Bacteria Criteria & Implementation Procedures Rule Revision Technical Support Document

Rule package WY-17-15, related to Chapters NR 102, 104, 210, and 219, Wis. Adm. Code

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TABLE OF CONTENTS

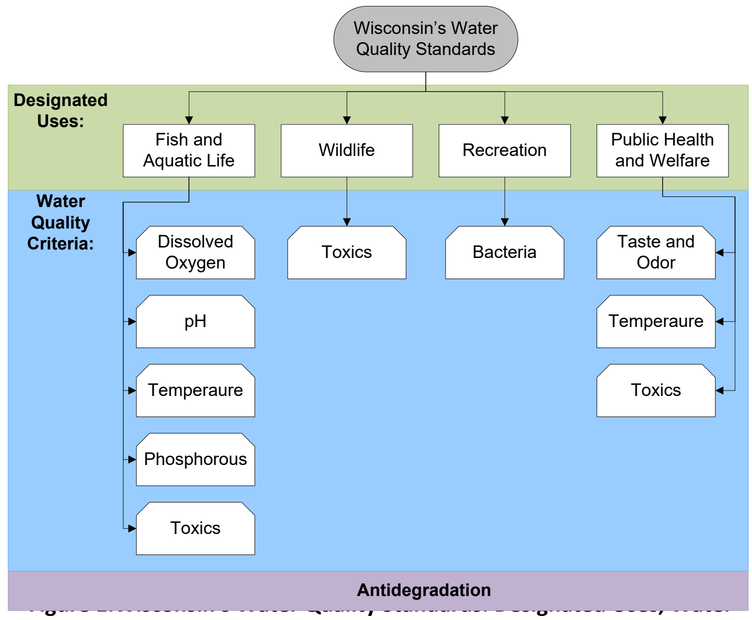
Introduction

OVERVIEW OF WATER QUALITY STANDARDS

The Clean Water Act established the objective of restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters. To meet this objective, the act established a national goal that "water quality shall provide for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water." The Clean Water Act requires States to adopt water quality standards to protect these functions. Water quality standards consist of three components: designated uses, water quality criteria, and antidegradation.

Designated Uses

Designated uses establish the appropriate water quality goals for a given waterbody. The CWA requires each state/tribe to set designated uses that protect aquatic organisms (e.g., fish, shellfish), wildlife, and recreation and allows States/Tribes to consider other uses. Wisconsin has four general designated use categories, which are defined in s. NR 102.04, Wis. Adm. Code: fish and aquatic life, recreation, public health and welfare, and wildlife (Figure 1). The recreation use is being addressed in the revised rule.



Quality Criteria, and Antidegradation

Water Quality Criteria

Water quality criteria represent the quality of water that supports a particular use. Water quality criteria are used to derive permit limits, make impaired waters listing decisions, and develop total maximum daily loads (TMDLs) for impaired waters. As criteria are designed to protect a particular use for a given waterbody, each designated use class has its own set of criteria (Figure 1). The bacteria criteria for the recreation use are being addressed in the revised rule.

Antidegradation

The antidegradation policy is designed to maintain and protect high quality waters. The policy establishes how proposed new or increased discharges to high quality waters are addressed to ensure that water quality is protected. While the antidegradation policy is a crucial component to water quality standards, it is not applicable to this rule package.

THE BEACHES ENVIRONMENTAL ASSESSMENT AND COSTAL HEALTH (BEACH) ACT

In 2000, the Clean Water Act was amended to include the Beaches Environmental Assessment and Coastal Health (BEACH) Act. This Act required States with coastal recreation waters[1] to adopt new or revised recreation/bacteria criteria consistent with national recommended criteria by April 10, 2004. For States that did not meet this deadline, the Act required the EPA to take federal action to promulgate these criteria for the State.

The Act also required the EPA to conduct studies associated with pathogens and human health and to publish new or revised national recommended criteria based on those studies. The EPA finalized its recreational criteria for pathogens in December 2012. To ensure that States are adequately protecting human health, the BEACH Act directs States with coastal recreation waters to adopt new or revised water quality standards no later than three years after EPA's publication of the new or revised national recommended criteria.

The BEACH Act also authorizes the EPA to award grants to States or local governments to develop and implement beach monitoring and assessment programs. This is a very important aspect of the Act as, in Wisconsin, these funds are used by local communities to monitor their beaches, notify community members in a timely manner when issues arise, and collect information necessary to restore problem beaches. Healthy beaches are important to business development, especially the tourism industry.

WATER QUALITY CRITERIA FOR RECREATION

The Clean Water Act requires States to adopt water quality standards to protect for recreation in and on the water. Since adoption of the Clean Water Act, the EPA has published recommended water quality criteria for bacteria protect people from illness caused by exposure to human fecal contamination. Human feces contain a number of pathogens including bacteria, viruses, and parasites. These pathogens can be spread through water and cause a wide range of diseases, such as cholera, gastroenteritis, and hepatitis. For the recreation water quality criteria, EPA employs the pathogen indicator concept in which the pathogen indicator does not cause disease, but, instead, signals the potential for illness caused by human fecal contamination. Pathogen indicators are used because they tend to be more numerous than pathogens in human fecal matter and are cheaper, safer, and easier to measure.

The first bacteria criteria were based on epidemiological studies conducted in the 1940s and 50s and used fecal coliform bacteria as the pathogen indicator (Figure 2). Since this time, more recent studies have found that *Escherichia coli* (*E. coli*) or enterococci are better pathogen indicators because they provide a better link between human illness and exposure to human fecal pollution. See Appendix A for more information on the history of national recommended bacteria water quality criteria for recreation.

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[1] In this context, "state(s)" means any state, territory or tribe that has received treatment as state status and "coastal recreation waters" are defined by the Act as the Great Lakes and marine coastal waters that States designate in their water quality standards for use for swimming, bathing, surfing, or similar water contact activities.

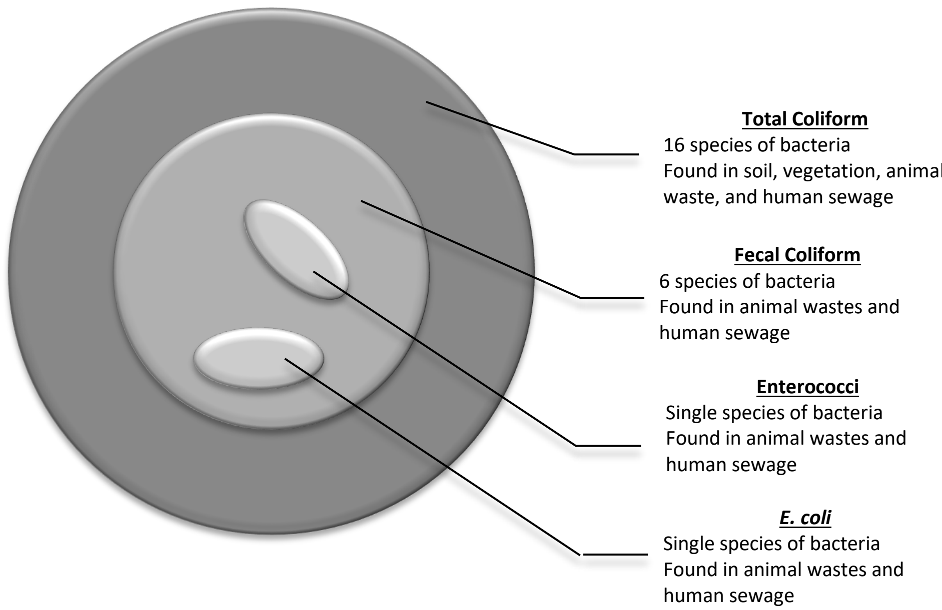

Figure 2. Diagram depicting the relationship between total coliform, fecal coliform, enterococci and *E. coli*.

Adapted from http://www.mfe.govt.nz/fresh-water/tools-and-guidelines/microbiological-guidelines-recreational-water

The EPA published revised national recommended recreation water quality criteria for bacteria in 2012.[2] These revised criteria are based on epidemiological studies conducted in 2003-2009 and use *E. coli* and enterococci as the pathogen indicators. In these recommendations, EPA gave States the choice of pathogen indicator bacteria (*E. coli* or enterococci) and risk level (Table 1). For each indicator, two types of criteria are established: geometric mean (GM) and statistical threshold value (STV). The GM corresponds to the 50th percentile of sample values in the available water quality distribution and the STV corresponds to the 90th percentile of values (Figure 3). Using both the GM and STV protect against spikes in bacterial densities while allowing for natural variation in water quality.

[2] For more information on EPA's recreational water quality criteria for bacteria, see https://www.epa.gov/wqc/2012-recreational-water-quality-criteria

Table 1. EPA's 2012 National Recommended Recreational Water Quality Criteria

Magnitude:				
Estimated Illness rate:	36 per 1000 primary contact recreators		32 per 1000 primary contact recreators	
Indicator	**GM (cfu/100 mL)**	**STV (cfu/100 mL)**	**GM (cfu/100 mL)**	**STV (cfu/100 mL)**
Enterococci (culturable)	35	130	30	110
E. coli (culturable)	126	410	100	320
Duration:	The waterbody GM should not be greater than the GM for the selected illness rate in any 30-day interval.			
Frequency:	There should not be greater than a 10% excursion frequency of the STV for the selected illness rate in the same 30-day interval.			

Both the GM and STV criteria consisted of three components: magnitude, duration, and frequency of exceedance. The magnitude is the maximum amount of the bacteria that may be present in a waterbody while supporting the designated use (i.e., the GM and STV values). The duration is the period of time over which the magnitude is calculated (i.e., a 30-day interval). The frequency of exceedance is the number of times the pollutant may be present above the magnitude over the duration without impairing the use (i.e., 10% of the time for the STV).

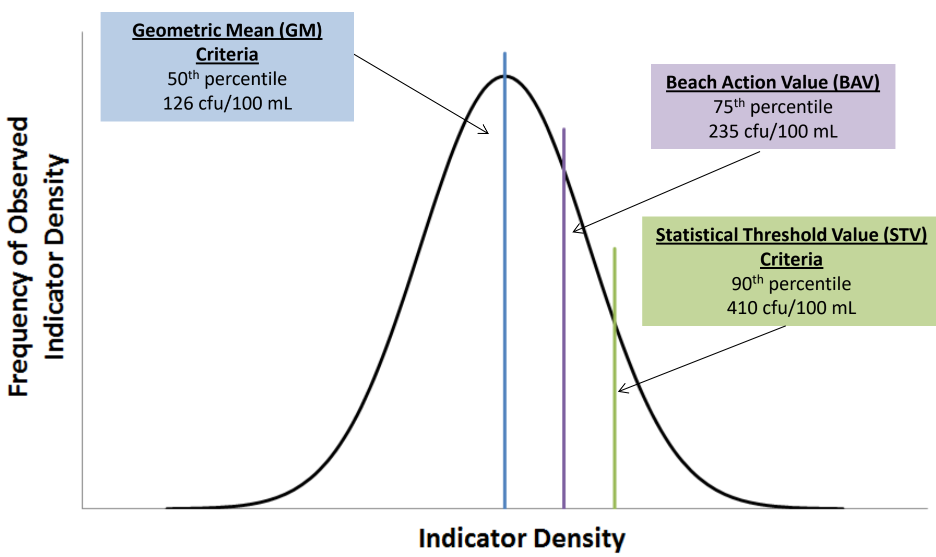

Figure 3. EPA's 2012 Recommended Geometric Mean Criteria, Statistical Threshold Value Criteria, and Beach Action Value.

Adapted from EPA's 2013 Stakeholder Webinar (EPA, 2013)

BEACH ACTION VALUE

As part of the Beach Act, all coastal states are required to monitor coastal beaches and notify the public when pathogen indicator levels exceed or are likely to exceed EPA's recreational criteria. In Wisconsin, the Department coordinates monitoring of Great Lakes and state park beaches while county health officials are responsible for managing all other inland beaches.[3] The Department uses a tiered approach for monitoring and notification in which beaches are ranked as high, medium or low priority. A beach's priority is based on the number of people that use the beach along with environmental factors of the waterbody. A beach's tier determines when, where, and how many samples to collect and when a beach advisory issued (Table 2).

Table 2. Wisconsin's Great Lakes and State Park Beach Monitoring and Notification Plan

<table>
<tr><th>Priority</th><th>Monitoring Requirements*</th><th>Advisory Posting</th><th>Beach Closure</th></tr>
<tr><td>High</td><td>At least 5 times a week
AND
After heavy rainfall
After major pollution event (leak, spill)
After exceedance of criteria</td><td>When any sample exceeds 235 cfu/100mL
AND/OR
When the geometric mean of at least 5 samples collected over a 30-day period exceeds 126 cfu/100mL.</td><td rowspan="3">When the local health department determines a human health hazard exists
After a major pollution event where potential exists that indicator levels may be expected to exceed standard (sewage leak, spill)
After a significant rainfall event that is determined to impact a beach area
When any sample exceeds 1000 cfu/100mL.</td></tr>
<tr><td>Medium</td><td>At least 2 times a week
AND
After heavy rainfall
After major pollution event (leak, spill)
After exceedance of criteria</td><td>When any sample exceeds 235 cfu/100mL</td></tr>
<tr><td>Low</td><td>Determined on a case-by-case basis</td><td>When any sample exceeds 235 cfu/100mL
(if monitoring weekly)</td></tr>
</table>

*Beaches are typically monitored from Memorial Day weekend through Labor Day weekend.

In its 2012 recreational criteria document, the EPA included the Beach Action Value (BAV) as a tool that States can use to make beach notification decisions (Table 3). The BAV value selected should be consistent with the illness rate used to establish the State's recreational bacteria criteria (i.e., the BAVs corresponding to an illness rate of 36 per 1,000 should be used in Wisconsin). The EPA emphasized that the BAV is not a component of EPA's recommended criteria and that States can use it for beach notification purposes without adopting it as water quality standard.

Table 3. EPA's 2012 Beach Action Values (BAVs) for the different pathogen indicators and risk levels

Illness Rate:	36 per 1,000	32 per 1,000
Enterococci –culturable	40 cfu	60 cfu
E. coli – culturable	235 cfu	190 cfu
Enterococcus spp. - qPCR	1,000 cce	640 cce

While the BAV is a new tool recommended by the EPA, the use of 235 cfu/100 mL *E. coli* as a standard for beach advisories is not. The BAV corresponds to the estimated 75th percentile of the enterococci and *E. coli* water quality

[3] More information on Wisconsin's Beach Program can be found at http://dnr.wi.gov/topic/beaches/ and http://www.wibeaches.us

distributions (Figure 3). In fact, Wisconsin has been using this standard to issue beach advisories since 2002. As such, the number of beach advisories and closures issued is not expected to be affected by this rule package.

WISCONSIN'S RECREATION WATER QUALITY CRITERIA

Wisconsin established bacteria water quality criteria for recreation in 1967. These original criteria used total coliforms as the pathogen indicator. In 1972, Wisconsin revised the criteria to be based on fecal coliform. Since this time, only minor adjustments have been made to the criteria. See Appendix A for more information on the history of Wisconsin's bacteria water quality criteria for recreation.

2004 Rule-making Effort

Objective

Revise Wisconsin's recreation designated use and water quality criteria and related implementation procedures to be consistent with federal recommendations and policies.

In 2004, the Department formed the Bacteria Standards Technical Advisory Committee to address the BEACH Act requirement to adopt revised recreation/bacteria criteria by April 2004. This Committee was composed of representatives from municipal wastewater treatment facilities, academics, attorneys, DNR staff, and local and state government staff. This Committee met regularly in 2004 and discussed issues ranging from disinfection requirements to designating a recreation season to establishing test methods.

On November 16, 2004, the EPA took federal action to promulgate bacteria criteria in Wisconsin. This over-promulgation did not replace the existing fecal coliform criteria, but instead made the federally-promulgated *E. coli* criteria apply in addition to the fecal coliform criteria for Great Lake waters. As a result, Wisconsin Pollutant Discharge Elimination System (WPDES) permits have fecal coliform limits, but discharges to the Great Lakes must monitor to ensure that the EPA's criterion for *E. coli* is not exceeded in the ambient waters.

During this effort, the Committee learned that EPA was in the process of revising the recreation bacteria criteria and that it would likely be a number of years before these criteria were finalized. In 2005, the Committee and the Department decided to postpone the rule-making effort until future progress was made by the EPA.

Current Effort

Wisconsin began rule-making to revise the state's criteria in 2015 to ensure compliance with the BEACH Act. The Governor of Wisconsin approved the Statement of Scope to update Wisconsin's water quality criteria for pathogens and recreational uses and WPDES permit implementation procedures for the revised water quality standards to be consistent with EPA's recreational water quality criteria on October 27th, 2015 and the Natural Resource Board approved the Scope on January 27th, 2016.

There are several reasons why recreation use and criteria revisions are being made at this time. First, Wisconsin's codified bacteria criteria are outdated and not adequately protective. Wisconsin uses fecal coliform bacteria as the pathogen indicator while EPA has recommended *E. coli* and *enterococci* as pathogen indicators since the mid-

1980s. With the revisions to EPA's bacteria criteria in 2012, Wisconsin is able to ensure that the criteria promulgated are based on the latest scientific knowledge and adequately protection recreation.

Secondly, States with coastal waters are required by the BEACH Act to adopt EPA's latest water quality criteria for pathogens no later than 3 years after publication. If these criteria are not adopted in a timely manner, EPA has the authority to promulgate water quality standards in any case where they determine that a revised or new standard is needed to meet the requirements of the Act (i.e., protect fish, shellfish, and wildlife and recreation in and on the water). If the EPA promulgates criteria for Wisconsin, its rule-making process is unlikely to include revisions to related rules (e.g. discharge permit requirements) and would not eliminate the state's published fecal coliform criteria. Additionally, if EPA promulgates bacteria criteria for the State, Wisconsin would lose the ability to select its own pathogen indicator and acceptable risk level and develop site specific criterion procedures.

Third, Wisconsin's bacteria criteria are applied inconsistently throughout the state. Because of the over-promulgation by EPA in 2004, Wisconsin has different standards for inland and Great Lakes waters. This has resulted in an additional burden on permittees to the Great Lakes as they are required to monitor for both fecal coliform and *E. coli* during the recreation period. This rule would eliminate the duplicative requirements during the disinfection period for recreation.

Fourth, revising the bacteria criteria at this time will also allow Wisconsin to continue to receive federal grants for beach monitoring and notification. To be eligible for these grants, the state's water quality program must be consistent with the performance criteria established by the EPA. In 2014, the EPA added adoption of new or revised recreational water quality standard as a performance criterion to ensure that all BEACH Act States have the most up-to-date regulations. These funds are crucial for supporting Wisconsin's beaches as the Department distributes these funds to local communities to monitor their beaches, notify community members in a timely manner when issues arise, and collect information necessary to restore problem beaches.

Proposed Changes

The Department is proposing changes to update Wisconsin's recreation water quality standard for bacteria and related implementation procedures for WPDES permit effluent limits.

- Chapter NR 102, Wis. Adm. Code, contains the water quality standards for Wisconsin's surface waters. In this code, the Department revised the recreation water quality criteria.
- Chapter NR 104 contains the criteria for Wisconsin's limited forage fish and limited aquatic life waters. In this code, the Department removed historic fecal coliform "variance" criteria for certain waterbodies.
- Chapter NR 210 contains the permit requirements for sewage treatment works facilities[4]. In this code, the Department revised the calculation procedures for effluent limitations during the disinfection period for recreation.
- Chapter NR 219 contains tables of EPA's approved analytical laboratory methods. These tables were updated to reflect U.S. EPA's most recent list of methods for bacteria-related tests.

[4] The implementation procedure changes addressed by this rule pertain solely to facilities subject to NR 210, Wis. Adm. Code, (i.e., publicly owned treatment works, privately owned domestic sewage treatment works).

The following sections of this document provide more details on each of the proposed changes.

BACTERIA CRITERIA

Recent studies have shown that *E. coli* and enterococci are better pathogen indicator bacteria because they provide a better link between human illness and exposure to human fecal pollution. In EPA's 2012 recreational criteria document, they recommended criteria for *E. coli* and enterococci at two different risk levels. The Department evaluated the pathogen indicator and risk level as well as the time frame of the criteria, to which waters the criteria should apply, and the frequency, duration, and minimum data requirements for assessment determinations. The Department added language to allow for the development of bacteria site-specific criteria and removed the fecal coliform "variance" criteria in NR 104, Wis. Adm. Code. Additional information on each of these changes is provided in this section.

Pathogen indicator

Since the adoption of the BEACH Act in 2004, Wisconsin and the other Great Lake States have monitored for *E. coli* in the Great Lakes. As such, there is a large amount of data on *E. coli* levels in the Great Lakes. Additionally, the Department has been assessing inland and Great Lakes beaches against EPA's 1986 *E. coli* criteria. Given these reasons, the Department chose to use *E. coli* as the pathogen indicator bacteria instead of enterococci for the revised bacteria criteria.

Risk level

In its 2012 recreational criteria document, EPA also gave States a choice between criteria values that correspond to risk levels associated with two different illness rates among primary contact recreators[5]. The risk level associated with a higher illness rate (36 per 1000) yields a less stringent criterion and is consistent with the level of protection provided by the EPA's previous criteria recommendations. The risk level associated with a lower illness rate (32 per 1000) yields a more stringent criterion and was included in EPA's 2012 criteria to address public comments received on the draft criteria document. EPA concluded that criteria based on either of the illness rates would provide adequate human health protection.

The Department's rationale for selecting the 36 per 1000 illness rate relates to the way that illness has been defined through time. In the 1986 criteria, EPA defined illness according to the Highly Credible Gastrointestinal Illnesses (HCGI) definition. HCGI includes any one of the following: vomiting, diarrhea with a fever or disabling condition (remained home, remained in bed, or sought medical advice due to symptoms) and stomachache or nausea accompanied by a fever.[6] In the 2012 criteria, the illness definition was broadened based on national

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[5] Wisconsin has a single "primary contact" recreation use category. A "secondary contact" use category is not under consideration at this time because EPA does not currently have recommended criteria for secondary contact waters.

[6] Dufour AP. 1984. Health Effects Criteria for Fresh Recreational Waters. U.S. EPA. EPA-600/ 1-84-004.

epidemiological data and became known as the National Epidemiological and Environmental Assessment of Recreational Waters Gastrointestinal Illnesses (NGI) definition. NGI defines illness as any of the following within 10-12 days after swimming: diarrhea (3+ loose stools in a 24-hour period), vomiting, nausea and stomachache, or nausea or stomachache and impact on daily activity.[7] With the broadened NGI definition used in the 2012 criteria, more illnesses qualify to be counted as "cases of illness" than using the HCGI definition. To ensure that the acceptable risk level expressed in the 2012 criteria would represent the same acceptable risk level of 8 HCGI per 1000 primary contact recreators that was expressed in the 1986 criteria, EPA used a translation factor of 4.5 NGI per HCGI which resulted in a risk level of 36 NGI per 1000 primary contact recreators.[8] Thus, the Department selected 36 per 1000 in order to remain consistent with current health protections.

The Department also evaluated other types of impacts of selecting the lower illness rate. Along with requiring lower effluent limits, selection of the lower illness rate would increase the number of impaired waters and beach advisories (Table 4). Furthermore, using the translation factor described above, 32 NGI per 1000 is equivalent to 7 HCGI per 1000, which the Department did not feel was a large enough decrease in human health risk to warrant the additional fiscal impacts and impaired waters listings. It should be noted that no other state has selected the more restrictive standard.

Table 4. Impact of Risk Level Selection on the Number of Impaired Waters and Beach Advisories

Risk Level	Impaired Waters (2016 Assessment Data)	Great Lakes Beach Advisories (2015 beach data)
36 per 1000*	29	484
32 per 1000	40	573
Increase	11	89

Criteria duration and minimum data requirements

Numeric water quality criteria consist of three components: magnitude, duration, and frequency. These three components are used when assessing a waterbody's impairment status and setting water quality based effluent limits (WQBELs). For waterbody assessments, magnitude is the numeric threshold for determining if the waterbody is meeting the criterion (i.e., the value at which the criterion is set), duration is used to select the period over which data are analyzed, and frequency of exceedance is used in determining whether the criterion is attained based on how frequently the magnitude threshold is exceeded. For permitting, magnitude is used to establish the level of pollutant that can be in the effluent and duration is used to determine what type of limit (short-term, long-term) should be applied. Frequency is not used directly in establishing WQBELs but can be used in determining whether or not enforcement should be taken when a violation occurs.

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[7] U.S. EPA. 2010. Report on 2009 National Epidemiologic and Environmental Assessment of Recreational Water Epidemiology Studies. EPA-600-R-10-168.

[8] Non-swimmer illness rates (baseline risk) between studies: 14 HCGI/1000 and 63 NGI/1000. To generate a translation factor, divide NGI baseline risk by HCGI baseline risk (63/14 = 4.5 HCGI/1 NGI). Therefore, 8 HCGI/1000 primary contact recreators x 4.5 HCGI / 1 NGI = 36 NGI/1,000 primary contact recreators. See Appendix A: Translation of 1986 Criteria Risk to Equivalent Risk Levels for Use with New Health Data Developed Using Rapid Methods for Measuring Water Quality for more information.

EPA does not consider minimum sample size to be part of a water quality standard. EPA recommends that minimum sample size be recommended within a state's assessment guidance, but not specified within code. The Department views minimum data requirements as a crucial component for assessing Wisconsin's water quality standards. Such requirements ensure that the data used for impairment and permitting decisions are accurate as too few samples can bias an analysis making it appear that a criterion is being met when it is not and vice versa. Wisconsin code currently contains a minimum sample size within the bacteria code, but to be consistent with EPA recommendations is relocating minimum sample size requirements from code to assessment guidance.

Wisconsin's current approach. Currently, the majority of assessments for bacteria are conducted at Great Lakes and inland beaches. Because EPA promulgated *E. coli* criteria for Wisconsin's coastal waters in 2004 as part of the BEACH Act, Wisconsin uses EPA's 1986 *E. coli* geometric mean criterion (126 cfu/100 mL) for assessments.[9] For consistency, inland beaches are also assessed using the same criteria and methodology. For these assessments, the current code requires a minimum of 5 samples per month. Because of limited monitoring (especially at inland beaches), the Department's current protocol has been to aggregate all data collected during the recreation season over the past five years by month.[10] While aggregating data ensures the minimum data requirements are met at as many sites as possible, this approach makes it difficult to interpret long-term trends and evaluate how extreme conditions may impact bacteria levels. In revising Wisconsin's water quality criteria for bacteria, the Department selected the minimum data requirements and durations that would ensure adequate protection of the recreation designated use but allow the Department to assess the waters of the state in a comprehensive and informative manner.

Duration and exceedance frequency options. In its 2012 recreational water quality criteria, EPA recommends a duration of 30 days with an exceedance frequency of zero for the GM criterion and a duration of 30 days with an exceedance frequency of 10% of samples for the STV criterion (Table 5). However, EPA produced a white paper clarifying that although 30 days was its recommended duration, up to 90 days was determined to be an acceptable and scientifically defensible duration (U.S. EPA. 2015. "Narrative Justification for longer duration period for recreational water quality criteria"). The Ohio EPA uses 90 days as the duration for both the GM and STV criteria because of concerns about the ability to collect enough representative data within 30 days (Table 5).[11] As Wisconsin shares the same concerns, the Department evaluated durations of 30 days and 90 days for both the GM and STV criteria. The Department selected a duration of 90 days for both Geometric Mean and Statistical Threshold Value criteria because this duration allows the Department to assess more waterbodies and allows for a clear evaluation of the waterbody's impairment status to be made, as discussed below.

Table 5. EPA's and Ohio's recreational water quality criteria

	EPA[1]		Ohio[2]	
	GM	**STV**	**GM**	**STV**
Magnitude:	126	410	126	410

[9] For more information, see the EPA's Ambient Water Quality Criteria for Bacteria - 1986

[10] For more information on Wisconsin's current assessment protocol for beaches, see section 4.5 of Wisconsin 2016 Consolidated Assessment and Listing Methodology (WisCALM)

[11] The Ohio EPA adopted revised recreation water quality criteria on Jan. 4, 2016 and the EPA approved these revisions on April 8, 2016.

Duration:	Any 30-day interval	Any 30-day interval	Any 90-day interval	Any 90-day interval
Frequency:	0	10% of samples	0	10% of samples
Minimum Sample Size:	N/A[3]		Not specified in code	Not specified in code

1. EPA's 2012 Recreational Water Quality Criteria
2. Table 7-13 in Ohio Administrative code 3745-1-07
3. EPA cannot consider minimum data requirements as an approvable element of a state's water quality standards as a result of Florida Public Interest Research Group vs. EPA

Geometric Mean Criterion

Wisconsin code currently requires a minimum of 5 samples per month for the existing fecal coliform criteria.[12] To be consistent with the existing criteria and assessment protocols described above, the Department selected 5 samples during a 90-day period as the minimum sample size for assessing the *E. coli* geometric mean criterion. This minimum sample size requirement will be specified in assessment guidance (WisCALM) rather than in code.

To select the most appropriate duration for the geometric mean criterion, the Department evaluated how many sites met the minimum data requirement using durations of 30 and 90 days at inland beach sites.[13] To evaluate a duration of 30 days, the Department determined the number of inland beach sites that had 5 or more samples for each month within the criteria season (i.e., May, June, July, August, and September). To evaluate a duration of 90 days, the Department determined the number of inland beach sites that had 5 or more samples between Memorial Day and Labor Day as the majority of recreation season samples assessed since 2011 (> 90%) were collected between Memorial Day and Labor Day (Figure 4).

[12] Ch. NR 102.04(6):"As bacteriological guidelines, the membrane filter fecal coliform count may not exceed 200 colonies per 100 ml as a geometric mean and may not exceed 400 colonies per 100 ml in more than 10% of all samples during any month. Samples shall be required at least 5 times per month."

[13] Inland beach sites were used in this analysis because they are assessed as part of Wisconsin's Water Quality Report to Congress (Integrated Report), but are more likely to have lower sample sizes than Great Lakes beaches as the BEACH Act requirements do not apply to these waters.

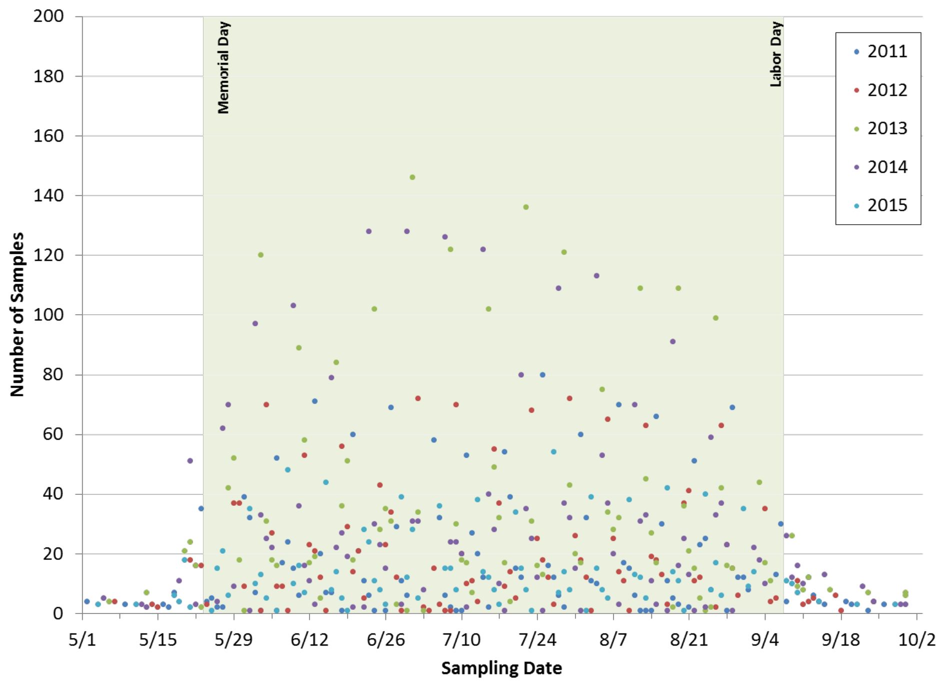

Figure 4. Dates of *E. coli* Sampling at Inland Beaches

Using a duration of 30 days, very few sites (3% on average) met the minimum data requirements for every month during the recreation season (Figure 5). Given that the majority of data are collected between Memorial Day and Labor Day, we also evaluated how many sites met the minimum data requirements for the months of June, July, and August and found that less than a quarter of sites (22% on average) met the requirements for this time period. On the other hand, the majority of sites (85% on average) met the minimum data requirements when using a duration of 90 days (Memorial - Labor Day).

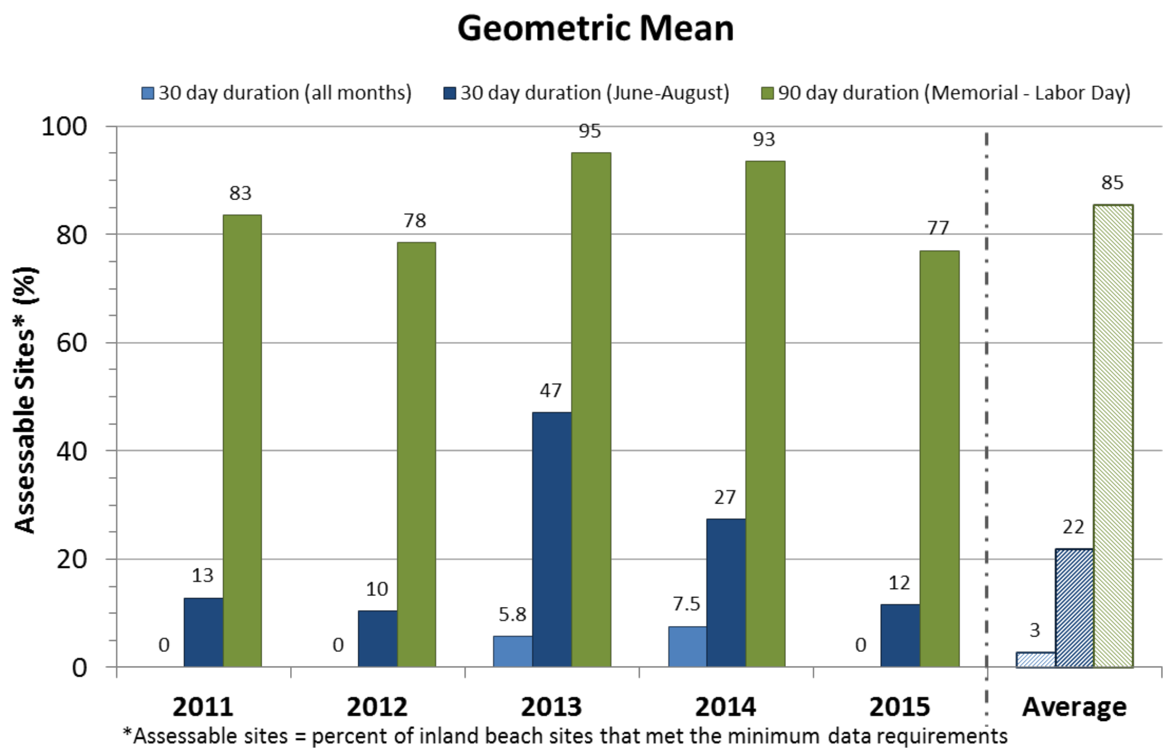

Figure 5. Inland beach sites meeting the minimum data requirement for geometric mean analysis using durations of 30 and 90 days

Another benefit of using a duration of 90 days is that a single impairment determination can be obtained for a given year while separate impairment determinations are obtained for each month using a 30 duration. As an example, the geometric mean criterion impairment status was determined for Spring Harbor Beach in Dane County from 2011 through 2014 (Table 6). When using a 90-day duration and an assessment period of Memorial Day – Labor Day, the beach exceeded the criterion in 2011, 2013, and 2014. Conversely, at least one month exceeded the criterion and one month met the criterion each year when using a 30-day duration. For instance, in 2014, the beach exceeded the criterion in July and August and met the criterion in June.

Table 6. Example Geometric Mean Assessment Status by Year (Spring Harbor Beach – Dane County)

Duration	Assessment Period	2011	2012	2013	2014
30-day	May	ND	ND	ND	ND
	June	Exceed	Meet	Exceed	Meet
	July	Exceed	Exceed	Exceed	Exceed
	August	Meet	ND	Meet	Exceed
	September	ND	ND	ND	ND
90-day	Memorial-Labor	Exceed	Meet	Exceed	Exceed

ND = not enough data for analysis

Statistical Threshold Value Criterion (90th Percentile)

According to its 2012 recreational criteria document, "EPA selected the estimated 90th percentile of the water quality distribution [as the STV criterion] to take into account the expected variability in water quality measurements…" Using EPA's recommended duration of 30 days and Wisconsin's standard data requirement of 5 samples, any sample above the STV criterion would be considered an exceedance. To allow for the natural variation of the water quality data to be considered during waterbody assessments, the Department evaluated extending the duration and increasing the minimum sample size.

The Department selected 11 samples during a 90-day period as the minimum sample size for assessing the *E. coli* statistical threshold value criterion because this allows for one exceedance in the assessment period to account for natural variation. This minimum sample size requirement will be specified in assessment guidance (WisCALM) rather than in code.

Table 7 shows a comparison between EPA's recommended and Wisconsin's proposed duration and frequency for the STV criterion. The Department selected a duration of 90 days for both Geometric Mean and Statistical Threshold Value criteria because this duration allows the Department to assess more waterbodies and allows for a clear evaluation of the waterbody's impairment status to be made.

Table 7. EPA's and Wisconsin's bacteria water quality criteria for recreation

	U.S. EPA[1]		Wisconsin	
	GM	**STV**	**GM**	**STV**
Magnitude:	126	410	126	410
Duration:	Any 30-day interval	Any 30-day interval	Any 90-day interval	Any 90-day interval
Frequency:	0	10% of samples	0	10% of samples
Minimum Sample Size:	N/A[2]		5	11

1. EPA's 2012 Recreational Water Quality Criteria
2. EPA cannot consider minimum data requirements as an approvable element of a state's water quality standards as a result of Florida Public Interest Research Group vs. EPA

Bacteria site-specific criteria (SSC)

Federal water quality standards regulations (40 CFR 131.11) require States to adopt water quality criteria that protect the designated use. When numerical criteria are established, they must be based on EPA's recommended water quality criteria (i.e., 304(a) Guidance), EPA's recommended water quality criteria modified to reflect site-specific conditions, or other scientifically defensible methods. The EPA must review and approve a State's criteria before they can be used for Clean Water Act purposes (e.g., establishing permit limits, assessing waters, developing TMDLs). The EPA approves a State's criteria if they are based on sound scientific rationale and contain sufficient parameters to protect the designated use.

A nationwide dataset was used to develop the EPA's bacteria criteria and the majority of these data were collected at beaches where the major source of bacteria was wastewater treatment plants. The EPA recognizes that there are sites where non-human and non-fecal sources may contribute to high bacteria levels while the probability of illness at these sites may be much lower than the probability of illness at sites with human sources.

As such, the EPA allows for site-specific criteria to be established if they are based on sound scientific rationale and contain sufficient parameters to protect the designated use.

The revised rule includes language that allows the Department to adopt a bacteria SSC by rule for a specific waterbody and allows any interested party to submit a proposed SSC to the Department for review. The Department determined that bacteria SSC should be adopted by rule because standardized processes for establishing bacteria SSC are not available.

Before a bacteria SSC can be adopted, it must be approved by the Department and the EPA. An SSC is approvable if it is more appropriate for the waterbody than the statewide criteria due to site-specific conditions, and is scientifically defensible and protective of the recreation use. To ensure that bacteria SSC adopted by the State are more appropriate, scientifically defensible and protective, all of the following conditions must be demonstrated:

1. For less stringent criteria, the predominant source of the bacteria is non-human or non-fecal.
2. The proposed SSC was developed using an EPA approved method, procedure, or tool and is based on sound scientific rationale.
3. The proposed SSC is as protective of the recreation use as the statewide *E. coli* criteria.

Predominant source of the bacteria is non-human or non-fecal

Recreational water quality criteria are derived to protect people recreating in the water from illness caused by exposure to human feces. In the revised rule, Wisconsin uses *E. coli* as the pathogen indicator bacteria to indicate when the risk from human fecal contamination is too high. Because bacteria criteria are established to protect recreators against exposure to human sources of bacteria, the Department has determined that a less-stringent bacteria SSC may be more appropriate for the waterbody than the statewide criteria if the predominant source for the bacteria is non-human or non-fecal.

While *E. coli* is used to indicate exposure to human fecal contamination, humans are not the only source of *E. coli* in the environment. Warm blooded animals have *E. coli* bacteria in their feces and may contribute to the *E. coli* detected in a waterbody. Some non-human sources of *E. coli* may contribute human pathogens to the waterbody while others may not. As such, the risk from non-human sources of *E. coli* may differ from the risk from human sources of *E. coli*. In addition to non-human sources, there are also non-fecal sources of *E. coli* in the environment. Sands, soils, plants, and biofilms can all be sources of indicator bacteria in a waterbody. The relationship between non-fecal sources of bacteria and the risk from human pathogens is still under investigation. Table 8 compares potential risk level to indicator bacteria source.

Table 8. Risk level associated with different sources of pathogen indicator bacteria.

Adapted from Fujioka et al., 2015

Risk Level	Source	Reason
High	Sewage	Includes fecal discharge from humans The intestinal tract is the major site where Indicator bacteria and human pathogens multiply
Moderate	Animal carriers of human enteric pathogens	Human pathogens can multiply in the intestinal tract of certain animals (e.g., cattle, pig, chickens, gulls)
Low	Most wildlife animals	Wildlife animals are generally not carriers of human pathogens
Very Low	Environmental matrices	Most human pathogens do not multiply outside of the intestinal tracts of humans or animals.

The proposed SSC was developed using an EPA approved method, procedure, or tool and is based on sound scientific rationale

For the Department to approve a bacteria SSC, it must be developed using an EPA approved method, procedure, or tool to ensure that the SSC is scientifically defensible. The EPA currently has three tools that can be used to develop a bacteria SSC: epidemiological studies, quantitative microbial risk assessment (QMRA), and alternative indicators or methods.[14] These tools can be used individually or in combination to develop a bacteria SSC.

The EPA used epidemiological studies to derive the 2012 recommended criteria in which gastrointestinal illness rates were measured in recreators (i.e., individuals who engaged in recreational activities) and non-recreators (i.e., individuals who did not have contact with the waters). Water samples were collected and the measured illness rates in recreators were correlated to indicator bacteria levels. These studies were conducted in waters primary impacted by human fecal contamination (secondary treated and disinfected human wastewater effluent).

Many factors can influence the relationship between indicator bacteria levels and health risk including fecal contamination source and age, solar radiation, turbidity, dissolved organic matter, temperature, nutrient content, predation of bacteria, interactions of the bacteria with sediment, and differential effects on indicator bacteria versus pathogens. Because these factors can impact the observed relationship between indicator bacteria and health risk, bacteria SSC can be derived from a site-specific or regional epidemiological study in which an alternative health relationship is established.

A bacteria SSC from an epidemiological study is scientifically defensible if it demonstrates a statistically significant correlation between indicator bacterial level and adverse health outcomes. Additionally, the study must be rigorous, peer-reviewed, and comparable to those used to develop the 2012 criteria (i.e., same study design preferred). The EPA is in the process of developing additional guidance on using epidemiological studies to derive bacteria SSC.

[14] For more information on EPA's tools for developing bacteria site-specific criteria, see Overview of Technical Support Materials: A Guide to the Site-Specific Alternative Recreational Criteria TSM Documents

Quantitative microbial risk assessment (QMRA) is a formal process of estimating health risks due to exposure of selected infectious pathogens. A QMRA can be used to estimate the risk of illness for recreational waters where no epidemiological data are available, understand which pathogens caused illness in existing studies, and compare the relative health risk associated with fecal contamination from various sources[15] . Through a QMRA, a bacteria SSC based on a different *E. coli* criteria value can be determined that is as protective as EPA's recommended criteria. The EPA has stated that a bacteria SSC developed using this tool can be considered scientifically defensible if it demonstrates a statistically significant correlation between indicator bacterial level and adverse health outcomes. The study must be rigorous, peer-reviewed, and comparable to those used to develop the 2012 criteria (i.e., same study design preferred). A bacteria SSC developed using this tool can be considered scientifically defensible if the study is well documented, follows accepted practices, and relies on scientifically defensible data. The EPA is in the process of developing additional guidance on this tool.

Bacteria site-specific criteria can be developed using alternative indicators or methods.[16] This tool can be used when there is a new indicator/method that offers advantages over the indicator/method already in use. In this process, the new method/indicator is compared to the methods and indicators used to establish EPA's 2012 recreational criteria. At sites where the predominant source of *E. coli* is non-human or non-fecal, an alternative indicator may provide a better measure of the link between water quality and health risk. Possible alternative indicators include *Bacteroidales*, *Clostridium perfringens*, human enteric viruses, and coliphages which are more specific to humans than *E. coli* and enterococci. A bacteria SSC developed using this tool can be considered scientifically defensible if it is demonstrated that the new indicator/method has a consistent and predicable relationship with the original method/indicator.

The proposed SSC is as protective of the recreation use as the statewide *E. coli* criteria

To be as protective as the statewide criteria, the bacteria SSC must protect recreation (i.e., all activities that involve contact with water such as swimming, water skiing, canoeing, kayaking, scuba diving, wading, boating, fishing and hunting). Because of the variability in risk level associated with different sources of pathogen bacteria, the Department will approve a bacteria SSC only if it is demonstrated that the proposed SSC is as protective of the recreation use as the existing *E. coli* criteria. Thus, it must be demonstrated that the health risk associated with the SSC is not any greater than the health risk associated with the statewide *E. coli* criteria. This can be demonstrated using one of the tools described above in which the health risk from human sources of the bacteria are distinguished from the health risks of the non-human sources.

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[15] One example of a QMRA can be found in: U.S. EPA. 2010. Quantitative Microbial Risk Assessment to Estimate Illness in Freshwater Impacted by Agricultural Animal Sources of Fecal Contamination. EPA-822-R-10-005.

[16] A step-by-step guide to developing bacteria SSC using an alternative indicator/method can be found here: Site-Specific Alternative Recreational Criteria Technical Support Materials for Alternative Indicators and Methods

Variance criteria in Ch. NR 104

When the statewide criteria for fecal coliform were promulgated in 1973, fecal coliform "variance" criteria were also established in NR 104, Wis. Adm. Code. At that time, the Department determined that the statewide criteria could not be met in these waters because of natural conditions or because pollution inputs could not reasonably be removed[17]. These criteria apply to the waterbodies listed in Table 9.

> **Fecal Coliform Variance Criteria**
>
> The membrane filter fecal coliform count shall not exceed 1,000 per 100 ml as a monthly geometric mean based on not less than 5 samples per month nor exceed 2,000 per 100 ml in more than 10% of all samples during any month.

The Department is removing all references to the "variance" fecal coliform criteria. These criteria are outdated and not adequately protective as they were based on recommendations by the National Technology Advisory Committee in 1968 for secondary contact recreation. As mentioned earlier, fecal coliform is no longer recommended as a pathogen indicator because studies conducted in the 1970-80s did not find a correlation between fecal coliform level and rate of gastrointestinal illness. Additionally, the EPA does not currently have criteria recommendations for secondary contact waters. Furthermore, the "variance" criteria were intended to be temporary with waters meeting these criteria by 1977 and the statewide criteria by July 1983[18]. As vast improvements in treatment technology have been made since these criteria were established, the Department determined that it is appropriate to apply the statewide *E. coli* criteria to the waters listed in Table 9.

The Department evaluated the impact of these changes on permittees. A detailed study has been completed as part the Milwaukee River Basin Total Maximum Daily Load[19] (TMDL) which found that waterbodies in this basin must meet the statewide criteria for fecal coliform to allow attainment of criteria in downstream waters. Waters covered by the TMDL are already required to meet the statewide bacteria criteria under the TMDL. Outside of the Milwaukee River basin, only one active municipal permittee uses one of the waterbodies in Table 9 as a receiving water. This facility has been disinfecting during the recreation season and receiving a fecal coliform limit of 400 per 100 mL since 2002. Given these findings, the Department does not anticipate that facilities discharging to one of the waterbodies in Table 9 will experience an additional burden from the removal of the variance criteria.

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[17] Wisconsin Department of Natural Resources. Final Environmental Impact Statement for Revisions to the State of Wisconsin Water Quality Standards. Sept. 1973.

[18] Department water quality standards notes, Duane Schuettpelz, March 18, 1974.

[19] CDM Smith on behalf of Wisconsin Department of Natural Resources and Milwaukee Metropolitan Sewerage District. 2018. Total Maximum Daily Loads for Total Phosphorus, Total Suspended Solids, and Fecal Coliform: Milwaukee River Basin, Wisconsin. https://dnr.wi.gov/topic/TMDLs/Milwaukee/index.asp

Table 9. Waterbodies receiving fecal coliform "variance" criteria

Waterbody	County
Underwood creek (below Juneau blvd)	Milwaukee Waukesha
Barnes creek	Kenosha
Pike creek	Kenosha
Pike river	Racine
Indian creek	Milwaukee
Honey creek	Milwaukee
Menomonee river (below the confluence with Honey creek)	Milwaukee
Kinnickinnic river	Milwaukee
Lincoln creek	Milwaukee
Milwaukee river (downstream from the North Avenue dam)	Milwaukee
South Menomonee canal Burnham canal	Milwaukee
Honey Creek (above the Clarno-Cadiz town line)	Green

IMPLEMENTATION

To ensure recreation is protected in Wisconsin's waters, dischargers of human waste are required to meet effluent limits for bacteria. These requirements apply to those facilities that are subject to NR 210, Wis. Adm. Code, including publicly owned treatment works and privately owned domestic sewage treatment works. These facilities are required to disinfect and are currently required to meet limits for fecal coliform. This rule revises the effluent limit calculation process in accordance with the water quality criteria updates to *E. coli* as the pathogen indicator. The following sections of this document provide more details on these changes.

Water Quality Based Effluent Limits for *E. coli*

In the existing language in NR 210, a fecal coliform limit of 400 cfu/100 mL applies to all facilities that are required to disinfect. This limit is a categorical limit and not a water quality based limit[20]. Facilities that are disinfecting should be able to maintain fecal coliform in their effluent below this level; however, this limit does not ensure that fecal coliform water quality criteria are met in the receiving water. The Department replaced the fecal coliform limit with water quality based effluent limits (WQBELs) for *E. coli* during the recreation season.

In the document entitled FAQ: NPDES Water-Quality Based Permit Limits for Recreational Water Quality Criteria, EPA noted that there are two general approaches for establishing short and long-term effluent limits stringent enough to meet water quality standards: the end-of-pipe approach and the technical support document (TSD) approach. The Department evaluated both approaches in this rule package, and determined that a modified end-

[20] Department disinfection policy document. 1986.

of-pipe approach would be the most appropriate. Table 10 compares the process, limits, advantages, and disadvantages of the end-of-pipe and TSD approaches, and they are described further below.

Table 10. Approaches for Establishing Water Quality Based Effluent Limits for *E. coli*

	End-of-Pipe Approach	TSD Approach
Process:	• Criteria applied directly as limits	• Limits are calculated from single duration expression of a criterion: i.e. the monthly geometric mean limit is converted to an equivalent weekly limit
Long-Term Limit:	• Average monthly limit • Equals the geometric mean criterion	• Average monthly limit • Equals the geometric mean criterion
Short-Term Limit:	• Maximum daily limit • Equals the statistical threshold value criterion	• Weekly average limit • Calculated from the monthly average limit • Dependent on the number of samples collected per month
Advantages:	• Straight-forward • Violations are easy to spot and can be addressed immediately	• Consistent with how we derive short-term limits for toxics • Using an average for the short-term limit allows for variability in the data • Consistent with federal regulations that require publicly owned treatment works with continuous discharge have limits that are expressed as weekly and monthly average[21]
Disadvantages:	• Differs from how we derive short-term limits for toxics	• Not as straight-forward an approach • Short-term limit is likely to result in violations of the surface water criteria for facilities with highly variable effluent • Violations are not as apparent and cannot be addressed as immediately

It should be noted that with either approach, application of the long-term limit is the same: the geometric mean used as the criterion is applied as a permit limit. However, the short-term limit is expressed differently depending on which of the two methods is selected.

In the end-of pipe approach for the short-term limit, the water quality criteria for *E. coli* are applied directly as permit limits at the discharge point. In this approach, the maximum daily limit (MDL) is typically set equal to the statistical threshold value and the average monthly limit (AML) is set equal to the geometric mean.

In the TSD approach, both short- and long-term limits are calculated from single duration expression of a criterion. In this approach, the monthly limit is based on the monthly geometric mean and a weekly geometric mean limit is derived from the monthly geometric mean limit using the following equation, which incorporates the number of samples taken in a month as well as the standard deviation of the natural log of measured E. coli concentrations.

[21] For the federal regulation language, see 40 CFR 122.45 (d) (2)

Equation 1: Geometric mean weekly limit = exp(ln(Geometric mean monthly limit) $- z_m\sigma_m + z_w\sigma_w$)

Where:
1. z_m and z_w are the z-scores for the exceedance probability of the GML and GWL (1% = 2.326, 5% = 1.645)
2. $\sigma_m = s/\sqrt{n_m}$ and $\sigma_w = s/\sqrt{n_w}$
3. s = the standard deviation of the natural log of measured E. coli concentration
4. n_m = the number of samples collected per month
5. n_w = the number of samples collected per week

The Department used the above equation to calculate the limits that would be generated using this approach, and determined that converting the monthly geometric mean to a weekly limit could result in exceedance of the STV short-term criteria in circumstances where a facility's samples are highly variable. Therefore, the Department did not select the TSD approach for calculating short-term limits and instead selected the end-of-pipe approach. The long-term limit is set as the geometric mean of 126 counts/100 mL and is calculated each calendar month. The short-term limit is set as the STV where there shall be no more than 10% of values above 410 counts/100mL in any calendar month. This has two modifications from EPA's description of the end-of-pipe approach. First, both geometric mean limits and the STV limits are applied on a calendar month instead of the 90-day rolling period used in the criterion. A monthly limit is simpler for facilities to apply and the shorter time frame is protective of the longer, 90-day criterion. Second, Wisconsin allows for 10% exceedance of the STV limit to allow for expected variability equivalent to the criteria. In EPA's described approach, they use the STV as a maximum value when applying it to permit limits, which results in a permit limit much more stringent than the criterion.

Repeal of redundant language in NR 210.06 (4) to (7)

The following subsections of NR 210.06 are proposed for repeal because they are redundant with more recent code language that was established in other rules.

(4) Language on compliance schedules is repealed because general language allowing compliance schedules for any point source discharger and any substance is found at ch. NR 205.14, with specific requirements provided at ch. NR 106.117.

- There is a slight difference in the time line specified in the two rules. Chapter NR 106.117(3)(a) states that "Any schedule of compliance under this section shall require compliance as soon as possible but may not extend beyond any applicable federal or state statutory deadlines. The schedule also may not extend beyond 5 years from the date that the permit is reissued or modified to include the new or more stringent effluent limitation, except as provided in par. (b) or as provided in other chapters." This differs slightly from the older language proposed for repeal in ch. NR 210.06 (4) which states that compliance schedules may not extend beyond 3 years unless there are circumstances beyond the permittee's control that require additional time for compliance. Although the two requirements are stated in reverse order (NR 210 stated no more than 3 years unless needed, while NR 205 states as soon as possible but up to 5 years), the department sees the two requirements as generally equivalent and deems it appropriate to treat bacteria compliance schedules consistently with all other compliance schedules.

(5) and (6) Language on tentative and final determinations related to the permit, public notice processes, and review procedures are provided in detail for all facilities in ch. NR 203, “Wisconsin Pollutant Discharge Elimination System Public Participation Procedures”, which covers public noticing of permit applications received and tentative and final determinations. It also covers permit actions such as final determinations and modifications or reissuance of permits.

(7) The department deems it inappropriate to require the same permit terms that existed in 1986. Permit requirements may change over time with advances in technology or changes to other regulations. Antibacksliding requirements in ch. NR 207, Subch. II, ensure that effluent quality is maintained into the future.

Analytical Methods

The US EPA has three approved analytical approaches for enumerating *E. coli*: membrane filtration (MF) single step, multiple tube/multiple well, and multiple tube. These approaches are approved by the Department for *E. coli* monitoring in wastewater effluent and are listed in ch. NR 219, Wis. Adm. Code. EPA developed their 2012 recommended *E. coli* criteria using membrane filtration methods. Therefore, counts generated using membrane filtration are the most directly comparable to the criterion. However, other analytical techniques are also approved by EPA for this purpose. A description of each of these approaches is provided below and a summary of the advantages and disadvantages of each is included in Table 11. Table 11 is a summary of *E. coli* analytical methods from 40 CFR Part 136 and ch. NR 219, Wis. Adm. Code. These methods are updated periodically.

Membrane Filtration

In the membrane filtration method, a water sample is filtered through a membrane and then the membrane is placed on growth media that is selective for *E. coli* (Figure 6). Because the bacteria are retained on the surface of the filter, they then grow on the media and develop into a visible colony. The number of colonies that are formed are counted and reported as the colony forming units (CFUs).

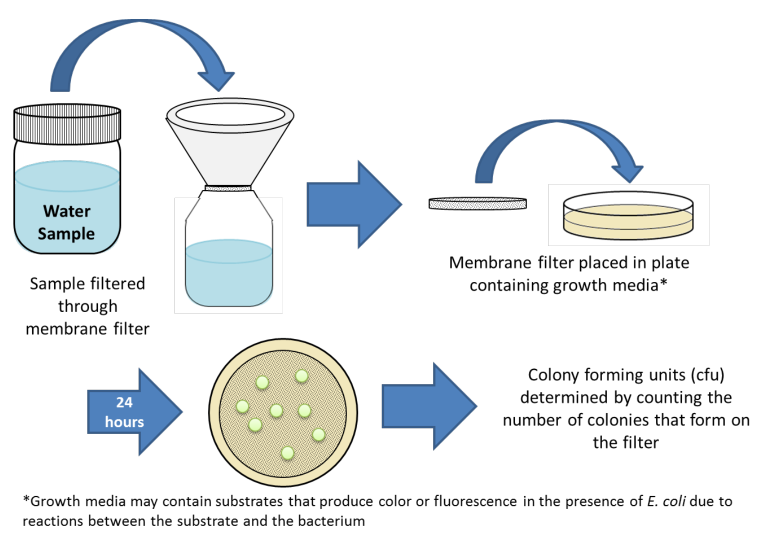

Figure 6. Schematic Depicting the Membrane Filtration Approach for Enumerating *E. coli*

Multiple Tube/Multiple Well

In the multiple tube/multiple well method, a water sample is mixed with a commercial reagent containing methylumbelliferyl-B-glucuronide (MUG) and then distributed into a multi-well plate (Figure 7). After incubating for 24 hours, the most probable number (MPN) is estimated from the number of wells that are positive for the presence of bacteria growth (i.e., show blue fluorescence) using a standardized table. The resultant MPN is a statistical estimate of the mean bacteria density and is not an actual bacteria cell count.

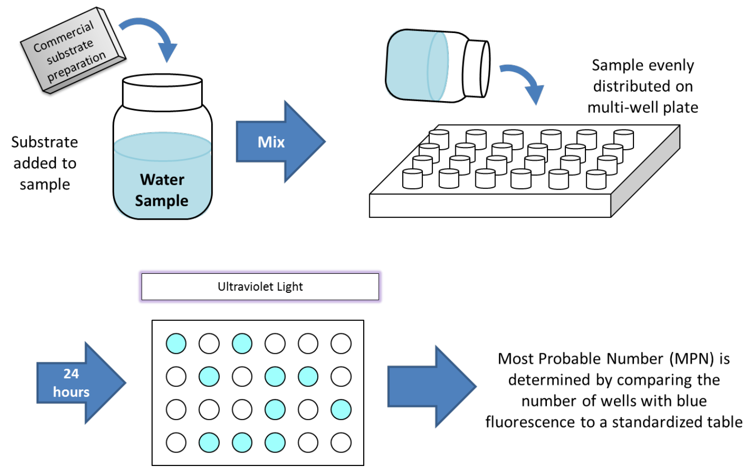

Figure 7. Schematic Depicting the Multiple Tube/Multiple Well Approach for Enumerating *E. coli*

Colilert

The most commonly used multiple tube/multiple well technologies are the Colilert® products by IDEXX Technologies. Both Colilert and Colilert-18 can be used for either presence/absence determination or bacterial quantification. With the The Quanti-Tray and Quanti-Tray/2000 systems, the sample is either manually or automatically subdivided into a large number of wells and the standardized MPN approach is used to determine the number of bacteria in the original sample.

Multiple Tube Fermentation

The multiple tube fermentation approach is a two-step process (Figure 8). First, a water sample is added to test tubes containing bacteria growth media and incubated for 24-48 hrs. Tubes that are positive for the production of acid and/or gas are then inoculated into a series of tubes with media containing MUG. *E. coli* enzymatically cleaves MUG forming a fluorescent product than can be detected under ultraviolet light. After 24 hours, the tubes are examined for fluorescence. The bacteria level is reported as the MPN and is a statistical estimate and not an actual count of bacteria cells. In this approach, the MPN is estimated from the number of tubes that are positive for the presence of bacteria growth using a standardized table. This method is not used much any longer as the precision is rather low unless a large number of samples are collected, and it is more labor and time intensive than the other technologies.

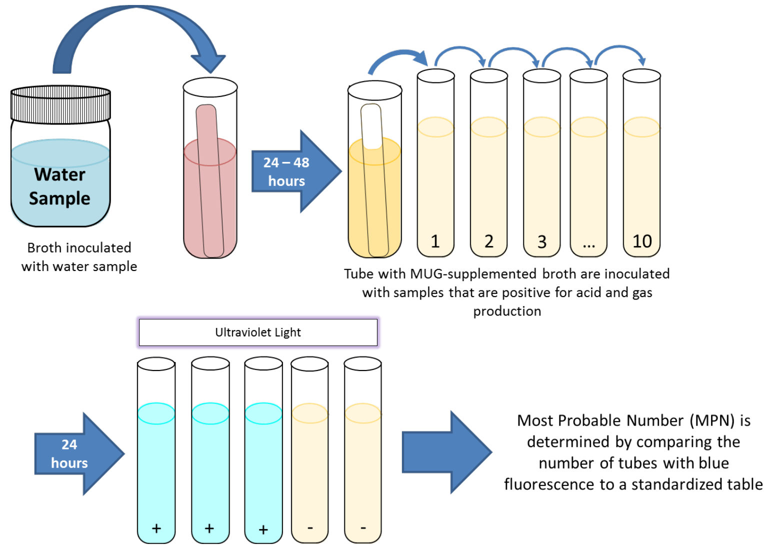

Figure 8. Schematic Depicting the Multiple Tube Fermentation Approach for Enumerating *E. coli*

Table 11. Advantages and Disadvantages of EPA's Approved *E. Coli* Enumeration Approaches

Analytical Approach	Approved Methods	Advantages	Disadvantages
Membrane filtration, single step or two-step	EPA 1603[1] m-ColiBlue24[2] SM 9222 B-2015/ 9222 I-2015[8]	• Readily available • Used to establish EPA's 1986 *E. coli* criteria[3] • Results can be compared directly to fecal coliform results[4] • Less costly	• Labor intensive • Materials intensive • Require high degree of technical skill to obtain, interpret, and confirm results
Multiple tube/multiple Well[5]	SM 9223 B-2016[6] AOAC 991.15[10] Colilert[6,9] Colilert-18[6,9]	• Commercially available • Uses standardized media • Can be used by persons with minimal training • Faster set-up and processing time than other methods • Requires fewer materials than other methods	• Yields greater bacterial densities than membrane filtration methods[7] • More costly • Requires specialized equipment
Multiple tube fermentation (MPN)	SM 9221B.3–2014/ 9221 F-2014[11,12,13]	• Historically used approach	• Labor intensive • Time intensive • Prone to false negatives • Not commonly used

SM = Standard Methods for the Analysis of Water and Wastewater. Methods can be purchased at www.standardmethods.org

1. Method 1603: *Escherichia coli* (*E. coli*) in Water by Membrane Filtration Using Modified Membrane-Thermotolerant Escherichia coli Agar (Modified mTEC), EPA-821-R-14-010. September 2014. U.S. EPA.
2. A description of the mColiBlue24® test, is available from Hach Company. http://www.hach.com/
3. In its 2012 recommended criteria, EPA used the *E. coli* data from its 1986 criteria to derive criteria values that were comparable to the recommended enterococci criteria values because only enterococci data were collected during the National Epidemiological and Environmental Assessment Research (NEEAR) studies.
4. For more information regarding this comparison, see the Data Comparison section below.
5. The advantages listed for the multiple tube/multiple well approach are specific to the Colilert methods.
6. These tests are collectively known as defined enzyme substrate tests.
7. For more information regarding this discrepancy, see the Data Comparison section below.
8. Subject coliform positive samples determined by 9222 B-2015 or other membrane filter procedure to 9222 I-2015 using NA-MUG media.
9. Descriptions of the Colilert®, Colilert-18®, Quanti-Tray®, and Quanti-Tray®/2000 may be obtained from IDEXX Laboratories, Inc. www.idexx.com Colilert-18® is an optimized formulation of the Colilert® for the determination of total coliforms and *E. coli* that provides results within 18 h of incubation at 35°C rather than the 24 h required for the Colilert® test and is recommended for marine water samples.
10. Official Methods of Analysis of AOAC International. 16th Edition, 4th Revision, 1998. AOAC International.
11. The multiple-tube fermentation test is used in 9221B.2-2014. Lactose broth may be used in lieu of lauryl tryptose broth (LTB), if at least 25 parallel tests are conducted between this broth and LTB using the water samples normally tested, and this comparison demonstrates that the false-positive rate and false-negative rate for total coliform using lactose broth is less than 10 percent. No requirement exists to run the completed phase on 10 percent of all total coliform-positive tubes on a seasonal basis.
12. After prior enrichment in a presumptive medium for total coliform using 9221B.2-2014, all presumptive tubes or bottles showing any amount of gas, growth or acidity within 48 h ± 3 h of incubation shall be submitted to 9221F-2014. Commercially available EC-MUG media or EC media supplemented in the laboratory with 50 µg/mL of MUG may be used.
13. 9221 F. 2-2014: This procedure allows for simultaneous detection of *E. coli* and thermotolerant coliforms by adding inverted vials to EC-MUG; the inverted vials collect gas produced by thermotolerant coliforms.

DATA COMPARISON

Comparison of Fecal Coliform and *E. coli* analytical approaches

Because *E. coli* are a subset of fecal coliform bacteria (Figure 2), it is reasonable to expect that *E. coli* counts should be lower than fecal coliform counts in any given sample. However, if different analytical approaches are used to measure each bacteria type, discrepancies can occur. Figure 9 shows fecal coliform and *E. coli* counts in effluent data from two dischargers. In Figure 9A, both fecal coliform and *E. coli* were measured using membrane filtration, while in Figure 9B, fecal coliform was measured using membrane filtration and *E. coli* was measured using the Colilert system. In Figure 9A, all points are below the 1:1 line showing the expected relationship between *E. coli* and fecal coliform – that is, fecal coliform counts were higher than *E. coli* counts in each sample. In Figure 9B, however, the points scatter around the 1:1 line which does not show the expected relationship between *E. coli* and fecal coliform.

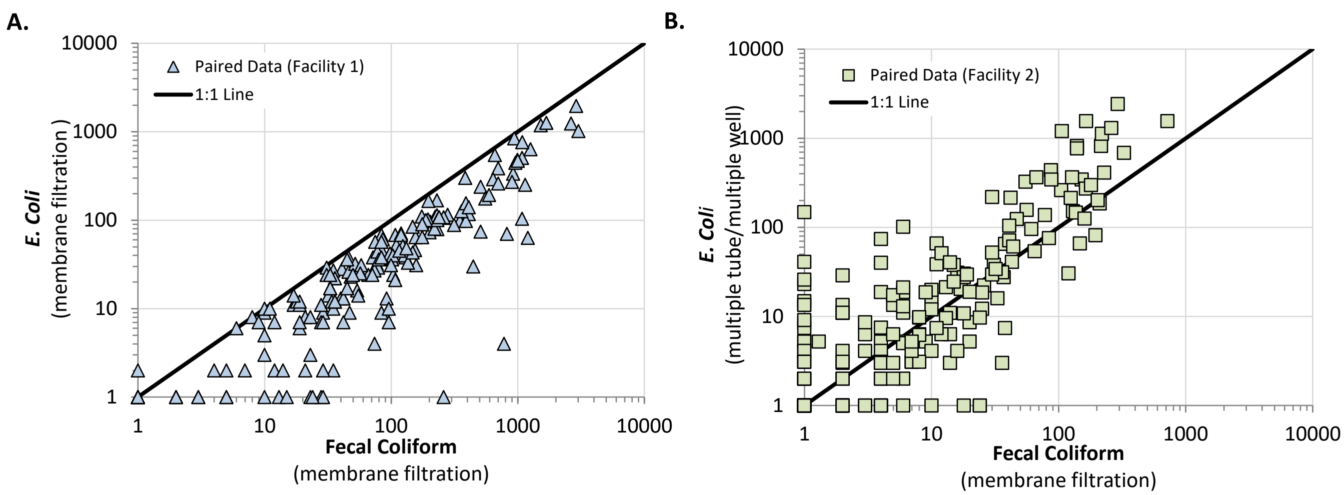

Figure 9. Paired Fecal Coliform - E. coli effluent data using the same (A) and different (B) enumeration method types

Comparison of *E. coli* analytical approaches

Given that different analytical approaches have the potential to produce different bacterial counts, it is a reasonable next step to investigate whether *E. coli* counts from a sample are similar when analyzed using different methods. Between April and December of 2016, the City of Racine Wastewater Utility (RWWU) conducted a study that analyzed effluent samples for *E. coli* using both membrane filtration and Colilert. They found that *E. coli* values obtained using the Colilert method were consistently higher than those obtained using the membrane filtration method. Figure 10 displays the results of the RWWU study comparing *E. coli* counts obtained using different methods. Blue squares represent the monthly geometric mean *E. coli* counts and gray circles represent the daily counts. Background colors represent whether values exceed the limit of 126 counts (green: below the limit based on both methods, orange: exceedance of limit based on one method but not the other, red: exceedance based on both methods). Both daily and monthly *E. coli* counts are above the 1:1 line, indicating that Colilert produced higher *E. coli* counts than membrane filtration. Looking at the rate of exceedance of permit limits, 1 monthly sample would be in exceedance regardless of which method was used, 4 samples would be below the limit regardless of analytical method, and 4 samples would be in exceedance if using Colilert but below the limit using membrane filtration. It should be noted, however, that confirmatory analyses were not conducted in this study so false positives or negatives may be included in this dataset.

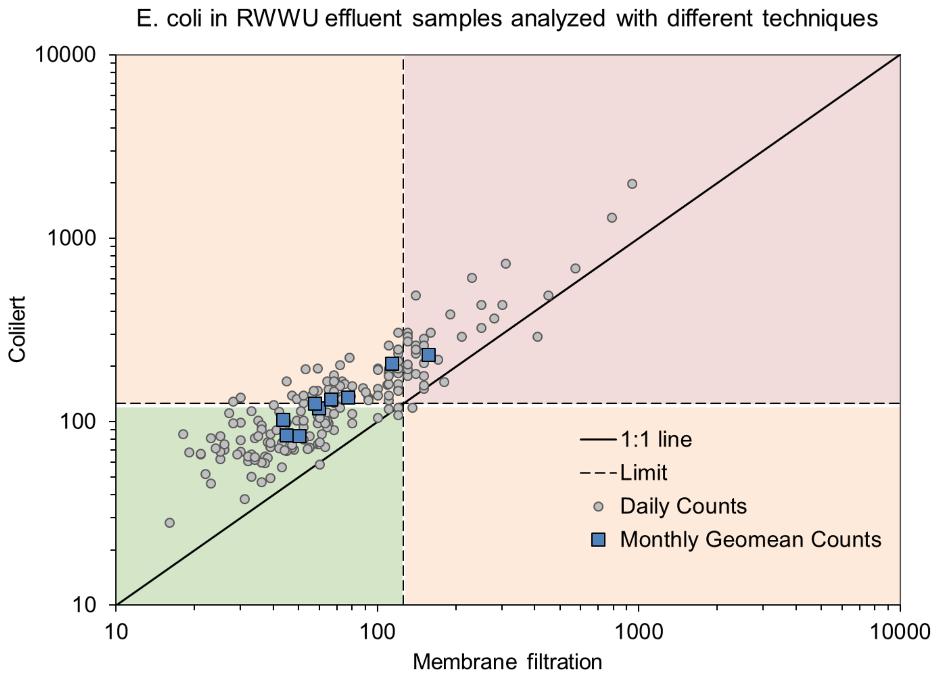

Figure 10. Comparison between the Colilert (IDEXX) and membrane filtration methods for enumerating E. coli in effluent samples [22]. Background colors indicate whether counts were in exceedance of the limit (green: below the limit based on both methods; orange: exceedance of limit based on one method but not the other; red: exceedance of the limit based on both methods).

There are several hypotheses as to the cause of the discrepancy observed in the RWWU study, including the fact that confirmatory analysis was not conducted and thus results may incorporate greater-than-average false-positive rates of the Colilert test and/or a high number of false negatives in the membrane filtration test. Another possible cause for the discrepancy in the RWWU may be due to Colilert being able to detect injured and viable but non-culturable (VBNC) bacterial cells while membrane filtration cannot[23,24,25,26]. The department conducted a literature search to determine whether the patterns observed in the data from RWWU were also documented in

[22] Figure adapted from data provided by Racine Wastewater Utility and referenced in their 2018 *Comments Regarding Proposed Bacteria Standard Rule Change*.

[23] Eccles, J.P., R. Searle, D. Holt and P.J. Dennis. (2004) A Comparison of Methods used to Enumerate Escherichia coli in Conventionally Treated Sewage Sludge. Journal of Applied Microbiology. Volume 96: 375-383.

[24] Garcia-Armisen, T., P. Lebaron and P. Servais. (2005) ß-D-glucuronidase Activity Assay to Assess Viable Escherichia coli Abundance in Freshwaters. Letters in Applied Microbiology. Volume 40: 278-282.

[25] Lifshitz, R. and R. Joshi. (1998) Comparison of the Novel ColiPlate™ Kit and the Standard Membrane Fiter Technique for Enumerating Total Coliforms and Escherichia coli Bacteria in Water. Environmental Toxicology and Water Quality. Volume 13, Number 2: 157-164.

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other studies. Several studies were found that measured *E. coli* in water samples from varying sources (i.e., wastewater, groundwater, surface water, drinking water, etc.) using different techniques and confirmatory analyses, but consistent patterns were not documented between studies. That is, some studies documented higher *E. coli* counts using Colilert and some documented higher *E. coli* counts using membrane filtration.

The department's conclusion from these studies is that data measured using different analytical approaches should not be directly compared and the advantages and disadvantages of each approach (Table 11) should be carefully evaluated before selecting an approach to use for compliance and water quality assessment monitoring. One consideration when evaluating analytical approaches is that of cost, as different techniques require different types of equipment and have different recurring annual costs. The department conducted an Economic Impact Analysis to assess potential costs associated with the revised rule, which can be found in Appendix C.

Further research that compares these methods to one another at Wisconsin wastewater treatment facilities is recommended, and the department may be able to initiate such a study in the future. Until such time further information is available, and because U.S. EPA has approved multiple methods for determining *E. coli* counts, facilities may determine which analytical technique they prefer to use.

UPDATE OF ANALYTICAL METHODS TABLES

Chapter NR 219 contains Table A, "List of Approved Biological Methods for Wastewater and Sewage Sludge", Table EM, "List of Approved Analytical Methods for Sludge", and Table H, "List of Approved Microbiological Methods for Ambient Water". These tables are revised as part of this rule package to align with EPA's methods for laboratory analysis of multiple substances, including several types of bacteria. This rule package includes updates to the portions of these tables dealing with bacteria: fecal coliform, total coliform, *E. coli*, fecal streptococci, enterococci, and salmonella. Additionally, in Table EM, a row on dioxins and furans is revised to delete an incorrect footnote referencing a document related to bacteria. EPA methods are currently undergoing revision and DNR coordinates with EPA to adopt their most recently approved methods. The timing of updates may cause slight discrepancies between the two sets of tables. Footnote numbering in DNR tables differs from EPA methods because EPA rows pertinent only to marine environments are not included in Wisconsin code.

Appendix A: History of the Bacteria Water Quality Criteria for Recreation

NATIONAL CRITERIA

1968 The National Technical Advisory Committee to the Secretary of the Interior recommended the first national bacteria water quality criteria for recreation.

- These criteria were based on epidemiological studies conducted by the United States Public Health Service in the 1940-50s. In these studies, swimmers and non-swimmers at beaches on Lake Michigan, Ohio River, and Long Island Sound were asked to report incidences of eye, ear, nose, and throat ailments, gastrointestinal disturbances, and skin irritations. They observed a correlation between illness incidence and bacterial levels was observed at one of the Lake Michigan beaches when the water had a median total coliform content of 2,300 per 100 mL and at the Ohio River beach when water had a median total coliform density of 2,700 per 100 mL.
- For the criteria, the Committee recommended using fecal coliform as the pathogen indicator instead of total coliform as the correlation between total coliform and fecal contamination was too variable. Work conducted in the Ohio River found that fecal coliforms represented 18% of the total coliform value. To obtain the recommended criteria, the total coliform level at which health effects were observed in the USPHS studies (2,300 total coliform/100 mL) was converted to a fecal coliform level and a safety factor was applied.
- Recommended criteria:
    - Primary contact recreation waters
      "As determined by multiple-tube fermentation or membrane filter procedures and based on a minimum of not less than five samples taken over not more than a 30-day period, the fecal coliform contact of primary contact recreation waters shall not exceed a log mean of 200/100 mL, nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 mL."
    - Secondary contact recreation waters
      "Fecal coliform content, as determined by either multiple-tube fermentation or membrane filter technique, should not exceed a log mean of 1,000/100 mL, nor equal or exceed 2,000/100 mL in more than 10 percent of the samples."

1972 The Committee on Water Quality Criteria of the National Academy of Sciences did not recommend any bacteria water quality criteria for recreation.

- The Committee felt that the epidemiological data used to develop the 1986 criteria were too limited to be scientifically defendable.

1976 The U.S. EPA published recommended national bacteria water quality criteria for recreation.

- Although the EPA acknowledged that a positive correlation between total coliform and increased illness rate was observed in the 1953 study, this correlation was not used as the basis for its recommended criterion.

- Instead, they used the results from a study that compared fecal coliform to *Salmonella* density. Salmonella is a bacterium that can cause typhoid fever, paratyphoid fever, and food poisoning. This study found that *Salmonella* is detected 85-98% of the time at densities of 200 fecal coliform per 100 mL or greater.
- Recommended criteria:

  "Based on a minimum on not less than five samples taken over a 30-day period, the fecal coliform bacterial level should not exceed a log mean of 200 per 100 mL, more should more than 10 percent of the total samples taken during any 30 day period exceed 400 per 100 mL."

1986 The U.S. EPA revised the national bacteria water quality criteria for recreation.

- These criteria were based on the results of a series of studies conducted by the EPA from 1972-1982 at marine and fresh water beaches. The intent of these studies was to determine if swimming in sewage-contaminated water carried a health risk for bathers, establish a quantitative relationship between water quality and health risk, and determine if the same criteria could be applied to both marine and fresh waters.
- A direct linear relationship was observed between swimming-associated gastroenteritis and *E. coli* or enterococci levels in fresh waters. However, a correlation between fecal coliform density and the incidence of swimming-associated gastroenteritis was not observed.
- The recommended criteria was set at a risk level equivalent to that of the 1976 fecal coliform criteria and consisted of a geometric mean and single sample maximum. The geometric mean was calculated from the swimming-associated health effects relationship. The single sample maximum values were calculated for various confidence levels and qualitative use intensities were assigned to these levels; lower confidence levels resulted in more stringent criteria and were recommended for more heavily used areas as a degree of caution.
- Recommended criteria:

  "Based on a statistically significant number of samples (generally not less than 5 samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following:

E. coli	126 per 100 ml; or
enterococci	33 per 100 ml;

  No sample should exceed a one sided confidence limit (C.L.) calculated using the following as guidance:

Designated bathing beach	75% C.L.
Moderate use for bathing	82% C.L.
Light use for bathing	90% C.L.
Infrequent use for bathing	95% C.L.

  Based on a site-specific log standard deviation, or if site data are insufficient to establish a log standard deviation, then using 0.4 as the log standard deviation for both indicators."

2000 The Beaches Environmental Assessment and Coastal Health Act (BEACH) of 2000 was signed into law by President Clinton. This Act:

- Required States with coastal waters* to adopt EPA's 1986 water quality criteria for bacteria by April 2004 and mandated EPA to promulgate criteria for states that did not meet this deadline.
- Requires EPA to conduct studies and publish new/revised criteria based on those studies every 5 years.
- Requires states with coastal waters to adopt new/revised criteria not later than three years after EPA's publication of these criteria.
- Authorizes EPA to award grants for the development and implementation of beach monitoring and assessment programs.

*Coastal waters are defined as the Great Lakes, marine coastal waters, coastal estuaries designated under the Clean Water Act Section 303[c] by a State for swimming, bathing, surfing, and any other water contact activities

2004 The U.S. EPA promulgated water quality criteria for bacteria for Wisconsin's Great Lakes (40 CFR 131.41).

- Criteria were based on EPA's 1986 bacteria water quality criteria for recreation.
- Freshwater criteria were promulgated for Illinois, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin.
- These criteria only apply to fresh coastal recreation waters (i.e., the Great Lakes beaches).
- These criteria apply concurrently with the State's codified criteria.

2012 The U.S. EPA updated the national bacteria water quality criteria for recreation.

- These criteria are based on the National Epidemiological and Environmental Assessment of Recreational Water Study (NEEAR) conducted at beaches throughout the United States from 2003-2009. One of the goals of this study was to obtain and evaluate a new set of health and water quality data to support the development of new or revised criteria for the protection of primary contact recreation.
- In this study, data for *E. coli* were not collected because EPA focused on selecting a single indicator that could be used for both marine and fresh waters. Instead, water quality criteria were established for enterococci and then used to extrapolate comparable *E. coli* values.
- The recommended criteria are applicable to all waters of the United States that are designated for primary contact recreation.
- These recommended criteria consist of a geometric mean (GM) and a statistical threshold value (STV). The GM corresponds to the 50th percentile of sample values in the available water quality distribution and the STV corresponds to the 90th percentile of values. EPA recommends including both the GM and STV as using only the GM would not protect for spikes in water quality.
- The EPA recommended criteria are based on two risk levels. Criteria corresponding to an illness rate of 36 per 1,000 correlate to water quality levels associated with the 1986 recommended criteria while those corresponding with an illness rate of 32 per 1,000 represent an incremental improvement of water quality.
- Recommended criteria:

Estimated Illness rate:	36 per 1000 primary contact recreators	32 per 1000 primary contact recreators

Indicator	GM (cfu/100 mL)	STV (cfu/100 mL)	GM (cfu/100 mL)	STV (cfu/100 mL)
Enterococci	35	130	30	110
E. coli	126	410	100	320

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WISCONSIN CRITERIA

1967 The Department of Resource Development promulgates Wisconsin's water quality criteria for recreation.

- Although the Federal Water Pollution Control Act of 1965 required states to adopt water quality criteria for interstate waters, national recommended criteria for bacteria were not available until 1968. Before this time, states developed criteria on their own. A review of States' criteria in 1963 found that 70% of states used a standard of 1000 coliforms per 100 mL.
- Code language:

  "A sanitary survey and or evaluation to assure protection from fecal contamination is the chief criterion in determining the suitability of a surface water for recreational use. In addition, the following bacteriological guidelines are set forth:

  (a) A water is acceptable for whole body contact if it has an arithmetic average coliform count of 1,000 per 100 ml or less and a maximum not exceeding 2,500 per 100 ml during the recreation season.

  (b) A water is acceptable for partial body contact if it has all arithmetic average coliform count of 5,000 per 100 ml or less and with no more than 1 of the last 5 samples exceeding 20,000 per 100 ml during the recreation season.

  (c) The Membrane Filter Coliform Count (MFCC) is the preferred method for determining coliform density; provided, however, that where turbidity due to algae or other material does not permit testing of a sample volume sufficient to produce significant results, or where low coliform estimates may be caused by high numbers of noncoliforms or the presence of substances toxic to the procedure, the Most Probable Number (MPN) is to be used to determine coliform density. The average is based on the last 5 test results. A more definitive test for fecal pollution is the Membrane Filter Fecal Coliform Count (MFCC). Tests by this method are acceptable where correlation relating the count to sanitary hazards has been demonstrated. Acceptable values based on MFFCC are not shown, but may be adopted in future revisions." [RD 2.02(4)]

1972 The Department of Natural Resources (Department) renumbered the administrative code containing the water quality criteria for recreation from RD 2 to NR 102.

- No changes were made to the code language

1973 The Department revised the bacteria criteria for recreation in NR 102.

- Revised criteria are consistent with the 1968 recommendations from National Technical Advisory Committee
- Code language:

  "A sanitary survey and/or evaluation to assure protection from fecal contamination is the chief criterion in determining the suitability of a surface water for recreational use. In addition, the following bacteriological guidelines are set forth:

  (a) The membrane filter fecal coliform count shall not exceed 200 per 100 ml as geometric mean based on not less than 5 samples per month, nor exceed 400 per 100 ml in more than 10% of all samples during any month." [NR 102.02(4)]

The Department added requirement for all municipal sewage treatment plants to disinfect their effluent. [NR 102.04]

1986 The Department revised the disinfection requirements for municipal sewage treatment plants.

- Blanket disinfection requirement for all municipal sewage treatment plants removed from NR 102.
- The Department added disinfection requirements for recreation and drinking water, effluent limits that must be met for facilities disinfecting, and factors to be considered when determining if disinfection should be required to NR 210.

1989 The Department added disinfection exemption to NR 102.

- Code was updated to be consistent with changes to disinfection policy that took effect in 1986. These changes allowed the Department to determine that disinfection is not required to protect the recreation use. In these cases, the bacteria water quality criteria for recreation did not apply.
- Code language:

  "A sanitary survey and/or evaluation to assure protection from fecal contamination is the chief criterion in determining the suitability of a surface water for recreational use.

  (a) Bacteriological guidelines. The membrane filter fecal coliform count may not exceed 200 per 100 ml as a geometric mean based on not less than 5 samples per month, nor exceed 400 per 102 (40 ml in more than 10% of all samples during any month

  (b) Exceptions. Whenever the department determines, in accordance with the procedures specified in s. NR 210.06, that wastewater disinfection is not required to protect recreational uses, the recreational use criteria and classifications as established in this subsection and in chs. NR 103 and 104 do not apply." [NR 102.04 (5)]

2004 The U.S. EPA promulgated criteria for Wisconsin's fresh coastal recreation waters (i.e., the Great Lakes beaches) based on its 1986 recommended bacteria water quality criteria for recreation.

- These criteria apply concurrently with the State's codified fecal coliform criteria

2010 The Department restructured the format of the recreation water quality standard in NR 102.

- Changes were made to the administrative code to clearly distinguish between the recreation designated use and the bacteria water quality criteria for recreation.
- Code language:

  "(5) Recreational Use. (a) General. All surface waters shall be suitable for supporting recreational use and shall meet the criteria specified in sub. (6). A sanitary survey or evaluation, or both to assure protection from fecal contamination is the chief criterion for determining the suitability of a water for recreational use.

  (b) Exceptions. Whenever the department determines, in accordance with the procedures specified in s. NR 210.06 (3), that wastewater disinfection is not required to protect recreational uses, the criteria specified in par. (a) and in chs. NR 103 and 104 do not apply.

  (6) Criteria for Recreational Use. As bacteriological guidelines, the membrane filter fecal coliform count may not exceed 200 colonies per 100 ml as a geometric mean and may not exceed 400 colonies per 100 ml in more than 10% of all samples during any month. Samples shall be required at least 5 times per month." [NR 102.04]

References

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- Water Quality Standards for Interstate Waters. *Wisconsin Administrative Code*, Chapter NR 102, 1971.
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- Water Quality Standards for Wisconsin Surface Waters. *Wisconsin Administrative Code*, Chapter NR 102, 1989.
- Water Quality Standards for Wisconsin Surface Waters. *Wisconsin Administrative Code*, Chapter NR 102, 2010.

Appendix B: States Comparison

This appendix summarizes recreation water quality criteria and implementation procedure policies from Minnesota, Michigan, Indiana, Ohio, Illinois, and Iowa.

WATER QUALITY CRITERIA

Minnesota

E. coli used as the pathogen indicator
Criteria based on EPA's 1986 criteria
Criteria consist of two components: geometric mean and single sample maximum
Separate criteria apply to Lake Superior, Class 2 inland waters (Aquatic life and Recreation waters), and Class 7 inland waters (Limited Resource Value waters)

	Lake Superior		**Class 2 Inland Waters**		**Class 7 Inland Waters**	
	Geometric Mean	Single Sample	Geometric Mean	Single Sample	Geometric Mean	Single Sample
Magnitude:	126	235	126	1,260	630	1,260
Exceedance frequency:	0	10% of samples	0	10% of samples	0	10% of samples
Duration:	Month	Month	Month	Month	Month	Month
Minimum data requirements:	5	None	5	None	5	None
Season:	4/1- 10/31		4/1- 10/31		5/1- 10/31	

Michigan

E. coli used as the pathogen indicator
Criteria are based on EPA's 1986 criteria
Criteria consist of two components: 30-day geometric mean and single-day geometric mean
Separate criteria apply to Total Body Contact and Partial Body Contact waters

	Total Body Contact		**Partial Body Contact**
	30 Day Geometric Mean	Single Day Geometric Mean	Single Day Geometric Mean
Magnitude:	130	300	1,000
Exceedance frequency:	0	0	0
Duration:	30 days	1 day	1 day
Minimum data requirements:	5	3	3
Season:	5/1 – 10/31		11/1 – 4/30

Indiana

E. coli is used as the pathogen indicator
Criteria are based on EPA's 1986 criteria
Criteria consist of two components: geometric mean and single sample maximum
The same criteria apply all waters designated as full body contact waters

	Geometric Mean	Single Sample Maximum
Magnitude:	125	235
Exceedance frequency:	0	1 sample (< 10 samples) 10% of samples (≥10 samples)*
Duration:	30 days	30 days
Minimum data requirements:	5	None
Season:	4/1 – 10/31	

* Only applies if exceedance is caused by discharge from WWTP and the geometric mean criteria is met in the waterbody

Ohio

E. coli used as the pathogen indicator
Criteria are based on EPA's 2012 criteria
Criteria consist of two components: geometric mean and statistical threshold value
The same criteria apply to bathing and primary contact waters, but separate criteria apply to secondary contact waters

	Bathing Water		Primary Contact		Secondary Contact	
	Geometric Mean	Statistical Threshold Value	Geometric Mean	Statistical Threshold Value	Geometric Mean	Statistical Threshold Value
Magnitude:	126	410	126	410	1030	1030
Exceedance frequency:	0	10% of samples	0	10% of samples	0	10% of samples
Duration:	90 days	90 days	90 days	90 days	90 days	90 days
Minimum data requirements:	Not specified					
Season:	5/1 – 10/31					

Illinois* Fecal coliform used as the pathogen indicator
Criteria consist of two components: geometric mean and single sample maximum
Separate criteria apply to general use waters that are considered suitable for primary contact recreation, the open waters of Lake Michigan, and the remaining Lake Michigan waters.

	Primary Contact Waters		**Open Waters of Lake Michigan†**	**Remaining Lake Michigan Waters**	
	Geometric Mean	Single Sample	Geometric Mean	Geometric Mean	Single Sample
Magnitude:	200	400	20	200	400
Exceedance frequency:	0	10% of samples	0	0	10% of samples
Duration:	30 days	30 days	30 days	30 days	30 days
Minimum data requirements:	5	None	5	5	None
Season:	5/1- 10/31		Not specified		

† Open waters of Lake Michigan means all of the waters within Lake Michigan in Illinois jurisdiction lakeward from a line drawn across the mouth of tributaries to Lake Michigan, but not including waters enclosed by constructed breakwaters.

* Illinois is in the process of revising its recreational water quality standards and implementation procedures

Iowa *E. coli* used as the pathogen indicator
Criteria are based on EPA's 1986 criteria
Criteria consist of two components: geometric mean and sample maximum
The same criteria apply to Class A1, A2, A3 waters

	Primary Contact Recreation (Class A1)		**Secondary Contact Recreation (Class A2)**		**Outstanding Water(s)***		**Children's Recreation (Class A3)**	
	Geometric Mean	Sample Maximum	Geometric Mean	Sample Maximum	Geometric Mean	Sample Maximum	Geometric Mean	Sample Maximum
Magnitude:	126	235	630	2,880	630	2,880	126	235
Exceedance frequency:	0	0	0	0	0	0	0	0
Duration:	Not specified							
Minimum data requirements:	Not specified							
Season:	3/15 – 11/15		3/15 – 11/15		Year-round		3/15 – 11/15	

*Applies to Outstanding Iowa Waters, Outstanding National Resource Waters, and any secondary Contact Recreation water with an aquatic life designation of cold water

SITE-SPECIFIC CRITERIA

None of the other Region 5 states have language specific to the development of site-specific criteria for bacteria.

EFFLUENT LIMITATIONS

Minnesota

Indicator: Fecal coliform

	Long-Term Limit	Short-Term Limit
Magnitude:	200	N/A
Duration:	Calendar month	N/A
Exceedance frequency:	0	N/A
Minimum sample size:	Not specified	N/A
Form:	Geometric mean	N/A

Michigan

Indicator: Fecal coliform

	Long-Term Limit	Short-Term Limit
Magnitude:	200	400
Duration:	30 days	≤ 7 days
Exceedance frequency:	0	0
Minimum sample size:	5	3
Form:	Geometric mean	Geometric mean

Indiana

Indicator: *E. coli*

	Long-Term Limit	Short-Term Limit*
Magnitude:	125	235
Duration:	Calendar month	Calendar month
Exceedance frequency:	0	10% of samples
Minimum sample size:	Not specified	10*
Form:	Geometric mean	Maximum value

*The short-term limit only applies when 10 or more samples have been collected; only the long-term limit applies if less than 10 samples are collected.

Ohio

Ohio River permittees

Indicator: *E. coli* (recreation season)
Fecal coliform (non-recreation season)

	Recreation (May-October)		Non-recreation (November-April)	
	Long-Term Limit	**Short-Term Limit**	**Long-Term Limit**	**Short-Term Limit**
Magnitude:	130	240	1,000	2,000
Duration:	Month	Week	Month	Week
Exceedance frequency:	0	0	0	0
Minimum sample size:	Not specified		Not specified	
Form:	Geometric mean	Geometric mean	Geometric mean	Geometric mean

All other permittees*

Indicator: *E. coli*

	Bathing & Primary Contact		Secondary Contact	
	Long-Term Limit	**Short-Term Limit**	**Long-Term Limit**	**Short-Term Limit**
Indicator:	*E. coli*		*E. coli*	
Magnitude:	126	284	1,030	2,318
Duration:	Month	Week	Month	Week
Exceedance frequency:	0	0	0	0
Minimum sample size:	Not specified		Not specified	
Form:	Geometric mean	Geometric mean	Geometric mean	Geometric mean

* Recreation (May-October)

Illinois*

Indicator: Fecal coliform

Limit: Effluent discharges to all general use waters may not exceed 400 fecal coliforms per 100 ml unless an alternate limit has been established

* Illinois is in the process of revising its recreation water quality standards and implementation procedures

Iowa Indicator: *E. coli*

	Primary Contact Recreation (Class A1)	Secondary Contact Recreation (Class A2)	Outstanding Water(s)*	Children's Recreation (Class A3)
Magnitude:	126	630	630	126
Duration:	Month	Month	Month	Month
Exceedance frequency:	0	0	0	0
Minimum sample size:	5*	5*	5*	5*
Form:	Geometric mean	Geometric mean	Geometric mean	Geometric mean
Disinfection Season:	March 15th – November 15th			

* At least 5 samples must be collected in one calendar month during each 3-month period from March 15 to November 15 (minimum of 15 samples per year)

Appendix C: Economic Impact Analysis

STATE OF WISCONSIN
DEPARTMENT OF ADMINISTRATION
DOA-2049 (R03/2012)

DIVISION OF EXECUTIVE BUDGET AND FINANCE
101 EAST WILSON STREET, 10TH FLOOR
P.O. BOX 7864
MADISON, WI 53707-7864
FAX: (608) 267-0372

ADMINISTRATIVE RULES
Fiscal Estimate & Economic Impact Analysis

1. Type of Estimate and Analysis
☐ Original ☒ Updated ☐ Corrected — Date: 07/18/2019

2. Administrative Rule Chapter, Title and Number
NR 102 – Water Quality Standards for Wisconsin Surface Waters
NR 104 – Uses and Designated Standards
NR 210 – Sewage Treatment Works
Clearinghouse Rule # 19-014

3. Subject
WY-17-15: Updating Wisconsin's water quality criteria for pathogens (bacteria) and recreational uses and related WPDES permit implementation procedures for the revised water quality standards to be consistent with EPA's recreational water quality criteria.

4. Fund Sources Affected	5. Chapter 20, Stats. Appropriations Affected
☒ GPR ☐ FED ☒ PRO ☐ PRS ☐ SEG ☐ SEG-S	20.370 (4)(ma)

6. Fiscal Effect of Implementing the Rule
☒ No Fiscal Effect
☐ Indeterminate
☐ Increase Existing Revenues
☐ Decrease Existing Revenues
☐ Increase Costs
☐ Could Absorb Within Agency's Budget
☐ Decrease Cost

7. The Rule Will Impact the Following (Check All That Apply)
☐ State's Economy
☒ Local Government Units
☒ Specific Businesses/Sectors
☐ Public Utility Rate Payers
☒ Small Businesses **(if checked, complete Attachment A)**

8. Would Implementation and Compliance Costs Be Greater Than $20 million?
☐ Yes ☒ No

9. Policy Problem Addressed by the Rule
Revisions to Wisconsin's water quality criteria for bacteria to protect recreation, and related implementation procedures, are necessary for several reasons.

- Wisconsin's current criteria are outdated and not adequately protective. Wisconsin uses fecal coliform bacteria as the pathogen indicator while the United States Environmental Protection Agency (EPA) has recommended using *E. coli* as a pathogen indicator since the mid-1980s. These revisions ensure that Wisconsin's criteria are based on the latest scientific knowledge and adequately protect people that are recreating in Wisconsin's waters.
- States with coastal waters are required by the Beaches Environmental Assessment and Coastal Health (BEACH) Act to adopt EPA's latest water quality criteria for pathogens (including bacteria) no later than 3 years after publication. If these criteria are not adopted in a timely manner, EPA has the authority to promulgate water quality standards to ensure the requirements of the Clean Water Act are met. EPA published their latest recommendations in 2012.
- Revising the bacteria criteria at this time will also allow Wisconsin to continue to receive federal grants for beach monitoring and notification. To be eligible for these grants, the state's water quality program must be consistent with the performance criteria established by the EPA. In 2014, the EPA added adoption of new or revised recreational water quality standards as a performance criterion. These funds are crucial for supporting Wisconsin's beaches as the department distributes them to local communities to monitor their beaches, notify community members in a timely manner when issues arise, and collect information necessary to restore problem beaches.
- Wisconsin's current bacteria criteria are applied inconsistently throughout the state. Wisconsin has different standards for inland and Great Lakes waters because EPA over-promulgated criteria for the Great Lakes in 2004. This has resulted in an additional burden on permittees to the Great Lakes as they are required to monitor for both fecal coliform and *E. coli*. This rule revision would apply the same criteria statewide during the disinfection period for recreation to reduce duplicative monitoring.

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10. Summary of the businesses, business sectors, associations representing business, local governmental units, and individuals that may be affected by the proposed rule that were contacted for comments.

Facilities that may be affected and other interested parties were contacted and given the opportunity to comment on the draft EIA during the public solicitation period.

11. Identify the local governmental units that participated in the development of this EIA.

Local governments and their treatment facility operators were given the opportunity to comment on the draft EIA during the public solicitation period. Comments were submitted by Milwaukee Metropolitan Sewerage District, City of Chilton Wastewater Treatment Plant, Watertown Wastewater Treatment Plant, Plymouth Utilities, Madison Metropolitan Sewerage District, Polk County Health Department, City of Racine Public Health Department, and the Municipal Environmental Group representing municipal treatment plants and including a study from Racine Wastewater Utility. WDNR prepared responses to all comments and revised portions of the EIA and the rule language accordingly.

12. Summary of Rule's Economic and Fiscal Impact on Specific Businesses, Business Sectors, Public Utility Rate Payers, Local Governmental Units and the State's Economy as a Whole (Include Implementation and Compliance Costs Expected to be Incurred)

This rule is expected to have a moderate economic impact estimated at an annual cost of approximately $2.1 million (rounded to two significant figures). The costs incurred will be due to increased disinfection needed for some facilities to comply with *E. coli* permit limits, and changes in analytical methods associated with monitoring each type of bacteria. These changes solely pertain to facilities subject to ch. NR 210, Wis. Adm. Code (i.e., publicly owned treatment works, privately owned domestic sewage treatment works). Of 354 total facilities that disinfect, over half (208) are expected to already meet permit limits based on *E. coli* with no additional treatment. The department estimates that 41% (146) will need to increase treatment, with a total annual cost of increased treatment for all facilities combined of $2,100,000. The department anticipates the total annual cost of sample analysis for facilities that monitor to be $53,000. Cost savings for 20 facilities that will be able to reduce monitoring are estimated at $22,000. Taken together, the net annual cost of compliance is anticipated to be $2,100,000. Throughout this analysis, costs are rounded to two significant figures; therefore the total cost in some tables may not be equal to the sum of all individual costs.

Impact of increased treatment

The proposed change in criteria and limits may require some facilities to increase their level of disinfection. Facility-specific costs for meeting the limit were estimated using facility-specific data and summed to estimate a state-wide compliance cost of the rule. Impacts due to increased treatment were assessed for a total of 354 facilities that utilize either chlorine or ultraviolet (UV) disinfection. Costs of meeting bacteria limitations were only assessed for facilities that treat domestic wastewater and are currently subject to bacteria limitations.

Fifty eight percent of facilities (208) are expected to be able to meet the proposed limits (monthly *E. coli* geomean of 126 counts/100 mL and STV of 410 counts/100 mL) at their current disinfection level, and no costs of increased treatment were attributed for these facilities. Approximately 41% of the total facilities in the state (66 facilities using chlorine disinfection; 80 facilities using ultraviolet disinfection) are expected to require additional treatment to meet the proposed change in criteria and limits.

Using a first-order kinetics model, a multiplier representing an increased level of ultraviolet or chlorine disinfection needed beyond the current treatment level was computed for each facility. The cost estimates developed in this analysis included capital costs and operation and management costs. Capital costs were amortized over 20 years using a nominal discount rate of 3.6%.

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- Based on the model developed, incremental flow-rated chlorine disinfection cost was estimated to be $220 ($/MGD/d/100% additional disinfection) with 4mg/L of chlorine as the baseline dose.
- The incremental flow-rated ultraviolet disinfection cost was estimated to be $72 ($/MGD/d/100% additional disinfection) with an operational transmissivity of 0.8.

The annual total cost of an increase in disinfection as a result of this rule is estimated at $2,100,000 per year (Table 1).

Table 1. Estimated cost increases due to increased disinfection.

	Facilities expected to need additional treatment	**Total Annual Cost (amortized over 20 years)**
Chlorine	66	$1,800,000
UV	80	$340,000
Total	146	$2,100,000

Impact of sample analysis
Facilities may also experience an increased cost for lab analysis of *E. coli* samples instead of fecal coliform samples. The department estimated costs for facilities currently monitoring for fecal coliform that will be required to switch to monitoring for *E. coli* during the disinfection period for recreation protection. Facilities may also incur increased costs associated with purchasing equipment to analyze *E. coli* samples using a multiple well method if they choose to use that analytical technique. To estimate lab analysis costs associated with this rule, the department looked both at costs for facilities to send samples to an external certified lab for analysis, and at an alternative of conducting analysis in-house if the facility has a certified lab.

The department obtained quotes from several commercial labs in the state for both fecal coliform and *E. coli* monitoring (per sample, *E. coli*: $25; fecal coliform: $19). This information, along with monitoring requirements in current permits, was used to estimate facilities' current cost of monitoring. Projected costs were then calculated assuming facilities will monitor for only *E. coli* at their current monitoring frequency from May 1 through September 30 (or other currently designated recreation period) and send samples to an external lab for analysis (Table 2). The analyses in this section do not assess monitoring costs during other parts of the year since this rule does not affect monitoring outside the recreation disinfection season.

Table 2. Estimated costs due to changes in analytical methods: Using external lab

Proposed Change	**Number of Facilities**	**Estimated Annual Change per Facility ($)**	**Total Annual Costs ($)**
Switch indicator from fecal coliform to *E. coli*; External lab analysis	336	160	**53,000**

Facilities with a certified lab in-house can determine whether it is more cost-effective for them to send their samples to an external lab or do the analysis in-house. If doing in-house analysis, facilities may use membrane filtration methods or multiple well methods. Most facilities are already doing membrane filtration for fecal coliform. If they continue with membrane filtration for *E. coli*, cost per sample would be generally equivalent. Some facilities may wish to instead purchase equipment to convert to multiple well analysis, which can save staff time and may be more efficient in the long-term. The department obtained cost estimates from a multiple well test manufacturer (IDEXX) for up-front capital costs as well as ongoing annual costs for facilities that choose to begin analyzing *E. coli* using a multiple well method rather than a membrane filtration method (Table 2). Costs shown in Table 3 are optional and would be in place of costs from Table 2 for facilities selecting this option.

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Table 3. Estimated costs due to changes in analytical methods: In-house lab analysis with multiple well methods

Proposed Change	Number of Facilities	Estimated Annual Change per Facility ($)		Total Annual Costs over 10 years ($)
Switch indicator from fecal coliform to *E. coli*; Purchase defined substrate analytical equipment (optional)	102*	First year**	5000	**51,000**
		Subsequent years**	140***	**14,000**

* assumes only 50% of facilities that have a laboratory certification may prefer this approach
** first year costs represent purchase of basic equipment; subsequent year costs represent UV bulb replacement
*** Ongoing costs may be lower if a facility chooses not to do multiple well analysis outside of the recreation disinfection period.

For some facilities, changes to the monitoring requirements will reduce costs. There are 20 municipal wastewater treatment facilities that are monitoring for both fecal coliform and *E. coli* during the recreation season. These facilities may see an economic benefit from this rule as they will no longer have to monitor for fecal coliform during the recreation season (Table 4). Each of these 20 facilities is estimated to save $1,100 annually, for a total of $22,000 combined annual savings.

Table 4. Estimated savings due to changes in monitoring requirements

Proposed Change	Number of Facilities	Estimated Annual Change per Facility ($)	Total Annual Savings ($)
Drop fecal coliform indicator; continue monitoring *E. coli*	20	-1,100	**-22,000**

Note: This analysis only calculates costs and savings during the time period for disinfection to protect recreation. Facilities that disinfect/monitor year-round and currently monitor for both indicators may be able to drop analysis for either fecal coliform or E. coli during the non-recreation part of the year as well, which could further increase savings.

13. Benefits of Implementing the Rule and Alternative(s) to Implementing the Rule

Revisions to the water quality criteria and effluent limits are likely to lead to improved water quality and reduced risk of illness in people recreating in Wisconsin's waters. While these benefits are hard to quantify, they are expected to result in an overall benefit to the citizens of Wisconsin.

While the alternative is to not revise the bacteria criteria and maintain the status quo, there are several disadvantages to that approach. First, the state would continue to use fecal coliform an indicator for recreation, which has been shown to be ineffectual for recreational protection. This would also perpetuate current inconsistencies in the permit limits required during the disinfection period for recreation at facilities in various parts of the state. Second, if the state's criteria are not revised the department may lose federal grant dollars that are passed through to local communities. Third, EPA could promulgate the revised criterion for Wisconsin as they did in 2004. If EPA does promulgate criteria for Wisconsin, its rule-making process is unlikely to include revisions to related rules (such as discharge permit requirements) and would not eliminate the state's published fecal coliform criteria that currently apply during the recreation time frame. Additionally, if EPA promulgates criteria, Wisconsin would lose the ability to select its own pathogen indicator and acceptable risk level and to develop site specific criterion procedures.

14. Long Range Implications of Implementing the Rule

The revision from fecal coliform to *E. coli* as the state's pathogen indicator for recreation protection will make the state consistent with EPA regulations. It will better protect public health and recreational opportunities by keeping bacterial levels in waterways low. Once a facility has come into compliance with their water quality based effluent limits, they must stay in compliance. Therefore, costs for disinfection and monitoring will be recurring annual costs as estimated in this analysis.

15. Compare With Approaches Being Used by Federal Government

Section 303(i)(1)(B) of the Clean Water Act requires states with coastal waters (including the Great Lakes) to promulgate criteria for pathogens/pathogen indicators (including bacteria) and submit these criteria to EPA for approval.

Section 303(c) of the Clean Water Act requires states to periodically review and modify or adopt, if necessary, water quality standards. This requirement applies to all surface waters in the state.

Federal regulations (40 CFR 131.10 and 11) require states to develop water quality standards comprised of designated uses and criteria to protect the uses. 40 CFR 131.10(j) requires states to conduct a use attainability analysis to remove or modify the designated uses specified in Section 101(a)(2) of the Clean Water Act, which include recreation. 40 CFR 131.11(b) states that the criteria must be based on federal guidance, federal guidance modified to reflect site-specific conditions, or other scientifically-defensible methods.

Section 301(b)(1)(C) of the Clean Water Act requires compliance with effluent limits needed to meet water quality standards.

40 CFR 122.44(d) requires that water quality based effluent limits be established when discharge levels have the potential to cause or contribute to an exceedance of a water quality standard.

40 CFR 122.45(d) requires that effluent limits be expressed as average weekly and average monthly values for publicly owned treatment works (POTWs) with continuous discharges.

16. Compare With Approaches Being Used by Neighboring States (Illinois, Iowa, Michigan and Minnesota)

In this rule package, the department has selected an approach that is consistent with neighboring states, selecting *E. coli* as the pathogen indicator for recreation protection. All neighboring coastal states (Michigan, Minnesota, Indiana, Ohio) except Illinois currently use *E. coli* as the pathogen indicator. Illinois is currently in the process of revising their criteria to use *E. coli*. Iowa is not a coastal state and is therefore not subject to the same BEACH Act regulations, but also uses *E. coli* as its indicator. The states vary in certain specifics associated with the criteria and permit implementation, since some states' criteria and implementation procedures are based on older EPA recommendations or they have selected different illness rates, etc. The department is generally consistent with the other states in approach but follows the most recent federal recommendations, similar to Ohio.

17. Contact Name	18. Contact Phone Number
Kristi Minahan	608-266-7055

This document can be made available in alternate formats to individuals with disabilities upon request.

ATTACHMENT A

1. Summary of Rule's Economic and Fiscal Impact on Small Businesses (Separately for each Small Business Sector, Include Implementation and Compliance Costs Expected to be Incurred)

Privately owned sewage treatment facilities that currently disinfect wastewater are likely to be affected by this rule. There are currently five such facilities that may be affected small businesses, such as mobile home parks or nursing homes. Some facilities may need to increase disinfection to comply with *E. coli* permit limits and/or change lab analysis procedures. The total annual compliance cost for these facilities combined is estimated at $2,200. This includes an estimated cost of $1,500 for increasing disinfection, and a cost of $660 for switching analytical methods from fecal coliform to *E. coli* during the recreation period.

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ADMINISTRATIVE RULES
Fiscal Estimate & Economic Impact Analysis

2. Summary of the data sources used to measure the Rule's impact on Small Businesses

Privately owned sewage treatment works that are currently disinfecting were identified through the department's permit program data system (System for Wastewater Applications, Monitoring and Permits, or SWAMP). A subset of five facilities identified may be small businesses, although WDNR does not have data that specifies this. The difference between current and projected monitoring costs for these facilities was calculated in the same way as described for publicly owned sewage treatment facilities.

3. Did the agency consider the following methods to reduce the impact of the Rule on Small Businesses?

- ☐ Less Stringent Compliance or Reporting Requirements
- ☐ Less Stringent Schedules or Deadlines for Compliance or Reporting
- ☐ Consolidation or Simplification of Reporting Requirements
- ☐ Establishment of performance standards in lieu of Design or Operational Standards
- ☐ Exemption of Small Businesses from some or all requirements
- ☒ Other, describe: See item 4 below.

4. Describe the methods incorporated into the Rule that will reduce its impact on Small Businesses

Two revisions were made to the originally proposed rule language that will reduce its effect on small businesses: (a) the monitoring frequency was kept at each facility's existing frequency instead of requiring a minimum of twice weekly; and (b) both types of permit limits are now set at a calendar month basis, which is the simplest approach. These adjustments reduce the fiscal burden for small businesses and make implementation easier.

5. Describe the Rule's Enforcement Provisions

Enforcement provisions are not included in the portions of the rule affected by the proposed order. These provisions are located in other portions of administrative rule not proposed for revision in this proposed rule order.

6. Did the Agency prepare a Cost Benefit Analysis (if Yes, attach to form)

☒ Yes (see summary table below) ☐ No

Five privately owned facilities currently subject to bacteria limits were identified that may be impacted by the rule. The potential small businesses identified here are a subset of the above group of all facilities; therefore these costs are not in addition to the costs above. The number of actual small businesses may be fewer than five, in which case total costs would be lower.

Table 5. Number of Small Business Facilities Assessed

	Chlorine Disinfection	**Ultraviolet (UV) Disinfection**
Total Number of Facilities	3	2
Facilities anticipated to meet EC limits with current treatment	0	1
Facilities expected to need additional treatment to meet EC limits	3	1

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Table 6. Estimated costs for affected small businesses.

	Number of Facilities	**Total Annual Cost** (amortized over 20 years)**
Total cost of increased disinfection	4	$1,500
Facilities using chlorine	3	$1,500
Facilities using UV	1	$39
Sample analysis*	5	$660
Total for increased disinfection & analysis for all facilities combined	**5**	**$2,200**

* Assumes facilities send samples to an external lab for analysis.
** Table shows two significant figures.