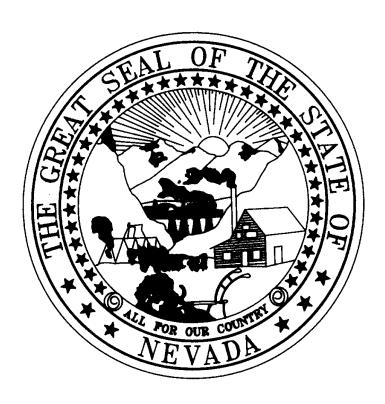# Rationale for Proposed Revisions to Ambient Water Quality Criteria for Bacteria

R 102-16

Prepared by:

Nevada Division of Environmental Protection
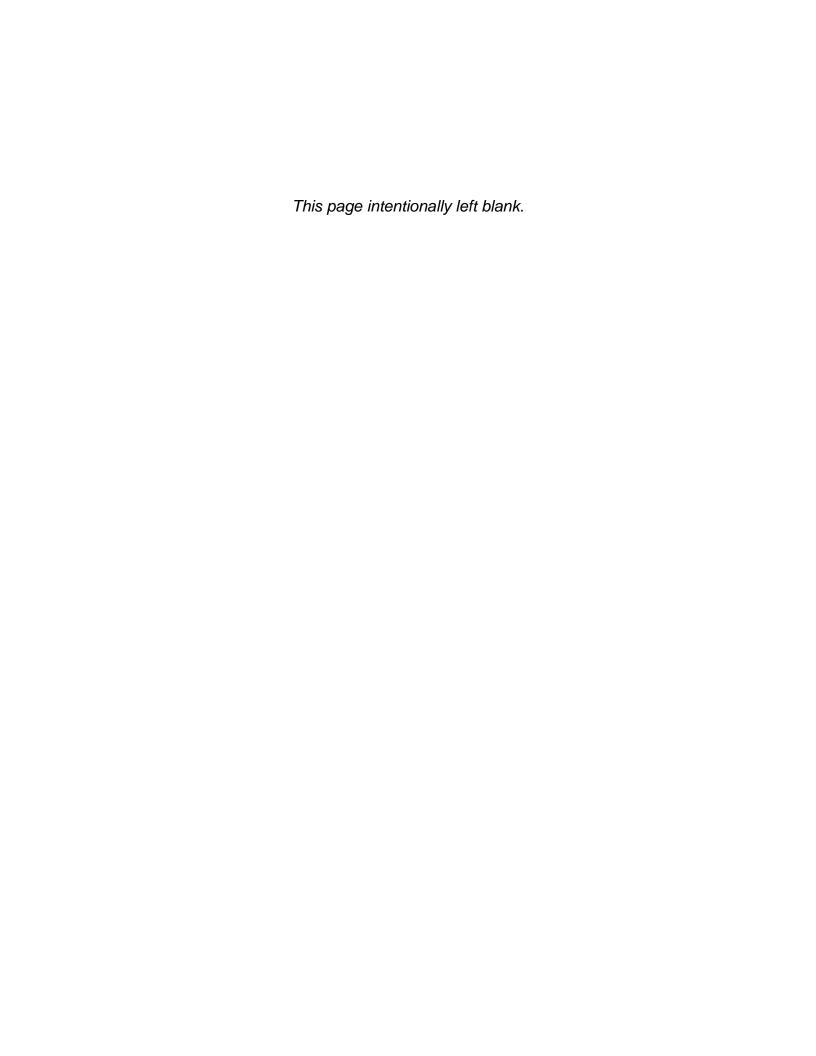**Bureau of Water Quality Planning**
September 2017

This page intentionally left blank.

Table of Contents

List of Tables

RATIONALE FOR PROPOSED REVISIONS TO WATER QUALITY CRITERIA FOR BACTERIA TO PROTECT CONTACT RECREATION

Introduction

The Clean Water Act requires U.S. Environmental Protection Agency (EPA) to periodically update ambient water quality criteria. In 2012, EPA released updated recommendations for recreational water quality criteria (RWQC) to protect human health in waters designated for primary contact recreation use. EPA last issued ambient water quality criteria for bacteria in 1986 (EPA 1986). In the 1986 guidance document, Ambient Water Quality Criteria, two bacterial indicators of fecal contamination, *E. coli* for freshwater and enterococci for marine and freshwater were recommended to protect human health during water-contact recreational activities (EPA, 1986). The current RWQC contained in the State of Nevada water quality standards (Nevada Administrative Code [NAC] 445A.070 – 445A.2234) are based on the 1986 criteria for *E. coli*. The Nevada Division of Environmental Protection (NDEP) is proposing to adopt the updated ambient water quality criteria for bacteria (EPA, 2012), in Regulatory Petition (R102-16) as discussed in this rationale.

Background on Water Quality Criteria for Bacteria

There has been a long history of fecal indicator bacteria (FIB) being used to protect the public from exposure to harmful levels of pathogens during water-contact recreational activities. In the 1960s, the U.S. Public Health Service recommended using fecal coliform as the FIB to identify potential for illness in surface waters contaminated by fecal pollution, and EPA recommended use of fecal coliform bacteria as water quality criteria in 1976 (EPA, 1976).

Water quality criteria for bacteria are levels of indicator organisms not to be exceeded in order to protect human health from pathogen-caused illness. Waterbodies may contain many different pathogens that cannot be measured directly; therefore, indicator organisms or fecal indicator bacteria are used to detect the level of fecal contamination in the water and to estimate the associated health risks from all pathogens residing in the waterbodies. These indicator organisms may not be the direct cause of an illness, but have demonstrated characteristics that make them good predictors of whether harmful pathogens, such as viruses, protozoa, bacteria, and other disease-causing microorganisms, are present in the waterbodies.

In the 1986 Criteria document (U.S. EPA 1986), EPA obtained data supporting the recommended water quality criteria for bacteria from a series of research studies that examined

the relationship between swimming-associated illness and the microbial quantity in the waters used for swimming and other recreational activities. The results of these studies demonstrated that fecal coliforms, the FIB recommended in 1968 by the National Technical Advisory Committee (NTAC) (National Technical Advisory Committee 1968) of the Department of the Interior did not provide a good correlation to swimming-associated illnesses. Other indicator organisms such as *E. coli* or enterococci were determined to provide a better correlation than fecal coliforms in fresh waters, whereas enterococci showed good correlations in both fresh and marine waters.

Since EPA last published recommended RWQC in 1986, scientific advances have been made in the areas of epidemiology, molecular biology, microbiology, and methods of analytical assessment. EPA's evaluation of these new scientific and technical advances was used in the development of the 2012 RWQC. Results of these studies strengthen the scientific foundation of EPA's criteria recommendations to protect the designated use of primary contact recreation. Primary contact recreation typically includes activities where immersion and ingestion are likely and there is a high degree of bodily contact with the water. Such activities include swimming, bathing, surfing, water skiing, tubing, skin diving, water play by children, or similar water-contact activities.

In the late 1970s and early 1980s, EPA conducted epidemiological studies that evaluated several organisms as possible indicators of fecal contamination. These studies showed two microorganisms consistently performed and correlated well as indicators of illness in the epidemiological studies: *E. coli* in freshwater and enterococci in both freshwater and marine waters. As a result, EPA published *EPA's Ambient Water Quality Criteria for Bacteria – 1986* ("the 1986 criteria") containing recommended RWQC for both *E. coli* and enterococci. Threshold values recommended for both microorganisms in the 1986 document provided the same level of water quality protection that had been previously provided by the use of fecal coliform as the water quality criteria.

The 1986 criteria contained two components: a geometric mean and a single sample maximum allowable value based on the frequency of contact recreational use and the corresponding degree of body contact with the water. NDEP proposed a statewide revision to the bacterial water quality criteria in 2002. This revision incorporated the 1986 bacterial water quality criteria for *E. coli* (shown below in Table 1) as a geometric mean determined on an annual basis and single sample maximum (SSM) value, based on use intensity, into the water quality standards. Through consultation with the Nevada State Health Laboratory, *E. coli* rather that enterococci was selected as the freshwater microbial indicator to be adopted.

Table 1. EPA 1986 recommended water quality criteria for bacteria in freshwater systems.

Indicator	Geometric Mean Value	Single Sample Maximum Allowable Values (MPN/100 ml)			
		Designated Beach Area	Moderate Full Body Contact Recreation	Lightly Used Full Body Contact Recreation	Infrequent Used Full Body Contact Recreation
E. Coli	126	235	298	410	576

Non-contact recreation (secondary contact recreation) is defined as incidental contact where the probability of ingesting appreciable quantities of water is minimal. Examples include fishing, commercial and recreational boating, canoeing, kayaking, wading by adults, and limited body contact associated to shoreline activity. The current *E. coli* water quality criterion for non-contact recreation is 630 most-probable number (MPN) per 100 milliliters (mL); calculated per EPA's 1986 Criteria recommendations as five times the primary contact geometric mean (GM) of 126.

In late 2012, EPA published a reevaluation of the recommended bacteria criteria for protecting people during recreational water activities (EPA 2012). The 2012 RWQC abandoned the concept of "use intensity" as a basis for recommending multiple SSM criteria. Instead, EPA recommended that states adopt both a GM and a statistical threshold value (STV), as the WQS for all primary contact recreation waters.

An important distinction with STVs versus SSMs is that a SSM is a "never to be exceeded" value. An STV is expected to be exceeded in some percentage of the samples collected. The STV approximates the 90th percentile of the water quality distribution and is intended to be a value that should not be exceeded by more than 10% of the samples used to calculate the GM. This makes more sense statistically than the previous SSMs, but also requires frequent sampling to make a practical difference.

The 2012 RWQC consist of three components: magnitude, duration and frequency. The magnitude is expressed as a GM value and a STV for the bacteria samples. Both the GM and STV are collectively used to assess whether the water quality is protective of the designated use of primary contact recreation. Using the GM alone would not capture the variability in water quality measurements because the GM alone is not sensitive to spikes in water chemistry. The STV represents a more conservative approach in evaluating water quality because once an exceedance is observed, at least ten more samples need to be below the STV before water quality is considered unimpaired.

The 2012 RWQC also recommend a duration period for evaluating the GM and STV, and an allowable frequency of exceedance. EPA recommends that the GM calculated from waterbody samples over a 30-day interval not exceed the GM criterion. Over this same 30-day interval, there should not be greater than a ten percent frequency of samples exceeding the STV. The GM of a waterbody is calculated the same way as recommended in the 1986 criteria by taking the $\log_{10}$ of sample values, averaging those values, and then raising 10 to the power of that average of logs (i.e., back-transform the average of the log-transformed values).

During development of the 2012 RWQC, EPA reviewed the analytical methods used for detecting and enumerating FIB. The 1986 RWQC for *E. coli* are expressed as the "most probable number" (MPN) per 100 mL, whereas the most recent recommended bacterial criteria are expressed as "colony forming units" (CFU) per 100 mL. MPN and cfu represent different enumeration methods and result in different method-specific units.

The MPN method provides an estimate of the number of bacteria in a sample based on a combination of positive and negative test tube results which are compared to statistical probability tables to provide a number that is more probable than any other number of the observed result. It is not an actual count of the bacteria present.

Membrane filtration methods, which produce results expressed as cfu, are culture-based and results are quantified by counting the number of colonies that arise from bacteria captured on the membrane filter per volume of water filtered. The enumeration method used to estimate cfu has been determined to be less variable that the method used to estimate MPN, and is the recommended method in the 2012 RWQC for estimating bacterial levels in a water sample.

In 2002, NDEP promulgated *E. coli* rather than enterococci as the indicator organism for ambient water quality criteria for bacteria. *E. coli* will be retained as the FIB criteria in NDEP's water quality standards. The recommended 2012 RWQC for *E. coli* are shown below in Table 2.

Table 2. EPA Recommended 2012 RWQC.

Criteria Elements	Estimated Illness Rate (NGI): 36 per 1,000 primary contact recreators	
	Magnitude	
Indicator	GM (cfu/100 mL)[a]	STV (cfu/100 mL)[a]
E. coli – fresh water	126	410
Duration and Frequency: The GM for a waterbody should not be greater than the selected GM magnitude in any 30-day interval. No more than ten percent of the samples should exceed the selected STV magnitude in any given 30-day interval.		

[a] EPA recommends using EPA Method 1603 (U.S. EPA, 2002b) to measure culturable *E. coli*, or any other equivalent method that measures culturable *E. coli.*

NDEP Proposed Criteria for Contact Recreation

NDEP proposes to adopt the above *E. coli* criteria for protecting human health in water bodies designated for primary contact recreation use. A footnote will be included in the water quality standards tables explaining that the GM must not be exceeded in any 30-day period. The single-value (SV) nomenclature already contained in the water quality standards tables for bacterial criteria will be retained but be interpreted as a SV. The SV criterion will have a footnote stating that the single value must not be exceeded in more than 10 percent of the samples collected in any given 30-day period.

For waterbodies having non-contact recreation (secondary contact recreation) as a beneficial use, the *E. coli* criterion will remain a AGM of 630 (five times the primary contact GM of 126) but the units of measure will be changed to cfu per 100 ml.

To maintain a more restrictive standard to protect the Lake Tahoe designation of a Water of Extraordinary Aesthetic or Ecological Value, the existing S.V. 126 standard is being retained and a GM is not being proposed for Lake Tahoe and its tributaries. The units are being changed from MPN to CFU and a footnote indicating that the S.V. must not be exceeded more than ten percent of the samples collected in any 30-day interval is being added.

Summary

The NDEP is proposing to amend NAC 445A.070 – 445A.2234, *Standards for Water Quality*, to align with the most current numeric criteria recommended and published by the EPA for *Escherichia coli* (*E. coli*) bacteria to protect the water contact recreation beneficial use. The proposed revisions include:

- changing the existing reference period from annual geometric mean (AGM) to geometric mean (GM) for all waters that have an existing AGM to protect the water contact recreation beneficial use;
- changing the unit of measurement from most probable number (MPN) per 100 mL to colony-forming-units (CFU) per 100 mL;
- replacing existing *E. coli* S.V. criterion with the recommended 2012 S.V. of 410 CFU/100 mL, which has been determined to be protective of all levels of contact recreation use;
- adding a footnote that explains frequency and duration limits of the GM and SV criteria; and
- adding a definition of CFU.

EPA's water quality standards regulations at 40 CFR 131.11(a)(1) require states to adopt protective criteria that are based on established scientific rationale. Nevada's existing *E. coli* bacteria standards for the protection of the water contact recreation beneficial use are based on EPA criteria published in 1986. EPA published updated *E. coli* bacteria criteria in 2012. The 2012 criteria reflect significant research and new scientific developments since the prior criteria issued in 1986. Adoption of EPA's 2012 criteria ensures the most appropriate protection for recreational users of Nevada's surface waters. Tables 3 and 4 show examples of the proposed changes to the criteria for *E. coli* in Nevada's recreational waters.

Table 3 Example of NAC 445A.1336 showing the proposed changes.

The proposed updates to the NAC are shown below with **deletions in red and strikeout** and *additions in blue*:

NAC 445A.1336 Snake Region: Goose Creek. (NRS 445A.425, 445A.520) The limits of this table apply to the body of water known as Goose Creek within the State of Nevada. Goose Creek is located in Elko County.

STANDARDS OF WATER QUALITY
Goose Creek

PARAMETER	REQUIREMENTS TO MAINTAIN EXISTING HIGHER QUALITY	WATER QUALITY STANDARDS FOR BENEFICIAL USES	Beneficial Use[a]										
			Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh
Beneficial Uses			X	X	X	X	X	X	X	X			
Aquatic Life Species of Concern													
Temperature - °C ΔT[b] - °C	ΔT = 0	S.V. May-Oct < 21 S.V. Nov-Apr < 13 ΔT < 1			*	X							
pH – SU	ΔpH ±0.5	S.V. 6.5 - 9.0			*	X		X					
Dissolved Oxygen - mg/l		S.V. ≥ 6.0	X		*	X	X	X		X			
Total Phosphorus (as P) - mg/l		S.V. ≤ 0.1			*	*	X	X					
Nitrogen Species (as N) - mg/l	Nitrate S.V. ≤ 1.0	Nitrate S.V. ≤ 10 Nitrite S.V. ≤ 0.06			*	X	X	*					
Total Ammonia (as N) - mg/l		c			*								
Suspended Solids - mg/l		S.V. ≤ 25			*			X					
Turbidity - NTU		S.V. ≤ 10			*			X					
Color – PCU		S.V. ≤ 75						*					
Total Dissolved Solids - mg/l	S.V. ≤ 185	S.V. ≤ 500	X	X				*					
Chloride - mg/l	S.V. ≤ 9.0	S.V. ≤ 250	X	X				*		X			
Sulfate - mg/l		S.V. ≤ 250						*					
Alkalinity (as CO₃) - mg/l		< 25% change from natural conditions			*					X			
E. coli - ~~No. /100 ml~~ *cfu/100 mL*		~~A.~~G.M. ≤ 126 *d* S.V. ≤ 410				*	X						
Fecal Coliform - No./100 ml		S.V. ≤ 1,000	X	*			X	X		X			

* = The most restrictive beneficial use.
X = Beneficial use.
[a] Refer to NAC 445A.122 and 445A.1332 for beneficial use terminology.
[b] Maximum allowable increase in temperature above water temperature at the boundary of an approved mixing zone, but the increase must not cause a violation of the single value standard.
[c] The ambient water quality criteria for ammonia are specified in NAC 445A.118.
[d] The geometric mean must not be exceeded in any 30-day period. The single value must not be exceeded by more than 10 percent in any 30-day period.

Table 4 Example of NAC 445A.1888 showing the proposed changes.

The proposed updates to the NAC are shown below with ~~deletions in red and strikeout~~ and *additions in blue*:

NAC 445A.1888   Walker Region: Topaz Lake. (NRS 445A.425, 445A.520)   The limits of this table apply to the body of water known as Topaz Lake at various points in Topaz Lake. Topaz Lake is located in Douglas County.

STANDARDS OF WATER QUALITY
Topaz Lake

PARAMETER	REQUIREMENTS TO MAINTAIN EXISTING HIGHER QUALITY	WATER QUALITY STANDARDS FOR BENEFICIAL USES	Beneficial Use[a]										
			Livestock	Irrigation	Aquatic	Contact	Noncontact	Municipal	Industrial	Wildlife	Aesthetic	Enhance	Marsh
Beneficial Uses			X	X	X	X	X	X	X	X			
Aquatic Life Species of Concern			Rainbow trout, cutthroat trout, brown trout, kokanee salmon and silver salmon.										
Temperature - °C ΔT[b] - °C	ΔT = 0	S.V. Nov-Apr ≤ 13 S.V. May-Jun ≤ 17 S.V. Jul-Oct ≤ 23 ΔT ≤ 2			*	X							
pH – SU		S.V. 6.5 - 9.0 ΔpH ± 0.5	X	X	*	*		X	X	X			
Dissolved Oxygen - mg/l		S.V. Nov-May ≥ 6.0 S.V. Jun-Oct[d] ≥ 5.0	X		*	X	X	X		X			
Total Phosphates (as P) - mg/l		A-Avg. ≤ 0.05 S.V. ≤ 0.10			*	*	X	X					
Nitrogen Species (as N) - mg/l	Total Nitrogen A-Avg. ≤ 0.6 S.V. ≤ 1.0	Nitrate S.V. ≤ 10 Nitrite S.V. ≤ 0.06	X		*	X	X	*		X			
Total Ammonia (as N) - mg/l		c			*								
Suspended Solids - mg/l	A-Avg. ≤ 6.0 S.V. ≤ 9.0	S.V. ≤ 25			*								
Turbidity - NTU	A-Avg. ≤ 3.0 S.V. ≤ 5.0	e			*			X					
Color – PCU	S.V. ≤ 21	S.V. ≤ 75				X		*					
Total Dissolved Solids - mg/l	A-Avg. ≤ 105 S.V. ≤ 120	A-Avg. ≤ 500	X	X				*					
Chloride - mg/l	A-Avg. ≤ 7 S.V. ≤ 10	S.V. ≤ 250	X	X				*		X			
Sulfate - mg/l	S.V. ≤ 25	S.V. ≤ 250						*					
Sodium - SAR		A-Avg. ≤ 8		*					X				
Alkalinity (as CaCO₃) - mg/l		< 25% change from natural conditions			*					X			
E. coli - ~~No. /100 ml~~ *cfu/100 mL*		~~A.~~G.M. ≤ 126[f] S.V. ≤ ~~235~~ *410*				*	X						

---

* = The most restrictive beneficial use.

X = Beneficial use.

[a] Refer to NAC 445A.122 and 445A.1882 for beneficial use terminology.

[b] Maximum allowable increase in temperature above water temperature at the boundary of an approved mixing zone, but the increase must not cause a violation of the single value standard.

[c] The ambient water quality criteria for ammonia are specified in NAC 445A.118.

[d] The dissolved oxygen standard from June to October applies only to the epilimnion.

[e] Increase in turbidity must not be more than 10 NTU above natural conditions.

[f] *The geometric mean must not be exceeded in any 30-day period. The single value must not be exceeded by more than 10 percent in any 30-day period.*

References

National Technical Advisory Committee. 1968. Water Quality Criteria. Federal Water Poll. Control Adm., Dept. of the Interior, Washington, DC.

U.S. EPA 1976. Quality Criteria for Water. U.S. Environmental Protection Agency: Washington, DC.

U.S. EPA 1986. EPA's Ambient Water Quality Criteria for Bacteria – 1986. U.S. Environmental Protection Agency: Washington, DC. EPA440/5-84-002.

U.S. EPA 2002b. Method 1603: *Escherichia coli* (*E. coli*) in Water by Membrane Filtration Using Modified Membrane-Thermotolerant *Escherichia coli* Agar (Modified mTEC).

U.S. EPA. 2012. Recreational Water Quality Criteria. U.S. Environmental Protection Agency: Washington, DC. U.S. EPA Office of Water 820-F-12-058