent in warm waters and limited forage fish communities. It is assumed that ELS are always present in cold waters and never present in limited aquatic life waters.

Building off of the information in the preceding paragraphs, the criteria equations in s. NR 105.06, Wis. Adm. Code are as follows:

Acute Toxicity Criteria:

$$ATC = \left(\frac{A}{1 + 10^{7.204-pH}}\right) + \left(\frac{B}{1 + 10^{pH-7.204}}\right)$$

where:

pH = the maximum expected effluent pH

Classifications	A	B
Coldwater 1 & Coldwater 4	0.275	39.0
Coldwater 2 & Coldwater 3	0.343	48.7
Coldwater 5, warmwater sportfish, warmwater forage fish, and limited forage fish	0.411	58.4
Limited aquatic life	0.633	90.0

The different coldwater criteria categories are defined in Section 2.01 and ch. NR 105, Wis. Adm. Code.

Chronic Toxicity Criteria 30-Day Criteria:

$$CTC = A \times \left(\frac{0.0676}{1 + 10^{7.688-pH}}\right) + C \times \left(\frac{2.912}{1 + 10^{pH-7.688}}\right)$$

where:

T = temperature in degrees C

pH = standard units

Classifications	A	C	D
Coldwater (1-5) and Warmwater Sportfish /Warmwater Forage Fish – Early Life Stages Present	0.854	minimum of (2.85) or ($1.45 \times 10^{(0.028 \times (25 - T))}$)	
Warmwater Sportfish/Warmwater Forage Fish – Early Life Stages Absent	0.854	$1.45 \times 10^{(0.028 \times (25 - D))}$	max of (actual temp) and (7°C)
Limited Forage Forage Fish – Early Life Stages Present	1	minimum of (3.09) or ($3.73 \times 10^{(0.028 \times (25 - T))}$)	
Limited Forage Forage Fish – Early Life Stages Absent	1	$3.73 \times 10^{(0.028 \times (25 - D))}$	max of (actual temp) and (7°C)
Limited aquatic life*	1	$8.09 \times 10^{(0.028 \times (25 - T))}$	

* Using the equation currently listed in code, LAL criteria continue to increase as temperatures drop below 7°C, but this is an error in the code (March 1, 2004 version) and will be corrected with the next revision to NR 105, Wis. Adm. Code. Currently, calculated LAL criteria are "capped" at a minimum temperature of 7°C.

4-Day Criteria (for all classifications):

The 4-day criteria are equal to the 30-day criteria times 2.5.

$$CTC = 30 - Day\ chronic\ toxicity\ criteria \times 2.5$$

Section 3.02: Early Life Stages

According to s. NR 106.31(3), Wis. Adm. Code, "Early life stages" (or ELS) means "the life stages of fish that include the pre−hatch embryonic period, post−hatch free embryo or yolk−sac fry, and the larval period, during which the fish feeds. Juvenile fish, which are anatomically similar to adults, are not considered an early life stage. The duration of the early life stage extends from the beginning of spawning through the end of the larval period."

Chronic toxicity is based on adverse impacts to growth and reproduction, and ELS of fish are often more sensitive to the chronic toxicity of ammonia than adult life stages. For example, toxicity data for fathead minnow, channel catfish, and bluegill suggest that early life stages of those species are more sensitive to ammonia. Since fathead minnow and bluegill are among the most sensitive of all represented warmwater species, the presence or absence of ELS significantly affects the calculated criteria. Therefore, s. NR 106.32(3), Wis. Adm. Code, allows for chronic criteria to be relaxed when these ELS are absent.

Table 4B of ch. NR 105, Wis. Adm. Code, lists chronic toxicity criteria for ammonia that vary based on the presence or absence of ELS of fish. Relaxation of chronic criteria based on ELS-absent conditions is only available in warmwater sport fish, warmwater forage fish, and limited forage fish waterbodies. Early life stages are considered to be present year-round in coldwater communities, so an assumption of ELS absence is not appropriate in those waters. Early life stage considerations are not applicable to limited aquatic life communities because fish are assumed not to be present in those waterbodies.

Since the presence or absence of ELS is considered when selecting the applicable chronic ammonia criteria equation, a site-specific determination of what months of the year ELS are expected to be present should be made.

Species of Concern:
Spawning of warmwater fish typically occurs in spring, usually during the months of April through May, though there are some exceptions. Fathead minnow early life stages coincide with a spawning period from late May through mid-August, which requires ELS protective criteria through the summer months (May into September). Other fish species have spawning periods before or during the month of April, and those spawning periods should be evaluated and addressed on a site-specific basis.

Northern pike and white sucker may spawn in March, but toxicity testing has shown that ELS of those species are not as sensitive as the concentrations represented by the ELS absent criteria. In other words the ELS absent criteria are protective of white sucker and northern pike ELS, so there is no need to extend the ELS present criteria to cover the month of March in waters where those species are actually or potentially present.

Burbot has an unusual spawning season of January through March; therefore, s. NR 106.32(3)(a), Wis. Adm. Code, requires ELS present criteria to be implemented in January through March in waters where burbot are present.

ELS Absent vs. Present Months:

Section NR 106.32(3)(a), Wis. Adm. Code, specifies when ELS present and absent criteria should be used. For some categories, code explicitly states which months should be considered ELS absent and present, as shown in Table 6. This code specifies when ELS absent and present criteria should be used for cold waters, limited aquatic life waters, and limited forage fish waters. But for warm water uses, this is not specified year-round. In cases where site-specific species information is available, it is recommended that staff consider whether ELS present criteria should apply, even if it is not listed in Table 6. For example, if there is information available showing that a species other than burbot that spawns in March is present in a WWSF water, ELS present criteria should be applied for that month.

For waters supporting warmwater sport fish or warmwater forage fish uses, s. NR 106.32(3)(a)2. states that ELS present criteria should apply in April and whenever receiving water temperatures are greater than 14.6°C. It is expected that spawning and ELS occur at around 14°C or higher for most species. The ELS present periods below are recommended considering that instream temperatures are generally greater than this threshold in May through September (as shown by the ambient temperatures given in Table 2 of ch. NR 102, Wis. Adm. Code). For any month or seasonal range where a background temperature of 14°C or more is considered, the ELS present criteria should be used. This is not a major issue for WWSF waters since the equations for ELS absent and present criteria produce identical results when temperatures are greater than 14.6°C.

Table 6: Early Life Stages Present and Absent Months

	April	May	June	July	August	September	October	November	December	January	February	March
Coldwater communities												
Warmwater sport/forage fish communities **without burbot**												
Warmwater sport/forage fish communities **with burbot**												
Limited Forage Fish												
Limited Aquatic Life												

ELS present specified in code
ELS present recommended
ELS absent specified in code
ELS absent recommended

Burbot Presence:

When determining limits for a discharge to a warmwater forage fish or warmwater sport fish water, staff should search the DNR Fisheries Database to determine if burbot are present or absent in the receiving water. In waters where a fisheries survey has not been performed, staff should consult with the regional fisheries biologist about the likelihood of burbot presence. Burbot are typically present in low-density populations, so it may be difficult to determine their presence based on a survey. DNR fisheries biologists have generally found that burbot:

- are more likely to be present in cool waters
- are usually found in medium to large streams
- generally spawn over gravel or rocks
- are more common in the northern part of the state

If after consulting the available resources, it cannot be determined whether burbot are present or absent, it is advisable to be conservative and assume that burbot are present in the receiving water and use criteria for protection of ELS in January through March.

Chapter 4 - Calculation of Ammonia Water Quality Based Limits

This chapter covers the formulas and procedures for calculating acute and chronic ammonia limits. The procedures for calculating ammonia limits for protection of downstream points where the receiving water changes to a higher classification and cases where there are multiple discharges that may share assimilative capacity are also subsequently addressed.

Section 4.01: Ammonia Effluent Limit Equations

Once representative receiving water background and effluent conditions have been determined and the applicable acute and chronic criteria have been calculated, ammonia effluent limits can be calculated. Acute criteria correspond with daily maximum limits and chronic criteria correspond with weekly average and monthly average limits, as specified in s. NR 106.33(5)(c), Wis. Adm. Code.

Ammonia Nitrogen Limitations Based on Acute Toxicity:
In accordance with s. NR 106.32(2), Wis. Adm. Code, acute limitations may be calculated using the same mass balance equation as used for other toxics limits, using the 1-Q_{10} receiving water low flow to protect the receiving stream from exceedances of acute water quality standards.

$$Daily\ Max\ Limit = \frac{(ATC \times [Q_S + (1-f)Q_e]) - C_s(Q_s - fQ_e)}{Q_e}$$

Where:

ATC =Acute toxicity criterion according to ch. NR 105, Wis. Adm. Code
Q_s = 1-Q_{10}, if the 1-Q_{10} flow data is not available, use 80% of the 7-Q_{10}
Q_e = Effluent flow (in units of volume per unit time) as specified in s. NR 106.06(4)(d), Wis. Adm. Code
f = Fraction of the effluent flow that is withdrawn from the receiving water
C_s = Background concentration of the substance (in units of mass per unit volume) as specified in s. NR 106.06(4)(e), Wis. Adm. Code.

The daily maximum limit cannot exceed two times the ATC in accordance with s. NR 106.32(2), Wis. Adm. Code. The more restrictive of the two approaches should be selected as the daily maximum limit unless it can be shown that the two time the ATC limitation is sufficiently protective of fish and aquatic life. It is important to note that code does not explicitly require use of the mass balance equation when this results in limits that are more restrictive than two times the ATC:

> To assure compliance with par. (a), the department **may** calculate acute water quality−based effluent limitations using the following procedure **if the department concludes that limitations calculated in par**. (b) or (c) are not sufficiently protective of fish and aquatic life. The department may include the calculated WQBEL in a permit if this limitation is more stringent than the limitation calculated in par. (b) or (c). (s. NR 106.32(2)(e) Wis. Adm. Code, emphasis added)

Although code says that the mass balance equation may be used, it is used by default when more restrictive than two times the ATC according to the following reasoning: The acute criteria are levels that should be met in the receiving water in order to be protective of aquatic life. The mass balance equation above calculates a daily max limit to ensure that the ATC is met in the receiving water. Therefore, a daily maximum limit higher than what is calculated by the mass balance equation would allow an exceedance of the acute water quality criteria in the receiving water. So by definition, a

two times the ATC limit is "not sufficiently protective of fish and aquatic life" when this level exceeds the mass balance limit calculation. This reasoning should generally determine daily maximum limits, however, code does technically allow limits as high as two times the ATC if its demonstrated that the discharge limit are "sufficiently protection of fish and aquatic life."

Ammonia Nitrogen Limitations Based on Chronic Toxicity:
Similar to the acute daily maximum limit equation, the mass balance calculation used to determinate chronic ammonia limits specified in s. NR 106.32(3), Wis. Adm. Code includes the allowable dilution, background concentrations, and total allowable ammonia in the receiving water. Unlike the limit calculations for other toxic substances, chronic ammonia limit equations include allowances for greater than 25% mixing zones depending on the ambient stream temperature. This variable mixing is allowed in s. NR 106.32(3)(c)3., Wis. Adm. Code, because ammonia degrades readily at warmer temperatures. It is assumed that a higher percent mixing can be allowed while still avoiding chronic toxicity impacts to aquatic life.

In accordance with s. NR 106.32(3)(c)3., Wis. Adm. Code, in summer, 100% of the streamflow is allowed because of the expected rapid ammonia decay, and intermediate 50% flow defaults are allowed in conditions similar to what would be encountered during spring or fall. Larger mixing percentages may be considered in any seasonal range if justified in a mixing zone study. Section NR 106.32(3)(c)2., Wis. Adm. Code also includes an option for limits based on real-time stream flow data instead of the use of low flow values.

The mass balance equation for weekly average and monthly average limits is as follows:

$$Ammonia\ Limit = \frac{(CTC \times Mixing\ Percentage \times [Q_S + (1-f)Q_e]) - C_s(Q_s - fQ_e)}{Q_e}$$

where:

Q_e = effluent flow rate

Q_s = the receiving water streamflow

7-Q_{10} or 4-B_3 for weekly average limits based on the 4-day chronic criterion

30-Q_5 or (85% of 7-Q_2) for monthly average limits based on the 30-day chronic criterion

Mixing Percentage = allowed mixing zone based on receiving water temperature:

100% for temperatures of 16°C or greater,

50% for temperatures greater than 11°C and less than 16°C, or

25% for temperatures of 11°C or less

CTC = Chronic criterion. See formulas in Section 3.01, note that separate 4-day and 30-day criteria apply

f = Fraction of the effluent flow that is withdrawn from the receiving water, and

C_s = Background ammonia concentration (Discussed in Section 2.03)

In cases where low flows are high or the receiving water has low pH, the calculated weekly or monthly limitations may be much higher (i.e., less stringent) than the calculated daily maximum limits.

Section 4.02: Protecting Downstream Waters

Section NR 106.32(1)(b), Wis. Adm. Code, specifies that ammonia "effluent limitations shall be established to protect downstream waters whenever the Department has information to make the determinations." There are a number of limited aquatic life and limited forage fish waters throughout the state with a relatively short distance to downstream higher use waters, and there are considerable differences in the ammonia criteria between these designated uses. This section is intended to provide guidance on when and how to set ammonia limits to protect downstream waters.

Because ammonia is not a conservative pollutant, some level of decay can be assumed in the discharge's travel time to the downstream use change. The factors that determine whether more restrictive ammonia limits will be needed for protection of downstream uses are the ammonia decay rate, travel time to the downstream water, and the available dilution in the downstream water.

Ammonia Decay Rate:
A wide range of ammonia decay rates have been reported in the literature:

Table 7: Ammonia Decay Rates in Literature

Site	Ammonia decay rate at 20°C, k_{20} (day^{-1})	Reference
Grand River, IL	0.8	Bansal 1976
Grasmere Lake, UK	0.001-0.013	Hall 1981
Truckee River, NV	0.09-1.30	Bansal 1976
Mohawk River, NY	0.23-0.40	Bansal 1976
Ohio River	0.25	Bansal 1976
Big Blue River, NB	0.17-0.25	Bansal 1976
Flint River, MI	0.76-0.95	Bansal 1976

Unfortunately, limited data on ammonia decay is available for smaller streams. Based on the available literature, a decay rate of 0.25 day^{-1} at 20°C is suggested as a default rate. Ammonia decay rates are dependent on temperature, so the amount of nitrification may be insignificant in the winter. Use of a temperature correction factor of $\theta = 1.08$ is also suggested for temperatures above 10°C ($k_{.t} = k_{20}\,\theta^{(T-20)}$). For temperatures below 10°C it may be prudent to conservatively assume no instream decay since the nitrification rate becomes negligible at lower temperatures.

Travel Time:
Travel time can vary widely in small streams. For sites with no stream velocity data available, a conservative travel time of 5 miles/day is recommended. This recommendation is based on the regression equation from the 1996 USGS Publication, 96-4013, "Prediction of Travel Time and Longitudinal Dispersion in Rivers and Streams." In this study, USGS evaluated the travel time data from nearly 1000 stream studies. The 5 mile/day value represents a conservative estimate of anticipated

velocity for small streams under low flow conditions. If site-specific stream velocity data is available, that data should be used over a default assumption of 5 miles/day.

Downstream Mixing:
At the point of discharge, the allowable dilution for calculating limits ranges from 25% to 100% of the stream flow depending upon temperature, as specified in s. NR 106.32(3)(c)3, Wis. Adm. Code. For the downstream receiving water, generally these same dilution ratios should be used.

In some cases, it may be assumed that the effluent has become completely mixed with the receiving water by the time it reaches the change in classification (100% mixing). This may be applied on a case-by-case basis when the stream classification change happens at a point in a continuous stream-segment. This assumption should not be used if the classification change happens at the confluence of the receiving water with a higher classification water or if the distance between the outfall and the point of classification change is unusually short.

Site Specific Determinations:
Site-specific data is preferred whenever possible. If a site-specific decay/travel time study is undertaken the following data collection elements are suggested:

- Collection of ammonia, temperature and flow data at each site. Collection of nitrate data should also be considered in order to estimate the rate of nitrification. Suggested sites for sampling are upstream of the outfall, at the outfall, downstream of the mixing zone where the effluent is well mixed with the stream, and at the point of waterbody use classification change. Collection of a few other sites prior to the classification change should also be considered to better characterize the stream's nitrification rate.
- A time of travel study conducted under similar flow conditions (typically a dye study). The time of travel study can be conducted at the same time, however care must be taken not to collect water chemistry samples in the dye plume as the dye may interfere with some colorimetric chemical analysis. The time of travel should be determined from the outfall to each site sampled.

Section 4.03: Multiple Discharger Situations

While not an overly common occurrence, there are a small number of sites where there are multiple dischargers of ammonia in relatively close proximity to one another. In such cases, care must be taken to ensure that the receiving water is not over allocated. Section NR 106.11, Wis. Adm. Code, addresses situations where multiple discharges may be utilizing the same assimilative capacity for a pollutant.

In general, the standard equation from s. NR 106.32, Wis. Adm. Code, will be used for determination of a group allocation of ammonia.

$$Ammonia\ Limit = \frac{(CTC \times Mixing\ Percentage \times [Q_S + (1-f)Q_e]) - C_s(Q_s - fQ_e)}{Q_e}$$

where:

Q_e = effluent flow rate

Q_s = the receiving water streamflow

Mixing Percentage = allowed mixing zone based on receiving water temperature

CTC = Chronic criterion. See previous formulas, note that separate 4-day and 30-day criteria apply

C_s = Background ammonia concentration (Discussed in Section 2.03)

Where multiple discharges are located in such close proximity that the mixing zones overlap, the value of Q_e in the above equation should be modified in order to account for the multiple discharges. The sum of the appropriate effluent flows as specified in s. NR 106.06(4)(d), Wis. Adm. Code, should be used. When determining the need for effluent limits, the 4-day and 30-day P_{99} values for each discharge should be combined in a flow-weighted average and compared to the calculated limit. If this process triggers the need for effluent limits for one individual permittee, effluent limits will be needed for all permittees that are discharging ammonia in the multiple discharge reach. Pursuant to s. NR 106.32(5)(b), Wis. Adm. Code, mass limits may also be included in the permit where there is more than one discharger.

Chapter 5 - Determining Final Ammonia Limit Recommendations

This chapter provides guidance on determining which limits are needed to be included in the permit. This is based on any limits in the current permit, reasonable potential, the treatment system, expression of limit requirements in s. NR 106.07, Wis. Adm. Code, and antibacksliding and antidegradation requirements in ch. NR 207, Wis. Adm. Code.

Section 5.01: Determining the Need for Ammonia Limits in WPDES Permits

The procedure for determining whether or not ammonia permit limitations are needed is detailed in s. NR 106.33, Wis. Adm. Code. To summarize, ammonia nitrogen limits can be required for the following reasons:

1. The current permit includes limits for ammonia nitrogen (s. NR 106.33(1)(b), Wis. Adm. Code)
2. The facility currently has ammonia limits and provides treatment for ammonia (s. NR 106.33(1)(b), Wis. Adm. Code)
3. The discharge is subject to a categorical limit for ammonia which is less restrictive than the calculated WQBEL limits. (s. NR 106.04(1), Wis. Adm. Code.) This situation is not common since categorical ammonia limits are rare. For example: chs. NR 230 and NR 247, Wis. Adm. Code.
4. Reasonable potential based on effluent ammonia data (s. NR 106.05, Wis. Adm. Code):
    a. Effluent data exceeds the limit:
        i. A single result exceeds the daily maximum limit
        ii. A consecutive 4-day average exceeds the weekly average limit
        iii. A consecutive 30-day average exceeds the monthly average limit
    b. If at least 11 detects are available: The calculated P_{99} exceeds the limit:
        i. The 1-day P_{99} exceeds the daily maximum limit
        ii. The 4-day P_{99} exceeds the weekly average limit
        iii. The 30-day P_{99} exceeds the monthly average limit
    c. If less than 11 detects are available: The average of all effluent data exceeds 1/5 of a calculated limit.

Chronic ammonia limits are dependent on several water quality parameters that vary based on season. Effluent ammonia levels are dependent on how much nitrification happens in the plant, so effluent data can also vary seasonally. Where data allows, seasonal chronic limits should be compared to the effluent data from that season to make accurate reasonable potential determinations. Reasonable potential can be shown for one seasonal range and not another, and in this case, limits are only required in the seasonal range where reasonable potential is shown. However, if there is reasonable potential to exceed the daily maximum (acute) limit, this limit is typically recommended year-round.

Approaches for determining reasonable potential based on a site-specific situations are detailed below. The process for determining the recommended limits is summarized in the flow chart in Appendix B.

Dischargers with Current Limits:

If a discharger already has limits in a WPDES permit, there has already been a determination in the past that permit limits were needed. In these cases, ammonia limits need to be continued in the reissued permit, as required in s. NR 205.067(5), Wis. Adm. Code. In a practical sense, if a treatment system is designed to meet a limit and that limit is met by using the system, removing the limit from the permit removes the requirement that the discharger continue to operate the system as efficiently as possible.

Daily maximum limits should be re-evaluated each permit reissuance due to possible changes in maximum effluent pH. If effluent pH levels have increased significantly, it may be necessary to recalculate daily maximum limits, since more restrictive limits would be needed for protection of water quality.

If chronic ammonia limits have been evaluated previously, and there have been no significant changes to the background conditions, flow rates, effluent ammonia levels, or criteria, chronic limits do not need to be recalculated. Where limits are needed for expression of limits purposes, limits from the previous WQBEL memo can be used rather than recalculating all chronic limits, as long as the input parameters have not changed significantly.

While it is not always necessary to recalculate chronic ammonia limits, whenever limits are recalculated, they should be included in the permit if:

- There is reasonable potential to exceed them, OR
- They are more restrictive than the limits in the current permit

If calculated limits are less restrictive, an antibacksliding and antidegradation review is needed to recommend limits that are less restrictive than those in the current permit. Without this review, no changes to the limits should be recommended. These decision processes are summarized in the flow charts in Appendices A and B.

Discharges without Current Limits:
For an existing discharger that does not currently have ammonia limits in a WPDES permit, the reasonable potential approach depends on the amount of effluent data available:

<u>No data available</u>**:**
If no effluent ammonia data are available from the permit application or discharge monitoring reports, then there can be no demonstration of reasonable potential for the discharger to exceed the calculated limits. If no ammonia monitoring has previously been required, this is most likely due to a determination that the discharger is an unlikely or minimal source of ammonia to the receiving water and was of low priority to generate effluent data. In this case, the reissued permit should contain a requirement for ammonia monitoring. The frequency and duration of this monitoring is best determined collaboratively between the effluent limit calculator, permit drafter, and compliance engineer. In most cases, testing should occur fairly regularly over a sufficient period to capture any seasonal trends in effluent ammonia levels. Once-weekly testing should be recommended in these situations unless there is a significant financial burden or if the type of discharge makes it unlikely that effluent results will be variable enough to warrant testing that frequently.

In some cases where its determined that minimal effluent data is necessary, monitoring may take place only during the fourth year of the permit term so information is available for the next reissuance. The monitoring frequency and duration is not normally recommended in the WQBEL memo unless this consultation with the permit drafter and compliance engineer occurs before the memo is finalized.

Little effluent data available:

In some cases, only a small effluent ammonia dataset is available. Discharges that previously were not expected to contain significant amounts of ammonia may only be required to report four ammonia results with each permit application. This may be a sufficient amount of data for discharges with ammonia levels far lower than the calculated limits. However, permit application monitoring is typically done in a small time window, so if the discharge could experience seasonal variability, this type of monitoring is not ideal.

When less than 11 ammonia detects are available, reasonable potential is determined by comparing the average of effluent ammonia data to one fifth of the calculated limits. This can result in triggering a limit that would not be required if more data were available. If the discharge has not changed significantly in the last permit term, it may be appropriate to utilize data from the previous permit application as well. To avoid the situation where there is continually limited effluent data, when averages exceed one fifth of the limits, monitoring at a frequency to ensure that least 11 effluent ammonia results are available should be required in the permit.

Large databases available:

When sufficient data is available, the need for ammonia limits can be determined by comparing the P_{99} of effluent data directly to the calculated limits. The procedures for calculating the P_{99} laid out in s. NR 106.05(5)(a), Wis. Adm. Code, are predicated on the fact that the data are not serially correlated. The more frequently effluent samples are taken, the more likely the data is to be serially correlated. If ammonia results do appear to be serially correlated, the P_{99} calculation should be adjusted using the procedures described in Appendix E of USEPA's Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001, 3/91; http://www.epa.gov/npdes/pubs/owm0264.pdf).

In cases where there are 4-day consecutive discharge data available, this data was generally collected either because the permittee already had ammonia limits, and/or there was an identified problem associated with the discharge of ammonia from that facility. When this data is available, consecutive 4-day averages can be compared to the weekly average limit in addition to the 4-day P_{99} to determine reasonable potential.

If new ammonia limits are needed:

Once it has been determined that a facility without current ammonia limits has reasonable potential to exceed newly calculated ammonia limits, the permit drafter and compliance staff should work together to develop a compliance schedule to be included in the next permit reissuance. This compliance schedule shall not exceed 5 years (s. NR 106.117(3)(a), Wis. Adm. Code), should result in compliance as soon as possible, and should be appropriate to the facility. For example, a facility may be able to optimize their current treatment system which would require a shorter timeline than a facility who would have to construct a minor upgrade. Wastewater treatment facilities can usually increase the amount of in-plant nitrification which occurs by increasing or improving the aeration. This may involve increasing the blower use (optimization) at a mechanical plant or installing aerators in a lagoon system

(minor upgrade). Compliance staff may reach out to the DNR Wastewater Operations Engineer or Plan Review Engineers if they are uncertain of potential treatment routes and necessary timelines. A compliance schedule may also be appropriate if there is limited ammonia data available or its otherwise unclear whether the applicable ammonia limits are readily attainable for the discharge.

New or Expanding Discharges:
For a new discharger or an existing discharger that is undergoing a treatment plant upgrade, past effluent data may not be representative of the discharge that will occur when the new plant is completed or the existing plant is upgraded. In this situation, effluent limits are typically requested as part of the facility planning process rather than a permit issuance or reissuance. These limits are generated mostly for informational purposes for the permitee/consultant to determine what level of treatment will be needed to meet ammonia limits. The limits should be calculated and provided to the plan reviewer and permittee even if no effluent data is available. When no representative effluent ammonia data is available, a reasonable potential determination cannot be made. All calculated ammonia limits should be included in the permit for discharges that are known to treat or contain significant sources of ammonia. For other discharges, the calculated ammonia limits can be provided to the permittee for informational purposes.

Industrial Discharges:
The need to include limits for industrial dischargers is determined on a case-by-case basis due to the fact that ammonia is not always present in industrial discharges. See Section 1.01 for a discussion on industry types that are likely to contain ammonia. If an industry has a treatment system designed for ammonia removal, limits should be included in the permit in accordance with s. NR 106.33(1)(b), Wis. Adm. Code. If, however, a permittee is not treating for ammonia, the need for permit limits should be determined using the standard approach in s. NR 106.05, Wis. Adm. Code, with the comparison of a P_{99} to a limit or the mean effluent concentration to one fifth of the limit.

Section 5.02: Expression of Limits and Antidegradation

Following the reasonable potential determination, the limits showing reasonable potential need to be compared to any ammonia limits currently effective in the WPDES permit and to the expression of limits requirements in 40 CFR Part 122.45(d) and s. NR 106.07, Wis. Adm. Code, prior to recommending the final set of limits. The process for determining the final limits to recommend in the permit is summarized in the flow chart in Appendix B.

Expression of Limits:
Sections NR 106.07 and 205.065, Wis. Adm. Code, require permits for continuous dischargers to include the following concentration limits for ammonia whenever limits are determined to be necessary:

- For municipal facilities subject to ch. NR 210, Wis. Adm. Code: Weekly average and monthly average limitations
- For all other facilities (including industry): Daily maximum and monthly average limitations

These requirements do not apply to non-continuous dischargers which do not meet the definition in s. NR 205.03(9g), Wis. Adm. Code.

The procedures for calculating additional limitations for continuous discharges are specified in ss. NR 106.07(3) and (4), Wis. Adm. Code, for municipal and industrial discharges respectively. To summarize,

- When calculating a limit for a longer averaging period: the additional limit is set equal to the shorter averaging period unless a more restrictive limit is needed for protection of water quality.
- When calculating a limit for a shorter averaging period: the additional limit is calculated by applying a multiplier from the EPA's Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001, 3/91; http://www.epa.gov/npdes/pubs/owm0264.pdf) to the existing limit unless a more restrictive limit is needed for protection of water quality.

The intention of these procedures is to limit pollutant discharges on both a short term and long-term interval without generating additional limits that are more restrictive than the existing limits. This sometimes results in "redundant limits". For example, it would be impossible to exceed an additional monthly average limit required by this code without also exceeding the weekly average limit that it is set equal to. However, both sets of limits are still required in order to meet the requirements in 40 CFR Part 122.45(d) and s. NR 106.07, Wis. Adm. Code.

This adds additional steps to determine which limits are necessary to include in the permit. After an original "reasonable potential determination" (detailed in Section 5.01), the limit calculator must ensure that expression of limits requirements are met. The "additional limits" should be compared back to the limits calculated for protection of water quality and the more restrictive of the two should be included in the permit (see appendix B).

Antidegradation and Antibacksliding:
Less restrictive limits can only be included without an antidegradation review if a criteria change is promulgated in code in accordance with s. NR 207.03(1), Wis. Adm. Code. Otherwise, any increase in

ammonia limits requires an antidegradation and antibacksliding review. This includes demonstrating a need for a higher limit as defined in s. NR 207.04(1)(a), Wis. Adm. Code. If facilities are not close to or exceeding their current ammonia limits, it is unlikely that this demonstration of a need for a higher limit can be made. The antibacksliding requirements in s. NR 207.12 Wis. Adm. Code, must also be met in order to receive a less restrictive limit.

Whenever the calculated limits are less restrictive than those in the current permit, the memo can state that less restrictive ammonia limits could be included in the permit if it is demonstrated that antidegradation and antibacksliding requirements are met. In absence of this demonstration, no changes to the current limit will be recommended. Permit drafters will then use this information to demonstrate compliance with antidegradation and antibacksliding provisions as part of the permit reissuance process.

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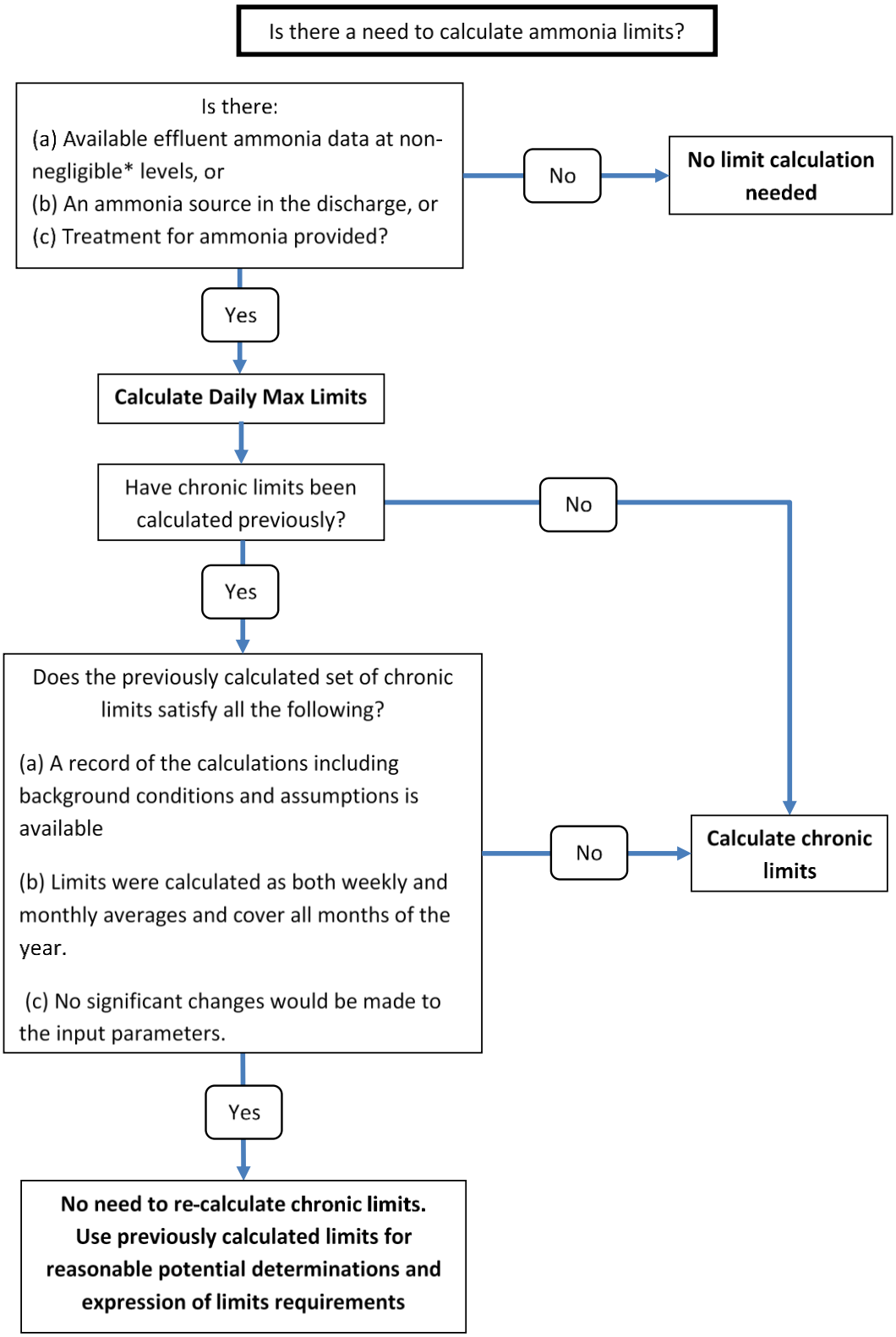
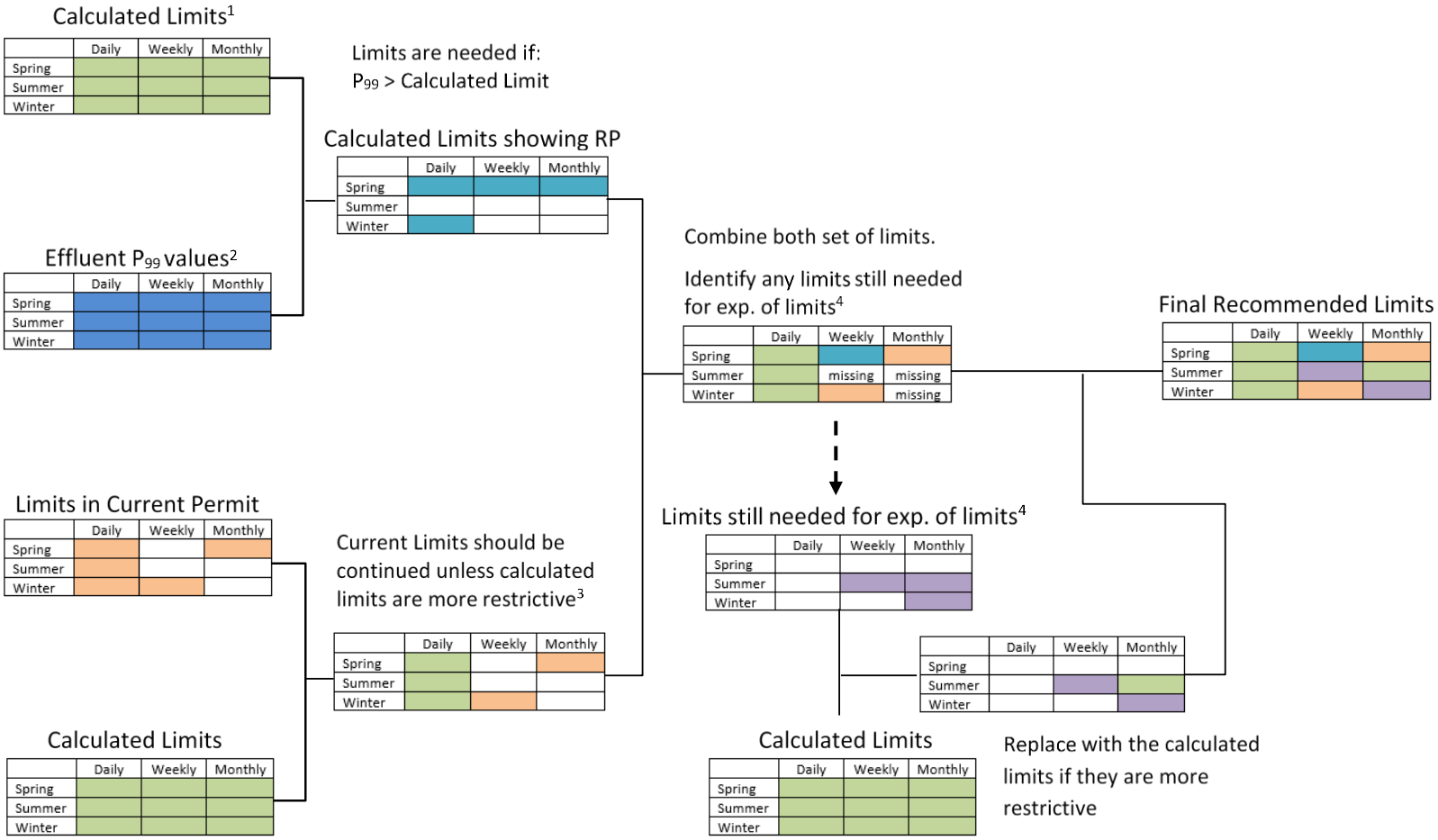
Appendix A – Need for Limit Calculation Flow Chart



*where "negligible levels" means low enough that reasonable potential would not be shown for the most restrictive ammonia limits that would be calculated

Appendix B – Final Limit Recommendations Decision Chart



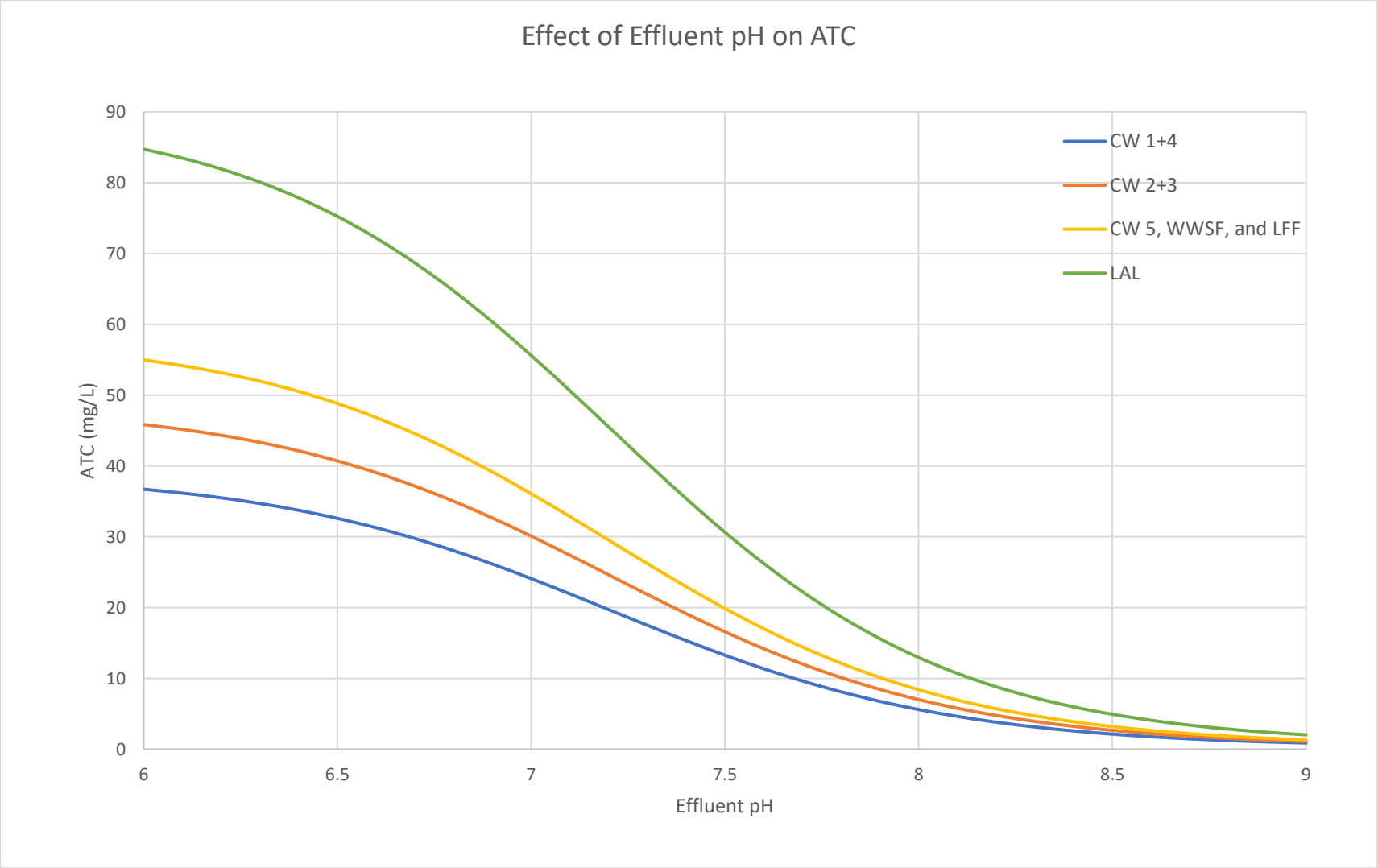
1- If less than 11 ammonia detect results are available, effluent data should be compared to 1/5th of the limit instead.
2- If less than 11 ammonia detect results are available, the average of effluent data should be used instead.
3- A calculated limit that's less restrictive than a limit currently in the permit can only be recommended if the antidegradation and antibacksliding requirements under NR 207 are met.
4- Expression of limits requirements are found in ss. NR 106.07(3) and (4), Wis. Adm. Code.

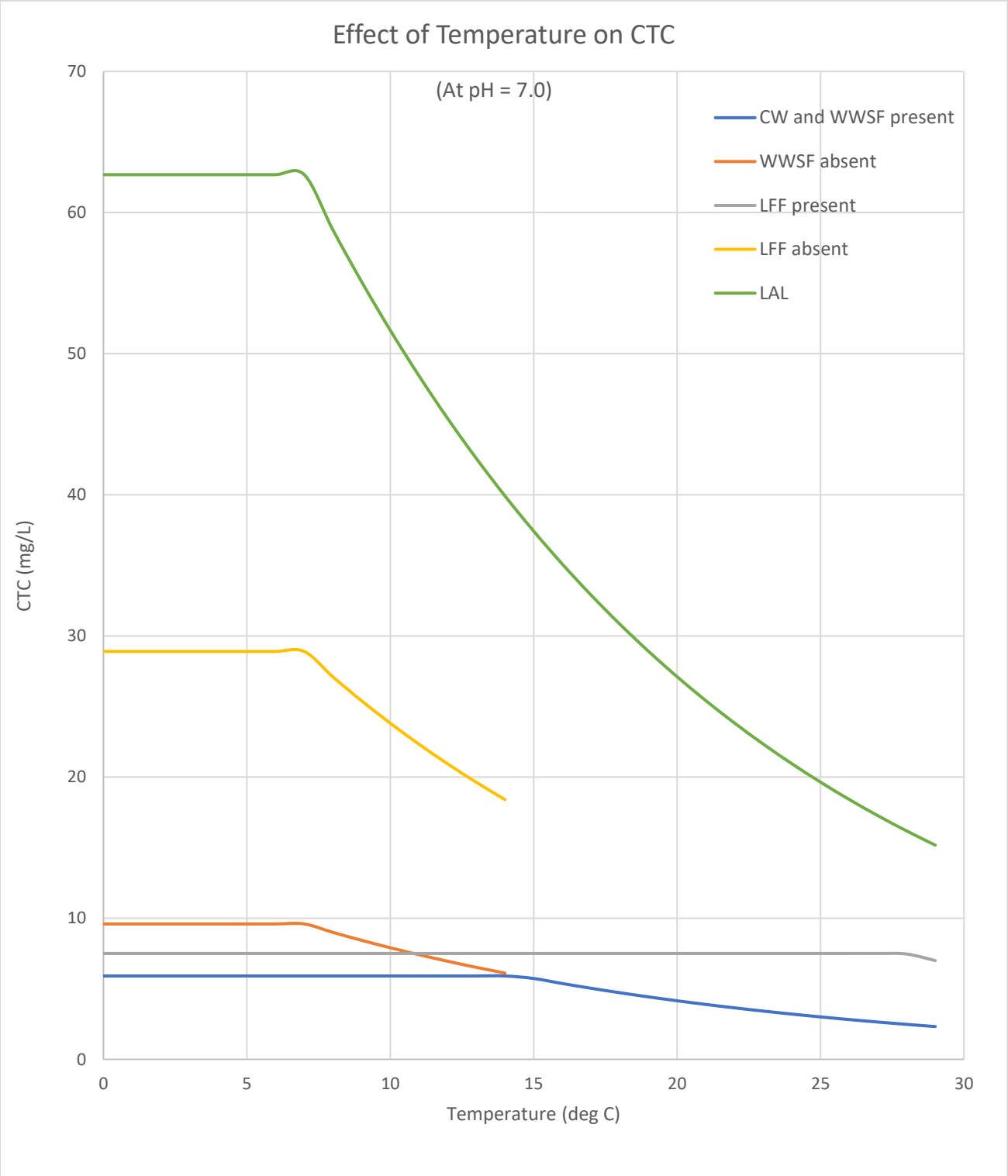
Appendix C – Monthly Ammonia Geomeans by Drainage Basin

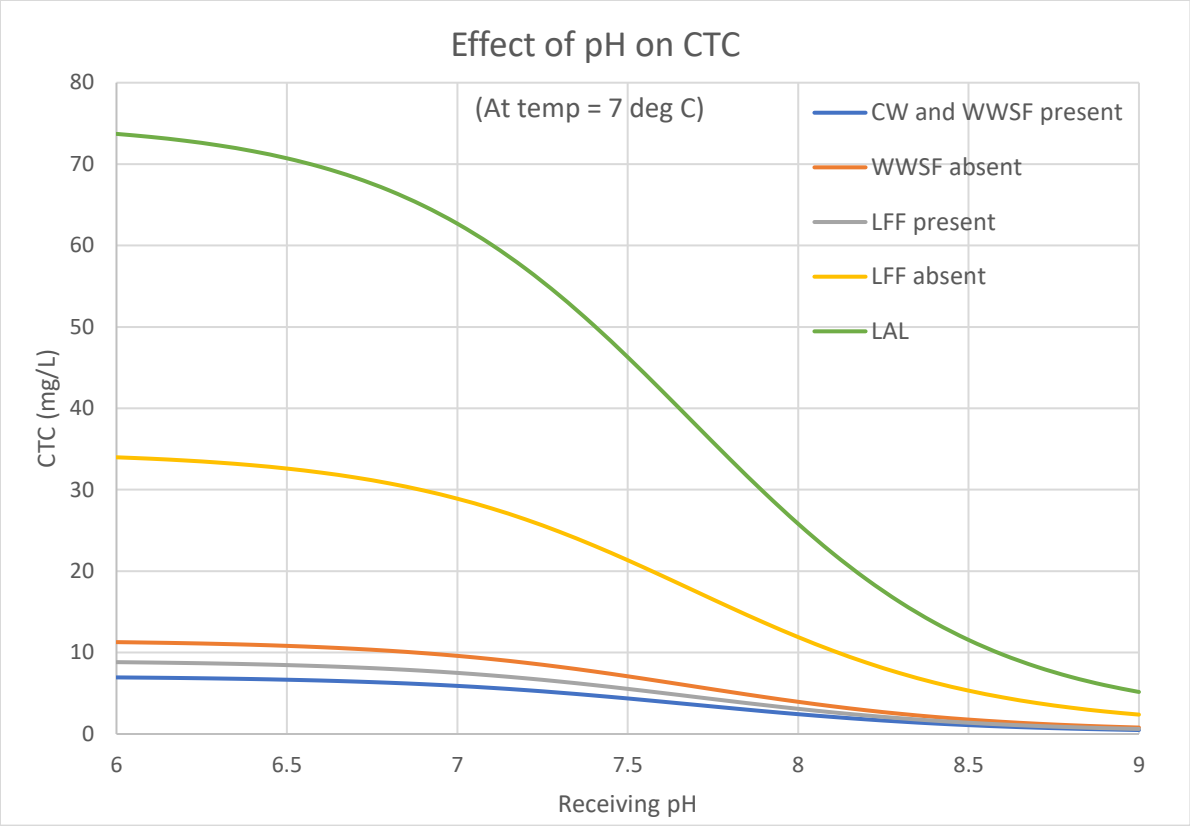
Geomeans of ambient ammonia in surface water for months where at least 8 data points are available. Methods for calculation are described in Section 2.03.

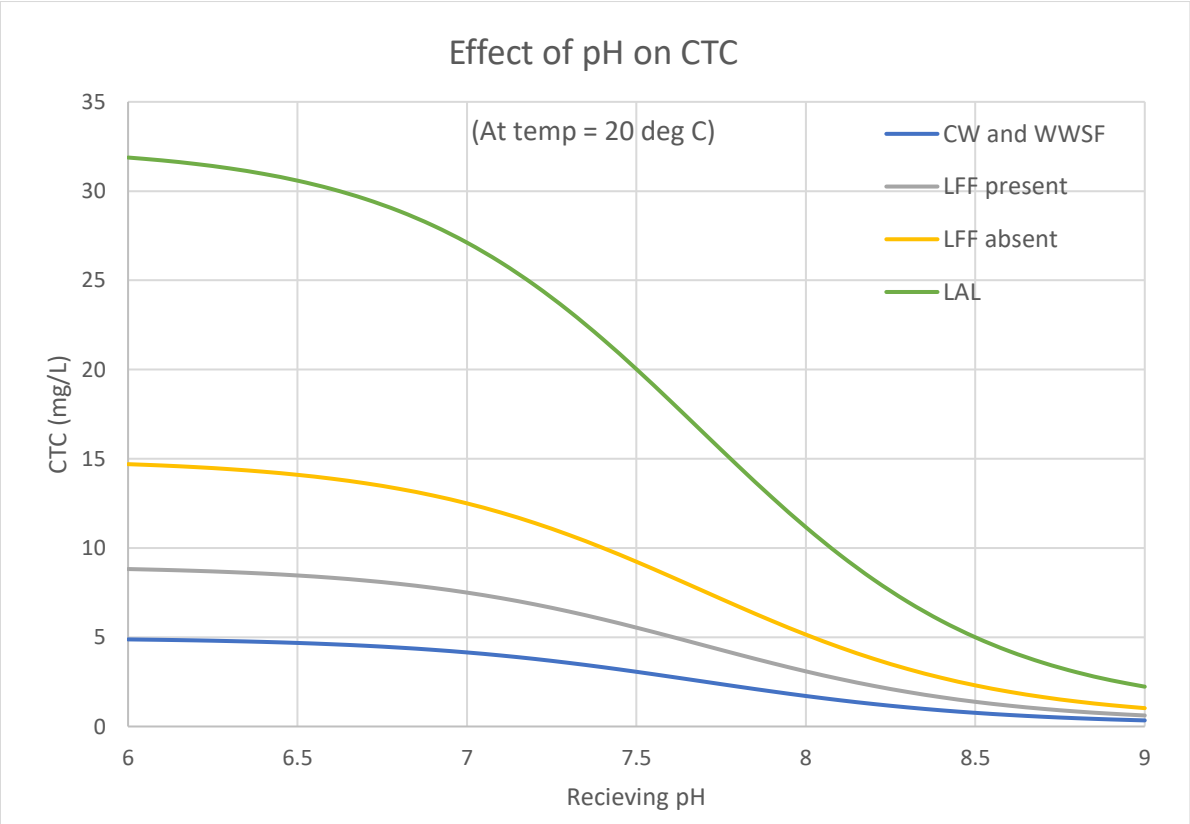
Ammonia-nitrogen (mg/L)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bad Axe - La Crosse	0.064	0.079	0.12	0.048	0.015	0.033	0.031	0.028	0.022	0.020	0.019	0.043
Black River	0.049	0.11	0.22	0.14	0.019	0.020	0.024	0.018	0.011	0.014	0.024	0.045
Buffalo - Trempealeau	0.13	0.30	0.35	0.13	0.043	0.025	0.018	0.025	0.011	0.018	0.026	
Central Wisconsin	0.053	0.10	0.15	0.055	0.041	0.032	0.028	0.030	0.028	0.014	0.021	0.050
Fox (IL)	0.033	0.076	0.064	0.031	0.040	0.034	0.026	0.021	0.031	0.025	0.045	0.035
Grant - Platte								0.038				
Green Bay	0.033	0.053	0.041	0.026	0.016	0.016	0.014	0.013	0.0081	0.0081	0.010	0.020
Lake Superior	0.013			0.010			0.008	0.019		0.0042	0.013	
Lower Chippewa	0.070	0.10	0.15	0.082	0.014	0.042	0.030	0.024	0.018	0.020	0.016	0.037
Lower Fox	0.084	0.094	0.094	0.036	0.073	0.13	0.068	0.030	0.026	0.033	0.12	0.11
Lower Rock	0.059	0.085	0.049	0.042	0.040	0.064	0.043	0.036	0.022	0.032	0.049	0.038
Lower Wisconsin	0.087	0.13	0.16	0.045	0.030	0.037	0.026	0.016	0.015	0.015	0.028	0.049
Manitowoc				0.018			0.022			0.016		
Sheboygan/Milwaukee	0.037		0.071	0.030	0.029	0.025	0.042	0.016	0.015	0.019	0.013	0.039
Southeast	0.046		0.064	0.030	0.0093	0.035	0.022		0.013	0.016		0.033
St. Croix											0.0094	
Sugar - Pecatonica	0.043	0.045	0.062	0.074	0.030	0.049	0.035	0.026	0.018	0.019	0.017	0.019
Twin - Door - Kewaunee							0.031			0.056		
Upper Chippewa/Upper Wisconsin	0.050			0.027			0.017		0.095	0.012	0.013	
Upper Fox	0.046	0.074	0.086	0.029	0.022	0.044	0.048	0.028	0.021	0.033	0.020	0.043
Upper Rock	0.11	0.19	0.072	0.044	0.028	0.033	0.031	0.034	0.017	0.019		0.032
Wolf River	0.033	0.064	0.088	0.023	0.022	0.029	0.024	0.014	0.013	0.014	0.0088	0.023

Appendix D – Input Parameter Effect on Water Quality Criteria




Effect of Temperature on CTC
(At pH = 7.0)
CW and WWSF present
WWSF absent
LFF present
LFF absent
LAL
CTC (mg/L)
Temperature (deg C)
0
10
20
30
40
50
60
70
0
5
10
15
20
25
30


Effect of pH on CTC
(At temp = 7 deg C)
CW and WWSF present
WWSF absent
LFF present
LFF absent
LAL
CTC (mg/L)
80
70
60
50
40
30
20
10
0
6
6.5
7
7.5
8
8.5
9
Receiving pH


Effect of pH on CTC
(At temp = 20 deg C)
CW and WWSF
LFF present
LFF absent
LAL
CTC (mg/L)
35
30
25
20
15
10
5
0
6
6.5
7
7.5
8
8.5
9
Recieving pH

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
NOTICE OF FINAL GUIDANCE & CERTIFICATION

Pursuant to ch. 227, Wis. Stats., the Wisconsin Department of Natural Resources has finalized and hereby certifies the following guidance document.

DOCUMENT ID

WY-19-0013

DOCUMENT TITLE

Calculating Ammonia Nitrogen Effluent Limitations for Surface Water Discharges

PROGRAM/BUREAU

Water Quality

STATUTORY AUTHORITY OR LEGAL CITATION

Section 283.31(3)(d)1 Wis. Stats and chs. NR 105 and NR 106, Wis. Adm. Code.

DATE SENT TO LEGISLATIVE REFERENCE BUREAU (FOR PUBLIC COMMENTS)

12/23/2019

DATE FINALIZED

01/14/2020

DNR CERTIFICATION

I have reviewed this guidance document or proposed guidance document and I certify that it complies with sections 227.10 and 227.11 of the Wisconsin Statutes. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is not explicitly required or explicitly permitted by a statute or a rule that has been lawfully promulgated. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is more restrictive than a standard, requirement, or threshold contained in the Wisconsin Statutes.

Signature

1/14/2020

Date