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Office of Water

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Draft Technical Support Document:

Implementing the 2018 Recommended Aquatic Life Water Quality Criteria for Aluminum

Notice: This question and answer (Q&A) document is intended to support states and authorized tribes wishing to adopt and implement the U.S. Environmental Protection Agency's (EPA's) recommended Clean Water Act (CWA) Section 304(a) *Final Aquatic Life Ambient Water Quality Criteria for Aluminum*. Pursuant to 40 CFR 131.11(b), when establishing numeric criteria designed to protect designated uses, states and authorized tribes should base those criteria on (i) 304(a) guidance, (ii) 304(a) guidance modified to reflect site-specific conditions, or (iii) other scientifically defensible methods. States and authorized tribes may also consider other approaches that are not described in this document.

EPA may update this Q&A document as new information becomes available. Also, although this document cites statutes and regulations that contain requirements applicable to water quality standards, it does not impose legally binding requirements on EPA, states, authorized tribes, other regulatory authorities, or the regulated community. EPA, states, authorized tribes, and other decision makers retain the discretion to adopt approaches on a case-by-case basis that differ from those recommended in this document, as appropriate and consistent with statutory and regulatory requirements. In addition to this document, EPA has posted its Response to Comments on the 2017 Draft Aluminum Ambient Water Quality Criteria document and its responses to external peer review reports of the toxicity assessments used to model bioavailability; these documents can be found at the Agency's website for aluminum criteria: https://www.epa.gov/wqc/aquatic-life-criteria-aluminum.

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Introduction

On December 21, 2018, EPA updated its national Clean Water Act (CWA) Section 304(a) recommendations for freshwater aquatic life criteria for aluminum. The 2018 updated recommended criteria supersede EPA's previous 1988 CWA Section 304(a) aluminum criteria recommendations. The 2018 recommended criteria are water chemistry-dependent; this means that different numeric criteria values may be calculated for different waters that have different water chemistry or even at different times or locations within the same water. To calculate aluminum criteria concentration values, EPA developed the recommended Aluminum Criteria Calculator (Criteria Calculator).[1] The numeric outputs of the Criteria Calculator vary depending on the concurrent values for pH, total hardness, and dissolved organic carbon (DOC) at a given site that are entered as *inputs*. The Criteria Calculator *outputs* for a given set of inputs are the numeric values for the acute and chronic criteria that are protective of freshwater aquatic life uses for that unique set of input conditions.

States and authorized tribes have options for adopting aluminum criteria that may be used singly or in combination:

(1) Adopting by reference to the applicable sections of the CWA Section 304(a) recommended criteria document.

(2) Adopting by reference to the Criteria Calculator [V2.0].

(3) Adopting the criteria value lookup tables; or,

(4) Adopting specific ecoregional, statewide, or localized criteria values for aluminum.

This document is intended to provide additional guidance to states and authorized tribes that are interested in implementing EPA's national CWA Section 304(a) recommended aluminum criteria through a state or tribal water quality standards program.

Section 1 describes some of the flexibilities available to states and authorized tribes if they choose to adopt the recommended criteria (or a modified version of the criteria) into state or tribal water quality standards. This section also recommends additional supporting documentation states or authorized tribes should include in their regulation or implementation documents.

Section 2 responds to technical questions about the Criteria Calculator and includes recommendations on water quality sampling and laboratory analysis.

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[1] EPA's CWA Section 304(a) recommended aluminum criteria are based upon multiple linear regression (MLR) models for fish and invertebrate species that use site-specific pH, total hardness, and DOC inputs to quantify the effects of these water chemistry parameters on the toxicity of aluminum to aquatic organisms. The MLR models normalize the available toxicity data to accurately reflect the effects of the site-specific water chemistry on the toxicity of aluminum to tested species. The normalized toxicity test data are then used in the recommended Criteria Calculator to generate protective acute and chronic values for specific ambient water chemistry conditions using EPA's *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their Uses*. The Criteria Calculator V2.0 is available in Microsoft Excel and in R on EPA's webpage for the Aquatic Life Criteria for Aluminum in Freshwater: https://www.epa.gov/wqc/aquatic-life-criteria-aluminum#2018.

Section 3 provides information to help develop protective criteria values for sites, considering the spatial and temporal variability of input parameters.

Section 4 provides recommendations for when there are insufficient data for pH, total hardness or DOC.

Section 5 provides information for implementing the recommended criteria through National Pollutant Discharge Elimination System (NPDES) permits.

Section 6 provides information for waterbody assessors who will be implementing the recommended criteria in assessing ambient waters, in determining whether to list waters as not attaining their water quality standards, and in developing Total Maximum Daily Loads (TMDLs) for those listed waters.

Section 1: Adopting the 2018 Recommended Aquatic Life Water Quality Criteria for Aluminum into State or Tribal Water Quality Standards

1.1. What are EPA's recommended criteria for aluminum?

EPA's recommended freshwater aquatic life criteria for aluminum[2] recognize that the bioavailability[3] (and thus toxicity) of aluminum is dependent on water chemistry. Therefore, the recommended criteria provide the means for states and authorized tribes to develop numeric criteria values at a given site, based on local water chemistry. Specifically, the recommended criteria incorporate a statistical technique, known as multiple linear regression (MLR), to model the relationship between pH, total hardness, and DOC measurements and the toxicity of aluminum based on extensive toxicity testing under different water chemistry conditions.[4] To generate numeric criteria values for a specific set of water-chemistry conditions, users input concurrent data for pH, total hardness, and DOC at a given site into the Criteria Calculator[5] or use lookup tables that provide the same information for those conditions.

Ambient water quality criteria recommendations developed under CWA Section 304(a) are typically expressed in two forms: 1) as *acute criteria* to protect against mortality that occurs due to a short-term exposure to a chemical, and 2) as *chronic criteria* to protect against longer term effects on survival, growth and reproduction that may occur due to a longer-term exposure to a chemical. Both the acute and chronic criteria have three components: concentration (*magnitude*) that is averaged over a given time period (*duration*) that should not be exceeded more than "X" times during a specified time period (*frequency*).

- The *magnitude* component of the recommended aluminum CWA Section 304(a) criteria corresponds to the concentration of aluminum that is protective of the aquatic life designated use under specific conditions of pH, total hardness, and DOC.
- The *duration* term accounts for the limit on exposure timeframe that will protect against adverse effects to aquatic life. Duration is expressed as the time over which a chemical concentration is measured and averaged; that is, as a one-hour average for acute exposures, and a four-day average for chronic exposures for aluminum.

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[2] Final Aquatic Life Ambient Water Quality Criteria for Aluminum 2018, EPA-822-R-18-001, December 2018, https://www.epa.gov/wqc/2018-final-aquatic-life-criteria-aluminum-freshwater.

[3] Not all forms of aluminum that may be present in ambient waters are biologically available or "bioavailable" to aquatic species. Bioavailable aluminum is the toxicologically relevant fraction(s) of aluminum. Large suspended particles, clays, and aluminosilicate minerals are not generally bioavailable.

[4] Two MLR models, one for invertebrates and one for vertebrates, were used to normalize freshwater aluminum toxicity values. These separate models correspond to effects on invertebrates and vertebrates due to differing effects of pH, total hardness, and DOC on aluminum bioavailability and toxicity, and therefore enable criteria magnitude values to be calculated as a function of the unique chemistry conditions at a given site, at the time at which pH, total hardness, and DOC were measured. Toxicity data show that aluminum toxicity is affected by the concentrations of – and interactions among – these parameters, and EPA's CWA Section 304(a) recommended criteria characterize these relationships.

[5] The Criteria Calculator V2.0 is available in Microsoft Excel and in R Code and Data V.2 on EPA webpage for the Recommended Aquatic Life Criteria for Aluminum in Freshwater: https://www.epa.gov/wqc/aquatic-life-criteria-aluminum#2018.

- The *frequency* term defines the maximum allowable number of exceedances of the magnitude and duration combination to ensure protection of aquatic life—once in three years on average for aluminum—consistent with recommendations of the 1985 Guidelines.[6]

Input parameters from ambient water samples will yield outputs that represent the recommended magnitude for acute and chronic criteria concentrations of aluminum that would be protective of aquatic life under those specific ambient water quality conditions (i.e., the desired conditions to protect the aquatic life designated use).

If a state or authorized tribe adopts the recommended criteria into its water quality standards, they would also need to adopt the recommendations for the frequency and durations into their standards, as well. In other words, the acute criterion should be expressed as a one-hour average total recoverable[7] aluminum concentration (in µg/L) and the chronic criterion should be expressed as a four-day average total recoverable aluminum concentration (in µg/L). Additionally, the acute and chronic criteria should be expressed as not to be exceeded more than once every three years to ensure protection of aquatic life.

1.2. What flexibility does a state or authorized tribe have when adopting EPA's recommended aluminum criteria into its state or tribal water quality standards, and what are the advantages and potential challenges of each approach?

The regulation at 40 CFR 131.11(a)(1) specifies that states must adopt water quality criteria that are based on sound scientific rationale and protect the designated use. There are several approaches a state or authorized tribe may take to meet this requirement as it relates to EPA's CWA Section 304(a) recommended aluminum criteria.

Under the regulation at 40 CFR 131.11(b)(1), in adopting water quality criteria, states and authorized tribes should adopt water quality criteria based on: EPA's recommended criteria; modifying the Agency's recommended criteria to reflect site-specific conditions, or other scientifically defensible methods.

The Criteria Calculator in EPA's CWA Section 304(a) recommended aluminum criteria to protect aquatic life in freshwater ecosystems generates criteria values that are dependent on the water chemistry at the site. EPA's CWA Section 304(a) criteria for aluminum are recommendations, and not requirements. As discussed below, there are a number of approaches states and authorized tribes may take in adopting these recommended criteria. States and authorized tribes should consider the advantages and potential challenges of each approach, as well as other approaches that may not be described in this document.

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[6] EPA. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses, PB85-227049, 1985. https://www.epa.gov/sites/production/files/2016-02/documents/guidelines-water-quality-criteria.pdf.

[7] As discussed further in Question 2.4, states and authorized tribes may choose to incorporate an analytical method (a variation in the sample preparation procedure) that measures bioavailable aluminum in ambient samples into its implementation efforts; if it chooses to do so, the state or authorized tribe should consider providing a reference to the modified method procedure in its water quality standards or other legally binding documents.

When states and authorized tribes choose to adopt both the water chemistry-dependent criteria and an associated derivation methodology; this concept – combining criteria with associated derivation methodology – is referred to as a "performance-based approach." EPA first formalized the concept of a performance-based approach for water quality standards in the preamble of the rule *EPA Review and Approval of State and Tribal Water Quality Standards.*[8] With a performance-based approach, the state or authorized tribe can adopt a process, such as a criteria derivation methodology, rather than a specific outcome, such as a concentration of a pollutant. If a state or authorized tribe adopts a process or methodology that is sufficiently detailed and has suitable safeguards that ensure predictable, repeatable outcomes, EPA can approve that process under CWA Section 303(c), and this initial approval would also serve as the approval of each outcome generated from following that process or method.

If a state or authorized tribe chooses to adopt EPA's recommended aluminum criteria, unchanged, into its water quality standards, EPA recommends choosing one, or a combination,[9] of the following approaches (see Table 1, below):

(5) Adopting by reference to the applicable sections of the CWA Section 304(a) recommended criteria document.

(6) Adopting by reference to the Criteria Calculator [V2.0].

(7) Adopting the criteria value lookup tables[10]; or,

(8) Adopting specific ecoregional, statewide, or localized criteria values for aluminum.

Table 1: Comparison of approaches to adopting the recommended aluminum criteria

Approach to adopting the recommended criteria	**Potential Advantages**	**Potential Challenges**
(1) adopting reference to the CWA Section 304(a) criteria document (which includes the Criteria Calculator and criteria value lookup tables).	This approach may provide the greatest amount of background information and context for the criteria. This approach may also provide the greatest flexibility to states and authorized tribes because it allows multiple ways to calculate criteria values. Statewide adoption of the entire recommended criteria	This approach may be difficult to implement due to individual states' or authorized tribes' legal and administrative requirements (e.g., whether a state's or authorized tribe's regulations allow them to adopt or incorporate by reference). Without additional clarity about aquatic life

[8] *EPA Review and Approval of State and Tribal Water Quality Standards* 65 Fed. Reg. 24641 (Apr. 27, 2000)
[9] For example, approaches (2) and (3) can be adopted together (the Criteria Calculator can be used to derive numeric criteria values (*outputs*) when input parameters (i.e., pH, total hardness, or DOC measures or estimates) are not displayed in the lookup tables). Also, ecoregional criteria default values may be adopted in addition to any of the first three listed approaches. When adopting a combination of approaches, the state or authorized tribe should specify the conditions under which each method would be applied.
[10] If the state or authorized tribe chooses to adopt lookup tables into their water quality standards, they should include information on rounding data when input parameter values for pH, total hardness, or DOC fall between values listed in the lookup tables. Lookup tables are published in Section 4.1, Appendix K of the CWA Section 304(a) criteria document.

Approach to adopting the recommended criteria	Potential Advantages	Potential Challenges
	document also provides transparency and regulatory certainty to the public and the regulated community and helps to expedite EPA's review of state or tribal water quality standards, as well as a single consultation on the Endangered Species Act.	protection through implementation, this approach may not provide sufficient regulatory certainty.
(2) adopting the Criteria Calculator [V2.0] (or similar method to calculate outputs based on the underlying MLR models).	This is likely the most adaptable and concise approach.	The Criteria Calculator requires users to input data to generate criteria values and therefore would require some data to exist in order to run. Future versions of the Criteria Calculator may require the state or authorized tribe to update their standards to incorporate the revised Criteria Calculator by reference. States and authorized tribes may choose to incorporate regulatory language to accommodate future software updates where the underlying models and toxicity data are the same.
(3) adopting the criteria value lookup tables.	This may be more transparent than adopting only the Criteria Calculator because the lookup tables do not require access to a computer. The lookup tables also display the full range of possible values that could be generated by the Criteria Calculator and therefore might be more transparent and familiar to some users than simply adopting the Criteria Calculator. The tables are included in Appendix K of the recommended criteria document and may be helpful when communicating to the public about the criteria implemented at a given site.	The state or authorized tribe may need to develop a standard procedure to determine which values for pH, total hardness or DOC to use if measured values are *between* the range of input parameter values provided in the lookup table. For example, a state or authorized tribe may decide to always round to the nearest value in the table for each input parameter or may decide to use the value which would yield the most protective criteria. States and authorized tribes may choose to combine this approach with the Criteria Calculator to address this issue of interpolation.
(4) adopting specific ecoregional[11] or	This would allow states and authorized tribes to apply consistent criteria	This approach may be too general for areas with complex geology. That is, use

[11] For more information on how ecoregions are defined, see https://www.epa.gov/eco-research/ecoregions.

Approach to adopting the recommended criteria	Potential Advantages	Potential Challenges
statewide criteria values.	throughout an ecoregion or state. This approach does not require a state to identify site-specific input parameters because the criteria values are the same for all sites within the ecoregion (or state), calculated based on representative water quality parameters for each ecoregion or state. Alternatively, a state or authorized tribe may choose to adopt such criteria as defaults for use in the absence of ambient data. Default criteria may also help to increase transparency of criteria for the public if they are adequately explained. This approach may be used in combination with the Criteria Calculator or lookup tables.	of specific ecoregional or statewide criteria values does not allow for the use of water chemistry data at individual sites for input parameters.

After adopting the aluminum criteria and obtaining EPA's approval, the state or authorized tribe may derive acute and chronic criteria values (i.e., criteria magnitude values) that correspond to a surface water or an entire geographic area with similar conditions for pH, total hardness, and DOC. EPA recommends that states and authorized tribes adopt criteria that will protect aquatic life over the full range of conditions, including when aluminum is most toxic, throughout the year (i.e., account for the variability of pH, total hardness, and DOC over time). Section 3 on characterizing spatial and temporal variability of input parameters provides more information about how to derive criteria values that will protect aquatic life throughout the temporal and spatial range of water chemistry conditions at a site, including those conditions when aluminum is most bioavailable (hence, most toxic to aquatic life). Bioavailable aluminum is the toxicologically relevant fraction(s) of aluminum, rather than dissolved aluminum generally. For more discussion on the relevant fractions of aluminum and appropriate analytical methods to measure them, see Question 2.4.

To promote transparent and repeatable outcomes, EPA recommends that states and authorized tribes consider making publicly available the input parameters, along with the calculations and the resulting values for aluminum criteria. A map showing the extent of the site to which the criteria values apply would also be helpful to communicate those criteria values to the public and to the regulated community. States and authorized tribes may also choose to include detailed methods, for example, in an appendix to their water quality standards or in a Continuing Planning Process document, as described in 40 CFR 130.5(b)(6). This provision of the CFR implements CWA Section 303(e) and requires that states and authorized tribes include, among other things, a process for establishing and assuring implementation for new or revised water quality standards, in continuing planning processes.

In summary, EPA's updated aluminum criteria provide users the flexibility to develop numeric criteria values based on site-specific water chemistry or use default values where water chemistry data are not available. Numeric criteria values can be generated using the Criteria Calculator or by using the lookup tables provided in the appendix. If the criteria were adopted as a statewide methodology, the numeric values at a site could be based on site-specific water chemistry.

1.3. If a state or authorized tribe adopts a methodology, what additional information should be included in their regulation or implementation documents to support such an approach?

When EPA approves a water quality standard in the form of both the water chemistry-dependent criteria and an associated derivation methodology, the state or authorized tribe may use the methodology to derive criteria values that are used for other CWA implementation purposes, without additional EPA review under CWA Section 303(c).[12]

To successfully establish such an approach to deriving aluminum criteria, the state or authorized tribe should demonstrate to EPA that it has a legally binding process or derivation methodology for using the Criteria Calculator (or lookup tables) with enough detail to ensure repeatable, predictable, and protective outcomes. The state or authorized tribe may describe the process in rule, or in a separate implementation document that is incorporated by reference into its water quality standards regulation, and would be legally binding to the extent allowed by state or tribal law. EPA recommends that states and authorized tribes include as part of this process the following, at a minimum, in water quality standards or other legally binding documents:

- A reference to applicable sections of the CWA Section 304(a) recommended criteria document (which includes the Criteria Calculator and criteria value lookup tables) and the Criteria Calculator version to be used;
- A statement of the duration and frequency applicable to the output;
- A statement of, or reference to, data and sampling requirements for Criteria Calculator inputs (i.e., pH, total hardness, and DOC);
- Where appropriate, methods for implementing criteria where sufficient data to run the Criteria Calculator are not available (e.g., default values);
- Where appropriate, information identifying seasons if seasonal criteria are to be used;
- A description of how data inputs will be incorporated into the Criteria Calculator;
- A description of representative sampling methods, how any continuous data will be used, and what standard procedures will be followed if one of the input parameters could not be collected; and

[12] *EPA Review and Approval of State and Tribal Water Quality Standards* 65 Fed. Reg. 24641 (Apr. 27, 2000)

- A description of how criteria will be generated from a distribution of Criteria Calculator output values for sites with varying conditions of pH, total hardness, and DOC over time.

EPA encourages states and authorized tribes to supplement the legally binding provisions with additional detail in implementation documents or guidance. For example, states and authorized tribes should consider whether to include additional information about sampling or quality assurance plans defining the spatial extent to which Criteria Calculator-derived criteria values would apply, what the state or authorized tribe considers to be “sufficient” ambient water chemistry data to run the Criteria Calculator, and how output values from the Criteria Calculator may be interpreted. Providing additional guidance will increase transparency and facilitate implementation.

1.4. If the recommended aluminum criteria are adopted in the form of the Criteria Calculator, how will the public and entities implementing the criteria know what numeric values represent the site-specific criteria for a given waterbody at a given time?

Where the Criteria Calculator is adopted as the criteria, states and authorized tribes establish criteria magnitude values to be used for CWA implementation purposes on a site-specific basis. In this scenario, the states and authorized tribes would not adopt static or fixed statewide criteria magnitude values into regulation, but instead would calculate those values using the Criteria Calculator as data are collected.

In this scenario, because the criteria magnitude values are calculated from data collected at a particular moment in time, EPA recommends that states and authorized tribes provide publicly available information about each calculated value, along with the spatial extent (i.e., waterbody segment) to which it applies.[13] Making information available to the public, the regulated community, and other stakeholders is important to ensuring regulatory certainty and clarity, particularly when a state or authorized tribe adopts an accompanying derivation methodology (see Question 1.2 for more information on these approaches). A state or authorized tribe may wish to describe how it derived the criteria values, including the data and data source(s) used. Such information may include (but not be limited to) the following:

- The location(s) from which samples were drawn to determine inputs to the Criteria Calculator or lookup tables;
- The timeframe over which samples were drawn, including the number of samples drawn over that timeframe to account for seasonal or other forms of variability;
- Whether the state or authorized tribe relied on site-specific input data, estimated data, or a combination, when developing the site-specific numeric criteria values (or outputs); and
- The date when the criteria values were developed.

[13] When developing criteria for any given site, consideration should be given to what area is defined as the site. See Section 3 for more information on ‘site’ definition and characterization.

Additionally, a permitting authority may wish to describe in the permit factsheet or statement of basis how it used the numeric criteria values to determine if there was reasonable potential and if there was reasonable potential how it used the criteria to derive water quality-based effluent limits (WQBELs). Likewise, for TMDL programs, states and authorized tribes may wish to describe how they derived the criteria values and used them to determine TMDL targets. States and authorized tribes may also wish to describe how they generated criteria magnitude values for the aluminum criteria used in assessment and listing methodologies and integrated reports for each assessed waterbody.

1.5. How does the adoption of the new aluminum criteria affect site-specific criteria developed using previous guidance?

Adopting the 2018 recommended criteria does not automatically invalidate existing aluminum criteria. However, EPA's 2018 recommended criteria for protecting aquatic life from the toxic effects of aluminum in freshwater systems represents the most current science. Historically, water effect ratios (WERs) have been used to adjust criteria values where ambient water chemistry was suspected to alter the bioavailability (hence, toxicity) of a metal. However, the MLR-based construct of the 2018 recommended criteria is superior to previously recommended criteria, by better reflecting aluminum toxicity based on water chemistry conditions at a particular site. Therefore, where the new recommended aluminum criteria are adopted, using WERs would be unnecessary. EPA recommends that states and authorized tribes replace any previous aluminum aquatic life criteria (whether statewide or site-specific) with statewide or site-specific criteria developed through the use of the Criteria Calculator, the look up tables, or the ecoregional default values in the 2018 CWA Section 304(a) recommended aluminum criteria.

Criteria already approved by EPA under CWA Section 303(c)—including criteria developed using previous guidance and methods—remain effective for CWA purposes until EPA approves a change to those water quality criteria, or until EPA establishes more stringent water quality criteria. States and authorized tribes are required by 40 CFR 131.20(a) to review their water quality standards every three years. As part of this triennial review, states and authorized tribes must update any criteria for which EPA has published a new or updated CWA 304(a) recommendation or must provide an explanation if they decline to update such criteria.[14]

1.6. Can a state retain an older version of the state's aluminum criteria while also adopting the new CWA Section 304(a) recommended criteria?

EPA recommends that states and authorized tribes have only one set of acute and chronic aluminum criteria applicable to each waterbody. This way, it is clear to the public what the criteria are and what

[14] 40 CFR 131.20(a) requires that "if a State does not adopt new or revised criteria for parameters for which EPA has published new or updated CWA Section 304(a) criteria recommendations, then the State shall provide an explanation when it submits the results of its triennial review to the Regional Administrator consistent with CWA Section 303(c)(1) and the requirements of paragraph (c) of this section."

criteria will be implemented for all aspects of the CWA programs, including NPDES permitting, CWA Section 303(d) listing, and TMDLs.

A state or authorized tribe, however, may elect to retain its older aluminum criteria statewide while it collects data and adopts new aluminum criteria on a site-specific basis. If a state or authorized tribe chooses this approach, then EPA recommends, in order to provide more clarity to the public, that the state or authorized tribe specify (either in rule or in accompanying implementation procedures) how it will select which set of criteria to be applied to specific waterbodies. Because EPA's national CWA Section 304(a) recommended aluminum criteria represent the most current science regarding aluminum toxicity, EPA recommends that states or authorized tribes apply the new aluminum criteria wherever there are sufficient data to do so. Where states or authorized tribes choose to provide for a transition period to the new criteria, EPA recommends they provide clear information on the length of that period.

1.7. Can states/authorized tribes develop their own regionally informed calculators, or modify the Criteria Calculator to reflect regionally important species or situations, rather than using the CWA Section 304(a) recommended criteria as is?

A state or authorized tribe may develop its own regionally informed calculator or may modify the Criteria Calculator to reflect regional conditions. The water quality standards regulation at 40 CFR 131.11(b)(1)(ii) provides states and authorized tribes with the opportunity to adopt water quality criteria that are "modified to reflect site-specific conditions." As with any criteria, site-specific criteria must protect the designated use, must be based on a sound scientific rationale, and must be approved by EPA. 40 CFR 131.11(a)(1).

One process that can be used to modify criteria to reflect site-specific conditions is the species deletion process (also known as the recalculation procedure).[15] The species deletion process is a process used to modify but retain the taxonomic composition of the toxicity dataset to better match the species assemblage that is known or expected to occur at a particular site, and is not simply removing non-resident species from the Criteria Calculator. This process creates a site-specific toxicity dataset (and corresponding site-specific species sensitivity distribution) that is appropriate for deriving site-specific aquatic life criteria. The species deletion process does this by correcting, adding, or deleting test results based on the resident species of the site. This process is intended to provide flexibility to states and authorized tribes to derive site-specific criteria that best reflect the expected resident species at a site. The species deletion process may result in site-specific criteria that differ from national criteria recommendations when there are demonstrated differences in sensitivity between the expected resident aquatic species and those that were used to derive the national criteria recommendations. In the case of aluminum criteria, a state or authorized tribe could consider generating its own calculator using the same basic datasets and underlying model equations as the national CWA Section 304(a) recommended criteria but adding additional data to account for locally important species and to adjust the species sensitivity distribution. EPA recommends that states and authorized tribes that wish to

[15] USEPA. 2013. Revised Deletion Process for the Site-Specific Recalculation Procedure for Aquatic Life Criteria. EPA-823-R-13-001

develop aluminum criteria based on the revised deletion process should engage their EPA regional office early in the state's or authorized tribe's criteria development process.

Critical species should be taken into consideration when using the species deletion process. The 2013 revised deletion process document explains that, "A critical species is a resident species that (a) is commercially or recreationally important at the site, or (b) is listed as threatened or endangered under section 4 of the Endangered Species Act, or (c) is a species for which there is firm evidence that its loss would yield an unacceptable impact on the site's commercially or recreationally important species, endangered species, abundances of a variety of other species, or structure or function. The species deletion process should not be undertaken unless toxicity data are available for at least one species in each class of aquatic plants or animals that contains a critical species."[16]

For the species deletion process, all species that occur at the site should be considered when deciding what species, if any, could be deleted from the dataset. Species not present at the site may be representative surrogates for other species for which there were no available toxicity data in the development of the Criteria Calculator database. Therefore, states and authorized tribes should consider how to demonstrate that a species (or any species for which that sensitive species might be a surrogate) is not present at the site before applying the species deletion process. States and authorized tribes that wish to develop site-specific aluminum criteria based on the revised deletion process should engage their EPA regional office early in the process. The Criteria Calculator or associated look-up table adopted into rule also would need to be revised to accurately reflect the revision.

States and authorized tribes using the species deletion process must also ensure that the resulting water quality standards "provide for the attainment and maintenance of the water quality standards of downstream waters" (40 CFR 131.10(b)). This requirement can be met in several ways, including using a combination of water quality standards and general policies. Additional information about this requirement can be found in *Protection of Downstream Waters in Water Quality Standards: Frequently Asked Questions*.[17]

1.8. What methods can be used to derive criteria values that will result in protection of aquatic life at a site, given a range of Criteria Calculator outputs?

EPA recommends that the criteria for each site be derived in a way that will protect aquatic life throughout the range of seasonal and flow conditions at a site, including those conditions of pH, total hardness, and DOC, when aluminum is most bioavailable (hence, toxic effects are greatest). EPA recommends the following three methods for deriving protective criteria values; states and authorized tribes may choose other scientifically defensible and protective methods, as well. Method 1 entails the greatest amount of input parameter data, and Method 3 involves the least (see below). EPA expects

[16] Ibid, 14.
[17] USEPA. 2014. Protection of Downstream Waters in Water Quality Standards: Frequently Asked Questions. EPA 820-F-14-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.
https://www.epa.gov/sites/default/files/2018-10/documents/protection-downstream-wqs-faqs.pdf

states and authorized tribes to clearly describe in their water quality standards or other legally binding document how these methods will be used.

Method 1: Identify protective criteria values by selecting one or more individual Criteria Calculator outputs based upon spatially and temporally representative data for inputs. Method 1 can be used where input datasets are more robust and inputs are measured frequently enough to statistically represent changes in the toxicity of aluminum, including water chemistry conditions under which aluminum is most toxic. In this case, the criteria values could be determined by selecting one or more individual outputs that will be protective of aquatic life under the full range of ambient conditions, including conditions of high aluminum toxicity. Method 1 could be used to also establish criteria values to apply on a seasonal basis where the data are sufficient.

Method 2: Generate protective criteria values from the lowest 10th percentile of the distribution of individual Criteria Calculator outputs, based upon spatially and temporally representative data from a site. Although the 10th percentile of outputs should be sufficiently protective in most cases, certain circumstances may warrant use of a different output (e.g., consideration of threatened or endangered species). Sufficient data to characterize the appropriate distribution of outputs are necessary to derive a protective percentile so that the site is protected under conditions where aluminum is most bioavailable.

Method 3: Select the lowest Criteria Calculator outputs calculated from available input data. This could include assessment of individual data points (sometimes referred to as a “point-by-point” approach). Under this method, the lowest values for the acute and chronic criteria would represent the most toxic conditions known at a site. EPA recommends Method 3 be used where few outputs are available (e.g., ten or fewer), due to the higher probability that a sample from a small dataset does not appropriately represent actual variability.

Either Method 2 or 3 is particularly useful when values of acute and chronic criteria need to be protective of particular site conditions, such as for NPDES permitting actions (as discussed in the Section 5 on NPDES permitting). Whichever method is selected, states and authorized tribes should consider developing written implementation methods and make these documents available to the public to maximize transparency, defensibility, and regulatory certainty. To the same end, EPA recommends states or authorized tribes make publicly available the following on the state’s or authorized tribe’s website, and, if applicable, referenced in the statement of basis for a draft public notice version NPDES permit, draft public notice Integrated Report, or draft public notice TMDL:

- Site-specific water chemistry data, including the inputs used in the Criteria Calculator and resultant criteria values.
- The geographic extent of each site.

As mentioned in Question 1.2, a state or authorized tribe may choose to adopt default criteria for all or some of the waterbodies within the state or tribal jurisdiction. Where a state or authorized tribe chooses to adopt default criteria values, the state or authorized tribe does not need an additional method for reconciling Criteria Calculator outputs, because the default criteria values should already have integrated the concepts above (i.e., ensuring protectiveness under the full range of ambient conditions, including those under which aluminum is most bioavailable; hence, when toxicity is greatest).

Section 2: Technical Questions on the Criteria Calculator, Sampling and Laboratory Analysis

2.1. Do the recommended criteria require data for all input parameters be collected concurrently?

EPA recommends that samples tested for all of the three input parameters (total hardness, pH, and DOC) to be used in the Criteria Calculator be collected concurrently, when possible. The criteria models incorporate the influence of input parameters, as well as interactions among those parameters and were based mainly on laboratory studies that had a 3x3x3 factorial design where the three parameters were changed for the laboratory tests.[18] However, if concurrent measurements of all three input parameters are not available, default values for DOC may be used.[19] For more information on the use of default input parameters, see Section 4 for more information on handling missing and insufficient data.

2.2. How can data from continuous monitoring be used with the Criteria Calculator?

EPA understands that continuous monitoring for pH is more common than continuous monitoring for total hardness or DOC, and pH is more likely to exhibit greater variability over a short time period when compared to total hardness and DOC. The variable nature of pH, throughout a day, season, or year of data collection, raises questions about how continuously collected pH data should be paired with discrete measurements of total hardness and DOC. For example, how would one know whether the grab samples collected for measurement of total hardness or DOC were taken at a time when pH was in a range that would yield protective criteria?

High-quality continuous monitoring data for pH can provide information on when grab samples for total hardness and DOC should be collected to ensure the inputs to the Criteria Calculator generate protective acute and chronic criteria values. The solubility of aluminum varies with pH. Aluminum is most soluble at low and high pH values, and most bioavailable at low and high pH values; therefore, EPA recommends the full range of observed pH values be used when evaluating the Criteria Calculator outputs.[20] When sufficient data for total hardness and DOC are available to characterize the expected spatial and

[18] DeForest, D.K., K.V. Brix, L.M. Tear and W.J. Adams. 2018. Multiple linear regression models for predicting chronic aluminum toxicity to freshwater aquatic organisms and developing water quality guidelines. *Environ. Toxicol. Chem*. 37(1): 80-90.
[19] EPA is developing a geospatial tool that will help determine appropriate input parameter estimates. This work is expected to be complete in 2021.
[20] For more information about the Criteria Calculator, please see the Final Aquatic Life Ambient Water Quality Criteria for Aluminum 2018, EPA-822-R-18-001, December 2018, https://www.epa.gov/wqc/2018-final-aquatic-life-criteria-aluminum-freshwater.

temporal variability, simultaneously collected pH data should be paired with discrete samples to generate a distribution of criteria values (see Question 1.8).

Selecting a conservative value for pH from the range of observed pH values in a continuous dataset as an input (e.g., low or high pH value depending on the range of pH) and using that value with a conservative total hardness or DOC value may also be acceptable; however, the effects are not linear. In some cases, total hardness can influence the criteria value, such that a higher pH input might produce a lower criteria value with a different hardness concentration (Figure A). In general, a neutral pH produces higher values for the criteria, as do higher concentrations of DOC. However, the precise interaction of the three input parameters can be difficult to predict. For this reason, EPA recommends that a user run a series of input parameters then select the one with the lowest criteria value output by the Criteria Calculator (for n < 10) or a low percentile (e.g., 10%) of the criteria values (for n>10). However, a user might decide to input a conservative DOC value in each calculation that included paired pH and total hardness values because the effect of DOC on criteria values is a monotonic reduction of toxicity (Figure B).

Figure A: Model output at constant DOC

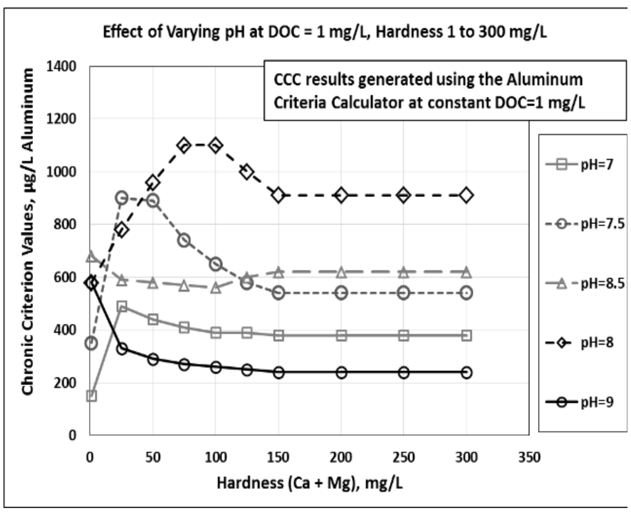
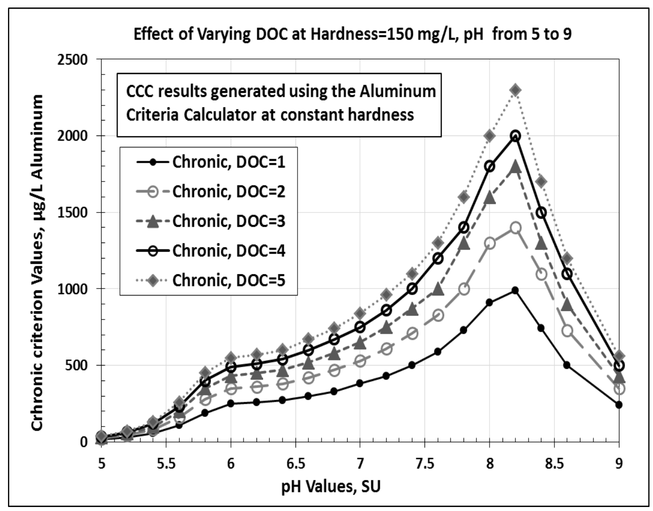


Figure B: Model output at constant hardness



2.3. What are the preferred analytical methods to measure the water quality input parameters required by the Criteria Calculator (pH, total hardness, and DOC)?

For analysis of pH and total hardness, EPA provides "Guidelines Establishing Test Procedures for the Analysis of Pollutants" at 40 CFR Part 136.[21]

[21] Information on these analytical methods is available at https://www.epa.gov/cwa-methods/approved-cwa-chemical-test-methods and https://www.gpo.gov/fdsys/pkg/FR-2017-08-28/pdf/2017-17271.pdf

Several well established methods are available for measuring DOC,[22] including EPA Method 415.3[23] and USGS Method O-1122-92. In addition, several well established methods for total organic carbon (TOC) are available, including ASTM D6317-15 and *Standard Methods for the Examination of Water and Wastewater* SM 5310. These methods discuss the stringent sample collection and processing measures that are necessary to minimize sample contamination, especially when the DOC concentrations are expected to be low. For example, the sampling container, filtration apparatus, filters and atmospheric exposure might introduce carbon to the sample and in some situations adsorb DOC. Standard Method 5310A identifies filtration protocols and additional quality control (QC) measures (e.g., filter blanks) that may be considered when using a TOC method (i.e., a method that lacks a filtration step) such as SM 5310B, adapted for DOC. Whichever method is selected, all of the specified QC operations are needed to assess the results of the field sample analyses. Example QC operations can be found at 40 CFR Part 136.7.

2.4. What are the preferred analytical test methods to measure aluminum in water?

EPA's CWA Section 304(a) recommended Criteria Calculator for aluminum is based on data for *total recoverable* aluminum. Therefore, it calculates outputs that can be used to generate criteria values for total recoverable aluminum. The approved test methods for measuring total recoverable aluminum in ambient water and wastewater use a variety of analytical instruments (the most commonly used methods are EPA Methods 200.7 and 200.8). However, recent research has indicated that a less aggressive digestion sample preparation procedure may more accurately reflect aluminum toxicity in ambient waters when using the approved analytical methods.

All of the approved total recoverable methods require that the unfiltered samples be preserved in the field by acidifying to pH<2 and digested in the laboratory with strong acid solution, with a pH of -0.05 to +0.7. This process dissolves the monomeric and polymeric forms of aluminum, in addition to colloidal, particulate, and clay minerals (i.e., aluminosilicate minerals known as phyllosilicates). However, under natural conditions not all of these forms would be biologically available to aquatic species. Over the last three decades, the scientific consensus has been that the total recoverable method for aluminum potentially overestimates the biologically available fraction and that a method that better addresses dissolved aluminum and aluminum bound to particulate matter would be useful and more accurately reflect toxicity under natural instream conditions (e.g., He and Ziemkiewics 2016; Ryan *et al*. 2019).[24] EPA's CWA Section 304(a) recommended criteria document also describes this issue.

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[22] See National Environmental Methods Index (website): https://www.nemi.gov/methods/analyte_results/?media_name=&source=&instrumentation=&analyte_name=dissolved+organic+carbon&category=.

[23] https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NERL&dirEntryId=214406.

[24] He YT, Ziemkiewicz PF. 2016. Bias in determining aluminum concentrations: Comparison of digestion methods and implications on Al management. *Chemosphere* 159:570–576; Ryan AC, Santore RC, Tobiason S, WoldeGabriel G, and Groffman AR. 2019. Total recoverable aluminum: not totally relevant for water quality standards. *Integrated Environmental Assessment and Management*. 15(6): 974–987.

As an example of an approach to better measure the biologically available forms of aluminum, research on new analytical methods was published that addresses concerns with total recoverable aluminum concentrations (Rodriguez *et al.* 2019).[25] Under this approach, the analysis does not digest the sample at pH -0.05 to +0.7 , but rather to pH 4 in order to measure only the bioavailable fraction of aluminum in the sample. The authors concluded that their proposed method is able to characterize and differentiate chronic toxicity effects attributable to bioavailable aluminum from nontoxic forms of aluminum (i.e., aluminum contained in the crystal lattice of aluminosilicate minerals) compared with existing methods for total or total recoverable aluminum. The methods for total or total recoverable aluminum may overestimate instream toxic effects by virtue of the digestion-induced dissolution of aluminum from clay minerals that would not dissolve in most ambient waters under ambient pH conditions.

EPA expects that an adjusted analytical method (referred to as a bioavailable analytical method) that uses a less aggressive initial acid digestion that liberates bioavailable forms of aluminum (including amorphous aluminum hydroxide) yet that minimizes dissolution of mineralized forms of aluminum (such as aluminosilicate minerals associated with suspended sediment particles) will better estimate the bioavailable fraction of aluminum under natural instream conditions.

The forms of aluminum introduced into the laboratory toxicity tests, upon which EPA relied for development of the CWA Section 304(a) recommended criteria, were highly soluble salts of aluminum, rather than clays or other aluminum-containing particulates typically found in natural waters. Aluminum from suspended solids and clays would normally be extracted using total recoverable methods that have a strong acid (pH <2) digestion step but would not be biologically available to aquatic species in natural waters. Empirical laboratory testing indicates that measured concentrations of total recoverable (pH -0.05 to +0.7 digestion) and bioavailable aluminum in laboratory waters are essentially equal up to approximately 1 mg/L of aluminum.[26] Studies are underway at Oregon State University with test solutions with greater than 1 mg/L of aluminum to better understand the relationship above 1 mg/L. Initial studies indicate there is little difference between “total recoverable” and “bioavailable” aluminum above 1 mg/L in laboratory waters.

EPA does not intend to develop or require a conversion or translation factor to compare field measurements using a bioavailable method against the promulgated aluminum total recoverable criteria. This is because both bioavailable and total recoverable analytical methods quantify the toxic fraction of aluminum equivalently in laboratory test waters given that standard toxicity test waters do not include suspended solids or clays per test protocols.

NPDES permit limits for metals must be expressed as “total recoverable” metals with the exception of specific circumstances that would not apply for aluminum. 40 CFR 122.45(c). This regulation exists because chemical differences between the effluent discharge and the receiving water body are expected to result in changes in the partitioning between dissolved and adsorbed or particulate forms of metals. However, for ambient water measurements, analytical methods that measure bioavailable aluminum

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[25] Rodriguez PH, Arbildua JJ, Villavicencio G, Urrestarazu P, Opazo M, Cardwell AS, Stubblefield W, Nordheim E, Adams W. 2019. Determination of bioavailable aluminum in natural waters in the presence of suspended solids. *Environmental Toxicology and Chemistry*. 38(8):1668-1681.

[26] *ibid*.

should provide more accurate quantification of the toxic fraction of aluminum. EPA acknowledges that for characterizing ambient waters, states and authorized tribes may utilize, as scientifically appropriate and as allowable by state and federal regulations, analytical methods that measure the bioavailable fraction of aluminum. Such methods employ a less aggressive initial acid digestion, such as to a pH of approximately 4 or lower, that includes the measurement of easily dissolved amorphous aluminum hydroxides, yet minimizes the measurement of mineralized forms of aluminum in aluminosilicate minerals, such as clays, which are associated with suspended sediment particles. Use of such a method for bioavailable aluminum would need to comply with other existing requirements in state or authorized tribal water programs, for example, any applicable quality assurance/quality control requirements. For assessment and listing purposes, ambient field measurements analyzed using a bioavailable analytical method may be compared directly to the criteria because that method represents the toxic fraction of aluminum. States and authorized tribes that adopt aluminum criteria should identify which analytical methods they will use to implement the criteria.

In some circumstances, assessing waters using the analytical method for total recoverable aluminum could result in identification of some waters as not attaining water quality standards for aluminum criteria (i.e., being identified as impaired), where the bioavailable analytical method may not indicate impairment. For example, ambient waters with high amounts of total suspended solids may show elevated concentrations of aluminum based on analysis of the total recoverable fraction, yet these concentrations could actually represent only non-toxic forms of aluminum. EPA's existing regulations applicable to implementation of CWA Section 303 programs, which include assessment and listing of waters, do not require use of analytical test methods promulgated at 40 CFR Part 136, nor do the regulations that apply to the determination of the need for a WQBEL. However, EPA's regulations require that states assemble and evaluate all existing and readily available water quality related data and information for use in developing their CWA Section 303(d) lists (40 CFR 130.7(b)(5)); this would include data for total recoverable aluminum. A state or authorized tribe is not required to use all available data and information to make listing decisions, including total recoverable data, where it can provide a technical, science-based rationale for the exclusion of such data and information. 40 CFR 130.7(b)(6)(iii), For example, a state or authorized tribe may be able to demonstrate that total recoverable aluminum samples are not representative of water quality conditions because non-toxic forms of aluminum are leading to an exceedance above the criteria. In such cases, the state or authorized tribe may decline to rely on total recoverable data, or may assign a greater weight to bioavailable data if it is more representative of water quality for listing purposes.

For developing TMDLs and load allocations, aluminum data from bioavailable analytical methods may also be used as the basis for identifying allocations for TMDLs. This includes both wasteload allocations (WLA) for point sources and load allocations (LA) for nonpoint sources. For implementing a WLA, the associated WQBEL must be assessed for NPDES compliance purposes using aluminum data from total recoverable methods, just as would be the case for other NPDES applications consistent with permitting regulations. NPDES permit limits for aluminum concentrations listed in compliance reports must, by regulation, be measured using analytical methods approved by EPA and published at 40 CFR Part 136. Currently the only approved methods at 40 CFR Part 136 are for "total recoverable aluminum."However, states and authorized tribes may use a bioavailable analytical method to measure aluminum concentrations from nonpoint sources (i.e., the LA for surface water runoff) because total suspended solids may include aluminosilicate minerals (e.g., clay minerals) containing aluminum that is not bioavailable under natural conditions.

2.5. What should states and authorized tribes do to ensure data quality for use in the Criteria Calculator?

EPA recommends that states and authorized tribes establish data quality guidelines for data to be input to the Criteria Calculator. Such guidelines would be similar to data quality guidelines used for other water quality criteria. EPA recommends that states develop Quality Assurance Project Plans[27] (QAPPs) for sampling protocols to assure that representative data are collected.

2.6. If data are available only for total organic carbon (TOC), can these be converted to dissolved organic carbon (DOC) for use as input to the Criteria Calculator?

In some cases, states, authorized tribes, or regulated facilities may only have collected data for TOC and not DOC, which is the input parameter for use with the Criteria Calculator. In these situations, a TOC to DOC conversion may be used. Some states have used various methods to convert TOC values to DOC. Data from the U.S. Geological Survey's (USGS) National Water Information System (NWIS) can also provide useful data to supplement state or tribal data when creating translations.[28] It is useful for states and authorized tribes who use a conversion to ensure the details of the conversion are available in the public record for the adoption of the Al criteria or in some other publicly available document.

The following examples demonstrate approaches states have taken to convert TOC data to DOC:

- Kansas uses the TOC to DOC conversion values detailed in EPA-822-R-07-001, *Aquatic Life Ambient Freshwater Quality Criteria – Copper*. See Appendix C-2: Dissolved, Particulate, and Estimated Total Organic Carbon for Streams and Lakes by State.
- Massachusetts uses a TOC to DOC conversion developed by USGS for surface waters in Massachusetts based on a regression of available NWIS data for concurrent measurements of TOC/DOC throughout the state. (See Equation 1)[29] (USGS Untitled Report, *in-prep*).

Equation 1. TOC to DOC conversion. $$DOC\left(\frac{mg}{L}\right) = 0.858 * TOC\left(\frac{mg}{L}\right) - 0.196$$

- Montana, New Mexico, and Ohio have been collecting both DOC and TOC data at selected sites. These states plan to develop conversion factors based on regression analysis of the TOC and DOC data.

[27] Further information on QAPPs may be found at https://www.epa.gov/quality/guidance-quality-assurance-project-plans-epa-qag-5.
[28] EPA is developing a geospatial tool that will help determine appropriate input parameter estimates. This work is expected to be complete in 2021.
[29] USGS Untitled Report, in-preparation. Publication expected Fall 2021.

- Oregon generated a translator to convert TOC data to DOC data for use with the Copper Biotic Ligand Model using a regression approach. A single statewide translator was developed using state and USGS NWIS data.

2.7. What information does a single run of the Criteria Calculator provide, and what are the limitations on the output from one set of inputs (single sample)?

The Criteria Calculator can be run for multiple samples of collected data for pH, total hardness, and DOC (inputs),[30] representing a range of conditions at a site. The samples may be taken from a single site throughout the year or from several different sites within a waterbody (or some combination of data collected over geographical space and time). Each sample would provide one set of input parameters and generate one set of outputs (i.e., the acute and chronic criteria). A single run of the Criteria Calculator could, therefore, provide a distribution of (in the case of the Excel version, up to 500) acute and chronic criteria values (outputs) which would be considered protective for each corresponding input sample. From the distribution of outputs, protective values for acute and chronic criteria may be selected. For more on identifying protective criteria values from a distribution of possible values, see Question 1.8.

As the number of samples of pH, total hardness, and DOC increases, the ability to reliably translate Criteria Calculator outputs to a protective criteria value also increases. A single output of the Criteria Calculator represents one moment in time at a single point and may not adequately characterize the variation in water chemistry for a site throughout the year. The uncertainty associated with a criterion based on only one single set of inputs is not a problem unique to the Criteria Calculator, as other water quality parameters vary spatially and temporally. Running the Criteria Calculator with data from multiple sampling events will yield a distribution of multiple output criteria values, from which a sufficiently protective set of criteria may be selected.

2.8. Can the Criteria Calculator still be used when the ambient data are outside the ranges included in the models used to develop the calculator?

Yes, the Criteria Calculator can be used when the ambient data for the input parameters are outside the ranges included in the MLR models. The Criteria Calculator incorporates a data extrapolation to cover a broader range of inputs for pH, and a slightly broader range for hardness. However, the Criteria Calculator does not process input values far outside of the model range. For input values outside the Criteria Calculator range, it will default to the nearest allowable Criteria Calculator input parameter

[30] The number of samples the Criteria Calculator can run at a time depends on the format: the Excel version can handle up to 500 samples. The Criteria Calculator is also available in R; both versions are available on EPA webpage for the Recommended Aquatic Life Criteria for Aluminum in Freshwater: https://www.epa.gov/wqc/aquatic-life-criteria-aluminum#2018. The R version uses the same formulas and data that are found in the Excel version, but the R code can handle a larger number of parameter inputs and can calculate faster. The R code and data are in an easy-to-download Zip file. They can be found under the “2018 Final Aquatic Life Criteria for Aluminum in Freshwater” header.

value. For example, entering a DOC value of 9.5 mg/L is within the range of the Criteria Calculator input values for DOC, therefore the Criteria Calculator will accept an input of 9.5 mg/L without change. However, an input value of 15 mg/L for DOC will default to an input value of 12 mg/L, the maximum allowable DOC value for the Criteria Calculator. The CWA Section 304(a) recommended aluminum criteria document (see pages xiv-xv)[31] explains the decisions the Agency made regarding the bounds of the input parameter ranges in the Criteria Calculator and its corresponding look-up tables.[32] Table 2, below, summarizes the information from the criteria document and compares the range of values used in the MLR models with the corresponding ranges allowable as inputs to the Criteria Calculator for each input parameter. As discussed in Section 4 of the CWA Section 304(a) recommended aluminum criteria document, the ranges incorporated into the Criteria Calculator will be protective across a broad range of ambient waters found in the United States.

Table 2: Comparison of MLR models and Criteria Calculator input parameters

Input parameter	MLR models range	Criteria Calculator range
pH	6.0 – 8.2	5.0 – 10.5
Total hardness (mg/L)	9.8 – 428	0.01 – 430
Dissolved organic carbon (mg/L)	0.08 – 12.3	0.08 – 12.0

2.9. How is the multiple linear regression (MLR) technique different from the Biotic Ligand Model (BLM)?

EPA considered multiple options when developing the national CWA Section 304(a) recommended criteria for aluminum, including the Biotic Ligand Model (BLM).[33] Both the BLM and the multiple linear regression (MLR) models are used to estimate the bioavailability – and resultant toxicity – of metals to aquatic species based on water chemistry at a site, including pH, total hardness, and DOC as inputs. The BLM, however, includes an additional seven inputs.

- The BLM, which is a mechanistic model, uses a series of submodels to estimate the capacity of metals to accumulate or bind to active sites on the gills of aquatic organisms. The submodels are

[31] Final Aquatic Life Ambient Water Quality Criteria for Aluminum 2018, EPA-822-R-18-001, December 2018, https://www.epa.gov/wqc/2018-final-aquatic-life-criteria-aluminum-freshwater.
[32] Two models, one for invertebrates and one for vertebrates, were used to normalize freshwater aluminum toxicity values. These separate models correspond to effects on invertebrates and vertebrates due to differing effects of pH, total hardness, and DOC on aluminum bioavailability and toxicity, and therefore enable the criteria magnitudes to be calculated as a function of the unique chemistry conditions at a given site.
[33] The BLM was formerly referred to as the "gill model." It is a metal bioavailability model that uses metal speciation across water chemistries and associated binding of a metal to fish gills with associated toxicity, receiving waterbody characteristics and monitoring data to develop site-specific water quality criteria. A BLM model was used to develop the 2007 CWA 304(a) aquatic life criteria recommendation for copper.

based on an underlying theory of how overall water chemistry, as defined by the ten input parameters, affects the toxicity of metals.

- The MLR approach used to develop the Criteria Calculator empirically curve-fits log-log pH, total hardness, and DOC relationships (with interaction terms) to the empirical data.

EPA evaluated the use of empirical, non-mechanistic MLR models for aluminum as a bioavailability-based approach for deriving water quality criteria as well as a BLM for aluminum. The Criteria Calculator associated with EPA's 2018 CWA Section 304(a) recommended criteria for aluminum uses the MLR approach. Given that the MLR and the BLM approaches performed comparably, EPA decided to use an empirical MLR approach in this aluminum criteria update rather than a BLM due to:

- the relative simplicity and transparency of the MLR model,
- the relative similarity to the available BLM outputs, and
- the decreased number of water chemistry input data parameters needed to derive criteria at different sites.

Under 40 CFR 131.11, states and authorized tribes may use EPA's CWA Section 304(a) recommended criteria with modifications or may use other scientifically defensible methods to develop their own criteria. Regardless of the method used, a state or authorized tribe must submit the criteria to EPA for review and approval. EPA's current recommendation, based on the latest scientific knowledge, employs an MLR model. It is possible to use other modeling approaches, such as the BLM, to predict aluminum toxicity and account for the water chemistry parameters that influence toxicity the most.

If presented with proposed aluminum criteria based on a BLM or different approach, EPA would evaluate its scientific basis and protectiveness of the designated use. For additional information and references, see Section 5.3 of the recommended criteria document available at: https://www.epa.gov/wqc/2018-final-aquatic-life-criteria-aluminum-freshwater.

Section 3: Characterizing Spatial and Temporal Variability of Input Parameters to Develop Protective Criteria Values

3.1. How should the *site* be defined for measuring input parameters to calculate protective numeric criteria values?

A *site* may be a state, region, watershed, segment of a waterbody, category of water (e.g., cold-water lakes), etc., but the criteria are to be derived to provide adequate protection for the entire site regardless of how the site is defined. A site could also be a facility mixing zone, an assessment unit, a watershed, or any spatial area that a state or authorized tribe has data to represent.

When defining a site, states and authorized tribes should consider the following:

- How the site definition will facilitate developing criteria values that are protective of the range of conditions expected to occur within the defined site.
- How the site definition will capture significant influences on water chemistry.
- How the size or spatial variability of the site can impact the number of water samples required to adequately characterize the spatial and temporal variability of a site.
- How to communicate a clear definition of the site's area or condition for which the criteria values apply.
- How, if at all, the site definition differs depending on the intended CWA program (e.g., is the receiving water site of a NPDES permit discharge location different from the assessment unit site?).

Regardless of how the "site" is defined, pursuant to 40 CFR 131.10(b), states and authorized tribes must consider downstream water quality standards when establishing protective criteria in upstream waters. For additional information on site-specific water quality criteria, see 40 CFR 131.10(b) and chapter 3 of EPA's *Water Quality Standards Handbook*.[34]

3.2. How does the definition of a site impact sampling design and number of sampling locations needed to characterize the spatial variability of a site?

The number of sampling locations needed to characterize spatial variability at a site will vary with physical and chemical characteristics of the site. Samples should be collected from enough locations so that the resulting dataset captures the expected spatial variability in pH, total hardness, and DOC of the site, based on the observed range of physical and chemical conditions.

When designing a sampling plan to develop inputs for the Criteria Calculator, unique characteristics of a waterbody segment should be considered such as size, flow, and presence of springs, tributaries, and outfalls. States and authorized tribes may also want to consider differences in hydrology, geology, eco-

[34] USEPA. 1994. Water Quality Criteria. Chapter 3 in *Water Quality Standards Handbook*. EPA 823-B-94-005a. U.S. Environmental Protection Agency, Office of Water, Washington, DC. https://www.epa.gov/wqs-tech/water-quality-standards-handbook.

region, watershed land use (e.g., urban, forested, cultivated, wetlands), trophic state (i.e., level of biological activity in the waterbody), and riparian condition within and among sites to inform decisions on the number of sampling locations needed. For example, land use within the watershed, the trophic state, and presence of discharges from a wastewater treatment plant can all influence the variability in concentrations of any of the input parameters.

Generally, relatively large or heterogeneous waterbodies will require more sampling locations to characterize the spatial variability, as compared to the number of sampling locations required to characterize small or homogenous systems. When a wide range of characteristics or water quality conditions is observed in a large waterbody, states and authorized tribes may consider dividing the waterbody into smaller segments or sites for purposes of establishing input values for the Criteria Calculator.

States or authorized tribes considering use of existing or new data for the development of default numeric values over larger geographic scales should evaluate existing data, monitoring strategies and other data sources to evaluate spatial and temporal representativeness of the data so that the variability in pH, total hardness, and DOC is understood. Sampling data from waterbodies with high levels of bioavailable aluminum should be included in the dataset to be representative of the observed site conditions.

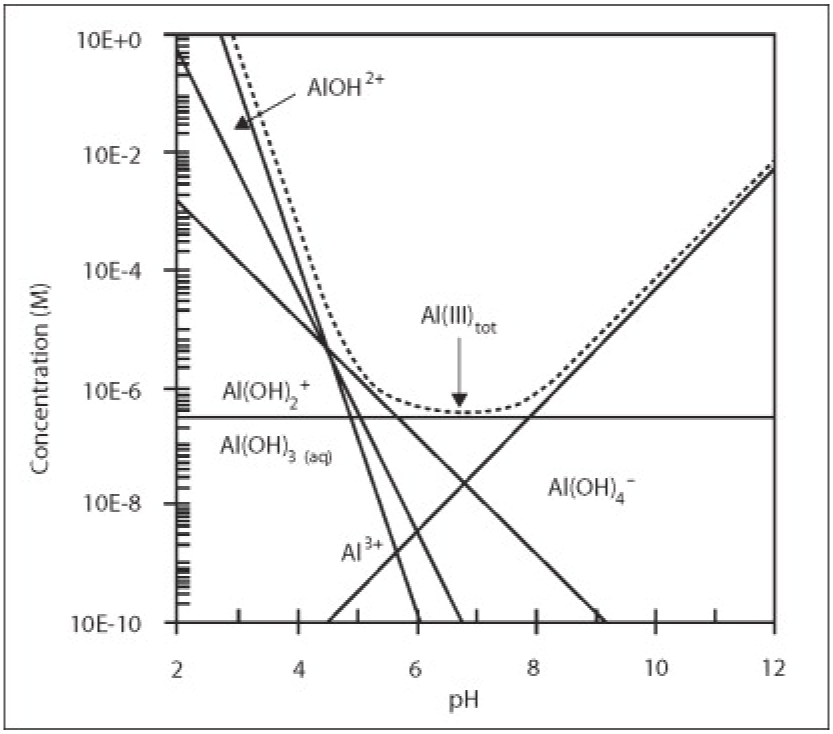
See the Section 5 on NPDES permitting for additional considerations for monitoring to characterize waters impacted by point sources.

3.3. How can a sampling plan be developed to capture the range of conditions that affect aluminum bioavailability (hence, toxicity) at a site?

Understanding how aluminum bioavailability changes with increasing or decreasing values of pH, total hardness, and DOC will help when designing sampling plans intended to capture the range of ambient chemistry conditions. A sampling plan should be designed to capture the conditions under which aluminum would be most bioavailable; these conditions have the highest acute toxicity, and also the highest chronic toxicity, with respect to aluminum. However, because the input parameters interact in complex ways, it is not possible to generalize about a universal set of input parameter conditions that would represent conditions of the highest toxicity, with respect to aluminum. Nonetheless, there are some general observations regarding pH, total hardness, and DOC:

- Values of pH in the circumneutral range are associated with lower solubility of aluminum (see Figure C) and conditions of lower bioavailability and toxicity with respect to aluminum (see Figures A and B). Values of pH may vary over several units due to photosynthetic activity in the waterbody (lowest pH at dawn and highest pH in early afternoon coincident with peak photosynthetic activity). Significant diurnal variation in pH values due to photosynthesis and respiration patterns can affect the calculated aluminum criteria values by 1,000 µg/L or more. Therefore, it would be useful to sample during times when pH is expected to be highest or lowest at a particular site, in order to capture conditions under which aluminum would be most bioavailable and toxic. Sampling early in the morning, before photosynthetic activity begins, and mid-afternoon, when photosynthetic activity peaks, may capture the extremes of pH at a site. Alternatively, data loggers could also be used to capture a range of pH values, including times (such as night) when sampling and monitoring is impractical (see Question 2.2 for more information on the use of continuous monitoring data). Effluent discharges to the waterbody that vary over the course of the day or week may also affect pH.

Figure C: Solubility of aluminum hydroxide over a range of pH. Minimum solubility (~0.000001 M) achieved under near-neutral conditions of pH.



Source: Membrane filtration: Managing aluminum in membrane filtration. Filtration + Separation. Volume 51(4):26-28. July-August 2014. https://doi.org/10.1016/S0015-1882(14)70145-4 (p 27)

- Total hardness in flowing waters may be related to stream flow or other factors that alter the concentrations of calcium and magnesium (the components of total hardness). These ions are derived mainly from weathering of rocks and minerals in natural settings and exist in the dissolved phase in most fresh waters.
- DOC can bind aluminum, rendering it less bioavailable (hence, less toxic). In general, DOC and bioavailability of aluminum are inversely correlated. That is, low concentrations of DOC are associated with higher bioavailability of aluminum; hence, yield more stringent (lower) aluminum criteria values. High concentrations of DOC bind aluminum and reduce bioavailability; hence, yield less stringent (i.e., higher) aluminum criteria values. Sampling at times when DOC is low could help capture conditions under which aluminum is more bioavailable (i.e., conditions are more toxic). Seasonal patterns in DOC concentrations at a site may vary depending on soil type, vegetation, upstream inputs, and climate.

A sampling plan should also consider other factors, such as precipitation events and snow-melt cycles, particularly for waters that receive stormwater flows. Increased flows may affect the pH and other chemical parameters of the waterbody for up to several hours following a storm event. Wet season and dry season flows may lead to extremes in the conditions that affect aluminum bioavailability. Considering the variety of factors that may affect toxicity over time at a site can help identify strategic times to sample. Strategically timed sampling is more likely to result in development of criteria values for a site that will be protective during more sensitive times (i.e., times when aluminum is most bioavailable). Conditions like time of day, date, and weather should be noted when sampling occurs.

The Criteria Calculator generates both acute and chronic criteria values from the same set of data inputs. The diurnal variability of input parameters may affect acute criteria values more than chronic criteria values, because chronic values are averaged over a four-day period. Capturing the variability of input parameter values on longer time scales (e.g., the average pH over a one- to four-day period) may be informative for chronic criteria values, because understanding that variability will help inform the design of routine sampling plans that include the collection of discrete measurements.

3.4. If monitoring shows seasonal differences in data, can seasonal data be separated out to generate seasonal criteria values?

If enough data are available and those data indicate significant seasonal differences in toxicity with respect to aluminum, it is possible to separate and create criteria values for application on a seasonal basis. For example, if spring snowmelt or heavy seasonal rainfall in the area significantly change the water chemistry parameters that affect aluminum bioavailability (hence, toxicity) during that season, then a state or authorized tribe may consider spring values that differ from values that apply during other seasons. The criteria values should protect the designated uses in all of the seasons. If states or authorized tribes choose to adopt seasonal criteria into their water quality standards, they should clearly define those seasons in their water quality standards.

Section 4: Handling Missing or Insufficient Data When Using the Criteria Calculator

4.1. Where can I find additional data to use as inputs to the Criteria Calculator?

The sufficiency of data for pH, total hardness and DOC will depend on the range of variation in the values of those parameters throughout the year. In general, more data are important for waterbodies with characteristics that exhibit a greater range of variability, to achieve an acceptable level of confidence as defined by the user. If a state or authorized tribe has limited data, EPA recommends that the state or authorized tribe consider data from the Water Quality Portal. The Water Quality Portal is a service provided jointly by the EPA, USGS, and the National Water Quality Monitoring Council that uses the EPA's Water Quality Exchange format to share over 380 million water qualtiy data records. It serves data collected by over 900 federal, state, tribal and other partners including the USGS's National Water Information System (NWIS) data (See: https://www.waterqualitydata.us/).[35] Note: Whatever dataset a state or authorized tribe uses, some level of quality assurance is vital, particularly with methods for handling total hardness or DOC, for which the analyst must comply with methodologies and holding times to ensure the resulting data meet state or tribal data quality requirements specified in the respective Quality Assurance Project Plans, or QAPPs.

4.2. Must states and authorized tribes have default input parameters or default criteria values for aluminum?

States and authorized tribes are not required to identify default input parameters or default criteria values for aluminum; however, states and authorized tribes are required to protect the designated uses of waterbodies within their jurisdictions.[36] The protectiveness of a state or authorized tribe's approach to adopting EPA's CWA Section 304(a) recommended criteria will be determined by both the *implementation methods* associated with the criteria and the *input parameter data* (for pH, total hardness, and DOC) used to calculate the criteria values for a given waterbody. See Question 1.2 for more information on approaches to adopting aluminum criteria, including default criteria.

For states and authorized tribes that choose to adopt the criteria in the form of the Criteria Calculator or lookup tables, the adoption of default input values or default criteria values can help to ensure that aquatic life uses will be protected in all waters within their jurisdiction, regardless of data availability for pH, total hardness, or DOC. When considering the establishment of default input parameters, it is especially important to keep in mind the complex (e.g., non-monotonic) relationship between pH and aluminum toxicity as well as the high natural variability of pH. Both issues make it uniquely challenging to establish protective pH default values. See Question 3.3 for more information. Having numeric default criteria values available may also help ensure that anyone implementing the criteria (e.g., a

[35] EPA is developing a geospatial tool that will help determine appropriate input parameter estimates. This work is expected to be complete in 2021.

[36] As provided at 40 CFR 131.11(a), state and tribal water quality criteria must be protective of the designated use based on a sound scientific rationale.

permit writer, or someone assessing the water) will have a clear numeric basis for implementation, providing transparency for the public and the regulated community.

4.3. Would default criteria be overly stringent?

Because default criteria are generally applied to a broad geographical area (e.g., ecoregions), it is possible that defaults will result in criteria values that are more or less stringent than the criteria values would be if calculated based on the water chemistry parameters at a given location. The accuracy of an established default value will depend on the method used to group together similar waterbodies that share common physical and chemical characteristics. After grouping similar waterbodies, the state or authorized tribe can derive default values for those waters in each group.

States and authorized tribes have flexibility in the method used to derive default values and may choose whatever grouping method they believe will result in the most accurate defaults, provided that they have sufficient data to support such a method. If states or authorized tribes believe that the default criteria values are more stringent than necessary to protect aquatic life in a specific waterbody, site specific ambient data may be collected and used in the Criteria Calculator to establish site-specific criteria values.

4.4. Must states and authorized tribes use EPA ecoregions to develop default criteria values or can they use the state's own approach?

As described in Question 4.3, states and authorized tribes have discretion on how to establish default criteria values, including how to identify the geographic units to which defaults will be applied, which datasets are used to generate the defaults, and how to generate the default values from those data. A key consideration is grouping waterbodies with similar water chemistry. One option is to group waterbodies based on ecoregions, geographic divisions for which EPA has already processed data and provided DOC estimates. However, states and authorized tribes may elect to use additional data or data divided into different regions. For example, Oregon has "geo-regional" divisions. States and authorized tribes may also choose to define default values by stream order if sufficient data exist to support such a division.

Section 5: Implementing the Recommended Aluminum Criteria in National Pollutant Discharge Elimination System (NPDES) Permitting

5.1. When using the Criteria Calculator for permitting (i.e., for reasonable potential analysis (RPA) or for developing WQBELs), how will an NPDES permit writer know what inputs to use?

NPDES permit writers should follow their state's criteria implementation guidance.[37] As stated in EPA's *NPDES Permit Writers' Manual,* [38] the goal of the permit writer is to derive effluent limitations that are enforceable, adequately account for effluent variability, consider available receiving water dilution, protect against acute and chronic impacts, account for compliance monitoring sampling frequency, and assure attainment of water quality standards and any applicable waste load allocation.

As described throughout this document, states and authorized tribes that adopt the recommended aluminum criteria should provide sufficient information and explanation in the criteria itself or in implementing documents so permit writers, the regulated community, and the public understand how the criteria operate to protect designated uses. In some cases, the state or authorized tribe may have adopted numeric criteria values for aluminum (e.g., Criteria Calculator outputs) as its water quality standards or adopted default input parameter values to be used in absence of ambient data. In other cases, the state may have adopted provisions specifying how ambient data, if available, must be used in the Criteria Calculator, and how criteria values must be generated. In the absence of state implementation guidance or other provisions, permit writers may also consider existing practices for similar model-based criteria. Permit writers may also wish to consult the water quality standards experts for the state or authorized tribe and the permitting authority may seek guidance from EPA.

5.2. When using the Criteria Calculator to derive criteria values to use for developing NPDES permits, should the inputs be based on upstream ambient waters, the effluent, or a measured or modeled mix of ambient waters and effluent?

The general principles regarding discharges affecting water chemistry in the context of NPDES permitting for aluminum are similar to permitting for discharges of other metals for which criteria are hardness-based. State water quality standards and permitting policies and procedures should include information on how to select locations for obtaining representative input water chemistry values in a manner that ensures calculated criteria are protective of applicable aquatic life designated uses. If

[37] Additional information on the calculation of design conditions can be found in EPA's *Technical Guidance on Supplementary Stream Design Conditions for Steady State Stream Modeling*. U. S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA-440-48-80-91. December 1988. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=00001JA6.txt

[38] USEPA. 2010. NPDES Permit Writers' Manual. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA-833-K-10-001. September 2010. https://www.epa.gov/sites/default/files/2015-09/documents/pwm_2010.pdf

obtaining chemistry values is not practicable or possible, model inputs could be calculated as described below.

When a discharge from a point source to a receiving water or tributary is expected to influence the chemistry of the receiving water at the permitted discharge location or a downstream location, ambient sampling locations should include locations representing conditions in the waterbody after complete mixing. The number of sampling locations and the frequency of sampling should be adequate to characterize the spatial and temporal variability of the site (see Question 3.2 and Question 3.3 for more information).

If the boundaries of the mixing zone cannot be determined, or if downstream sampling reflecting conditions after mixing is not practicable, input parameter values representing those conditions may be estimated from concentration and flow values for the point source or tributary and the waterbody. In doing so, a range of observed or expected upstream and effluent/tributary conditions should be evaluated. Care should be taken to consider the buffering capacity (alkalinity) of the waters being mixed when estimating the mixed pH.

In general, effluent water chemistry alone should not be used to determine model input parameters. However, this might be appropriate in an effluent-dominated stream. For more information on effluent-dominated streams, see Question 5.4.

5.3. If the state or authorized tribe has adopted the Criteria Calculator or lookup tables, how may a permit writer account for both the most appropriate conditions with respect to receiving water chemistry in deriving appropriate criteria values and "critical conditions" used in reasonable potential determinations and calculating a WQBEL?

In general, as discussed in EPA's *Technical Support Document for Water Quality-Based Toxics Control* and *NPDES Permit Writers' Manual*, NPDES permit writers seek to represent "critical conditions" in their calculations so that the resulting WQBELs will be set at a level necessary to meet water quality standards under those critical conditions and therefore under other foreseeable conditions.

Deriving applicable water quality criteria values (taking into account the most sensitive water chemistry conditions) is one calculation. Developing WQBELs based on those criteria values and using "critical conditions" is a subsequent calculation. The two steps are described below:

Step 1: If the state has adopted aluminum criteria values as static numeric values for a site, the permit writer would use those values. If not, the permit writer should use the Criteria Calculator as follows:

> The permit writer should run the Criteria Calculator using data that represent the spatial and temporal variability at the site, including the most sensitive conditions. The criteria should protect aquatic life throughout the year, over the range of expected conditions, including conditions under which aluminum would be most bioavailable (hence, most toxic) to aquatic life (see Question 1.2 for more information). The criteria values derived from the distribution of

criteria values should protect for the full range of conditions. (See Section 3 on characterizing spatial and temporal variability for more information).

Step 2: Determine the Need for and Derive WQBELs

After applicable criteria values are derived to protect for the range of conditions, the permit writer must determine whether a facility's discharge is causing, has the reasonable potential to cause, or contributes to an excursion of that criteria (also known as "reasonable potential analysis", or RPA). If a WQBEL is needed, then NPDES permit limits should be derived based on the criteria and assuming "critical conditions" to ensure the WQBEL is as stringent as necessary to meet the criteria.[39]

NPDES permit writers often complete RPAs and derive WQBELs based on a set of steady-state conditions, called "critical conditions" in order to ensure that the WQBELs will protect receiving water quality. Commonly, the 7Q10 or 4B3 stream flow is used to determine wasteload allocations based on chronic aquatic life criteria, and the 1Q10 or 1B3 stream flow is used to determine wasteload allocations based on acute aquatic life criteria. The NPDES authority may also use other critical flows as specified in the relevant water quality standards or permitting policies and procedures. Critical low flows represent relatively little available dilution in the receiving water. Permit limits are then based on the wasteload allocation, acute or chronic, whichever is more restrictive. EPA has provided guidance regarding critical low flows for permitting.[40]

The critical low flow used in RPA and WQBEL calculations may not correspond to the flows typically associated with water chemistry conditions under which aluminum would be most bioavailable (hence, most toxic). In order to ensure water quality is protective of the designated use, criteria values that will be protective of the range of conditions, including conditions under which aluminum would be most bioavailable, should be applied in conjunction with the critical conditions used in RPA and WQBEL calculations. This would ensure a protective limit.

EPA recommends that as RP and WQBELs are reevaluated at permit reissuance, permit writers consider potential changes to water chemistry since the last issuance. Conditions that render aluminum more or less bioavailable in receiving waters could change as the result of a newly permitted discharge or modification of an existing discharge, land-use changes, or changes to hydrologic conditions; all of which may affect pH, total hardness, and DOC.

5.4. Would the recommended aluminum criteria be appropriate for deriving criteria values in effluent-dominated streams?

Yes, the Criteria Calculator and lookup tables can be used to derive criteria values in effluent-dominated streams. As in any case, the nature of the discharge in relation to stream conditions should be

[39] For more information on critical conditions, see Chapter 6 of the NPDES Permit Writers' Manual.
[40] For more on critical conditions, see EPA's *Technical Support Document for Water Quality-based Toxics Control* (March 15, 1991). https://www3.epa.gov/npdes/pubs/owm0264.pdf.

considered when determining a sampling approach. EPA is aware that in some cases, sampling for inputs to model-based criteria is conducted upstream of the discharge (or the "natural" receiving water, absent any effect of the effluent). However, in other cases sampling for inputs reflects the water chemistry that will exist in the receiving water *after* the receiving water and effluent completely mix (downstream of the discharge). The upstream approach would be more conservative/protective if the discharge itself has characteristics that mitigate aluminum toxicity, such as high concentrations of DOC.

5.5. Can the recommended aluminum criteria be implemented in an NPDES permit for a facility that has not yet started discharging?

Permitting (both determining the need for and deriving a WQBEL) is always a predictive exercise based on critical effluent projections and critical stream conditions that are anticipated during the permit term. The predictive models for both the criteria calculation and for effluent and receiving water mixing are always improved with more refined input values; however, the analyses can be performed using expected ranges of input values even before a discharge occurs.

5.6. To the extent input parameters to the Criteria Calculator vary throughout the year (e.g., seasonally), and thus criteria values may vary, should permit limits also vary?

Seasonal WQBELs can be developed based on calculated seasonal criteria values. As discussed in the response to Question 3.4, the Criteria Calculator may be used to generate seasonal water quality criteria values. The NPDES authority could use the different criteria as the basis for determining reasonable potential and deriving the WQBELs.

Additionally, even in cases where there are not seasonal criteria, NPDES authorities have discretion to provide seasonal or tiered flow limitations in NPDES permits based on seasonal critical conditions, where appropriate, unless the state's water quality standards prohibit this. Where not prohibited, seasonal WQBELs could be based on year-round criteria values but different flow scenarios and background concentrations. To develop seasonal WQBELs, the permit writer would have to model the critical stream flow, background concentrations, and effluent and stream flows during any season in which the criteria were applicable.

EPA recommends that as reasonable potential and WQBELs are reevaluated at permit reissuance, permit writers consider potential changes to water chemistry since the last issuance. Conditions that render aluminum more or less bioavailable in receiving waters could change as the result of a newly permitted discharge or modification of an existing discharge, land-use changes, or changes to hydrologic conditions; all of which may affect pH, total hardness, and DOC. In some cases, additional data and/or monitoring would be required to determine when the various seasonal or tiered flow limits apply.

5.7. Does EPA have any recommendations on criteria development at the watershed scale, or the potential for shared data collection and implementation at multiple NPDES facilities located in the same general vicinity?

EPA has not developed specific guidance on watershed scale permitting for toxic metals, though specific TMDLs may provide some examples of how to gather and share data to support use of the Criteria Calculator. A key question for the state to consider is whether the water quality data used as inputs to the Criteria Calculator would be representative of the entire area to which the criteria would apply. For more information regarding site characterization, see Section 3 on characterizing spatial and temporal variability. If a TMDL exists for a particular waterbody or watershed, more information may be available that could be used in considering the appropriate watershed scale. More information on watershed-scale permitting is available at https://www.epa.gov/npdes/watershed-based-permitting.

Section 6: Implementing the Recommended Aluminum Criteria in Assessments, Listings, and Total Maximum Daily Loads (TMDLs)

6.1. How will assessment and listing staff know what numeric values represent "the criteria" when assessing waters with respect to the recommended aluminum criteria?

As described throughout this document, states and authorized tribes that adopt some or all of the recommended aluminum criteria should provide sufficient information and explanation in the criteria itself or in implementing documents so permit writers, the regulated community, and the public understand how the criteria operate to protect designated uses. As discussed in Question 1.2 above, states have options for how to adopt EPA's aluminum criteria recommendation. Specifically, states may develop criteria values at different scales (e.g., statewide, ecoregional, site-specific) using EPA's recommended tools (e.g., the Criteria Calculator, look up tables) and submit those values as criteria to EPA for approval under CWA Section 303(c). States may also adopt both the water chemistry-dependent criteria and an associated derivation methodology whereby the same tools are described along with criteria derivation and implementation methods. EPA recommends that criteria derivation and implementation be included in the state's or authorized tribe's water quality standards. As such, states and authorized tribes should be able to determine the applicable water quality criteria for aluminum for completing water quality assessments by consulting EPA-approved aluminum criteria and associated criteria derivation and implementation methods.

6.2. How should states and authorized tribes prepare to transition to assess waters based on their new Criteria Calculator-based aluminum criteria, particularly for waters for which input parameter data are unavailable?

State and authorized tribes should monitor for input parameters and aluminum if they plan to transition to uses of the 2018 recommended criteria. The Criteria Calculator relies on ambient data, so collecting as much data as feasible before running the Criteria Calculator will facilitate assessment of these criteria. During the time of transition to the new criteria, states may maintain aluminum listings on the CWA Section 303(d) list that were based on the state's or authorized tribe's previously applicable aluminum criteria until water quality can be evaluated using the new criteria for aluminum.

6.3. If the state or authorized tribe only has data on aluminum in the dissolved form (when the criteria are expressed as total recoverable), how does that affect assessment and listing?

As described in EPA's CWA Section 304(a) recommended aluminum criteria document, measurements of dissolved aluminum do not sufficiently characterize the full spectrum of forms of aluminum that contribute to toxicity. EPA recommends that if a state or authorized tribe adopts the recommended criteria, it collects data in a form that appropriately characterizes the bioavailability of aluminum.

EPA's regulations require that states and authorized tribes assemble and evaluate all existing and readily available water quality-related data and information in developing their CWA Section 303(d) lists (40 CFR 130.7(b)(5)), which would include data and information on the dissolved form of aluminum. However, a state or authorized tribe is not required to use all available data and information to make listing decisions where it can provide a technical, science-based rationale for the exclusion of such data and information. 40 CFR 130.7(b)(6)(iii). For example, a state or authorized tribe may demonstrate that the use of dissolved aluminum measurements in impairment decisions may underestimate the bioavailable aluminum in the waterway and not be representative of the water's impairment status, especially when the levels of aluminum measured as dissolved are below the Criteria Calculator values. However, dissolved aluminum measurements that show concentrations above the criterion would likely indicate that the criterion is exceeded. If a state or authorized tribe decides not to use dissolved aluminum data and information for making listing decisions, particularly measurements that show concentrations above the criterion, it must provide a technical, science-based rationale.

6.4. How does EPA recommend applying the Criteria Calculator for a water that is impaired with respect to one or more of the input parameters?

In some situations, the values for the input parameters would themselves cause impairment of the water (e.g., pH that is outside the range of an approved water quality standard for a state's pH criteria which specify a pH range between 6.5 and 9). If a state or authorized tribe finds that values for input parameters indicate nonattainment of state standards, then the waterbody should be placed on the list of impaired waters for these and any other parameters that are not meeting water quality standards (per 40 CFR 130.7(b)(1)).

The water may or may not be impaired with respect to aluminum, even if one or more of the input parameters causes impairments of other water quality criteria. The Criteria Calculator can be used with a wide range of inputs, regardless of whether those inputs themselves would be considered causes of impairment. For more information about using the Criteria Calculator for values inside and outside the ranges covered by the Criteria Calculator, see Question 2.8.

The Criteria Calculator-derived aluminum criteria are not a substitute for other integrating measures of water quality, such as biological assessments and ambient toxicity tests. When available, the result of these integrative tests should be considered data and information that states and authorized tribes are required to assemble and evaluate for assessment determinations (40 CFR 130.7(b)(5)).

6.5. When both the water chemistry-dependent criteria and an associated derivation methodology are adopted into WQS which aluminum value should be used to develop TMDLs?

States and authorized tribes should develop TMDLs to address the applicable aluminum criteria adopted by the states and authorized tribes and approved by EPA. States and authorized tribes have the option of choosing one, or a combination, of the approaches described in Question 1.2 above.

States and authorized tribes that adopt a methodology as part of their criteria should include implementation methods in their water quality standards or other legally binding documents, as described in Question 1.3. Such implementation methods should clearly describe which aluminum criteria value is applicable for TMDL development purposes, particularly for states that adopt a combination of the approaches listed above (e.g., ecoregional default values and criteria values derived from the Criteria Calculator).

6.6. When should states and authorized tribes develop TMDLs based on EPA's recommended aluminum criteria?

CWA Section 303(d) requires states and authorized tribes to develop a TMDL when they identify a waterbody as not meeting applicable water quality standards and place the impairment on their biennial CWA Section 303(d) list. As part of the biennial list, states and authorized tribes are required to prioritize impairments on their CWA Section 303(d) lists for TMDL development, taking into account the severity of the pollution and the uses to be made of such waters, and include a schedule of TMDLs that will be developed over the next two years. See 40 CFR 130.7(b)(4). The opportunity to prioritize impairments for TMDL development provides states and authorized tribes flexibility on scheduling TMDL development for waters not meeting the aluminum water quality standard. Such flexibility may be important to states and authorized tribes that identify impaired waters for inclusion on the 303(d) list using small datasets (such as in method 3 in Question 1.8) because the criteria value may not represent conditions under which aluminum is most bioavailable. In these circumstances, states and authorized tribes can consider scheduling these TMDLs for development once the criteria value for the site is derived in a way that will protect aquatic life throughout the range of seasonal and flow conditions at a site, including those conditions of pH, total hardness, and DOC, when aluminum is most bioavailable.

6.7. Can states and authorized tribes write a TMDL to achieve a presumptive aluminum criteria value that is based on a planned change to one of the input variables?

States and authorized tribes should develop TMDLs for the aluminum criteria value that exists at the time of developing the TMDL rather than a presumptive aluminum criteria value based on a planned increase or decrease to one or more of the input parameters (i.e., pH, total hardness, and DOC). As discussed in Question 1.8, the methods for deriving the recommended criteria value are based on input variable values observed in the field. The methods do not provide for a consideration of presumptive, or potential, input variable values that may be realized in the future after practices are put in place to change the input variables. However, as discussed in the previous question, states and authorized tribes have flexibility on prioritizing and scheduling TMDLs for development. As such, instead of developing a TMDL based on the current aluminum criteria value, a state or authorized tribe may first choose to calculate a new criteria value after measures are taken to change the input variables and those changes are realized in the field.