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WATER QUALITY STANDARDS HANDBOOK

CHAPTER 3: Water Quality Criteria

EPA

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List of Acronyms

AWQC	Ambient water quality criteria
BAF	Bioaccumulation factor
BCF	Bioconcentration factor
BEACH Act	Beaches Environmental Assessment and Coastal Health Act
BLM	Biotic ligand model
BSAF	Biota sediment accumulation factor
CCC	Criterion continuous concentration
CFR	Code of the Federal Register
CMC	Criterion maximum concentration
CSF	Cancer slope factor
CWA	Clean Water Act
EPA	United States Environmental Protection Agency
ESB	Equilibrium partitioning sediment benchmarks
FCR	Fish consumption rate
MCL	Maximum contaminant levels
MCLG	Maximum contaminant level goals
NHANES	National Health and Nutrition Examination Survey
NPDES	National Pollutant Discharge Elimination System
N-STEPS	Nutrient Scientific Technical Exchange Partnership and Support
PAH	Polycyclic aromatic hydrocarbons
RfD	Reference dose
RSC	Relative source contribution
SABS	Suspended and bedded sediments

SDWA	Safe Drinking Water Act
WQBEL	Water quality-based effluent limit
WQS	Water quality standards
WER	Water-effect ratio
WET	Whole-effluent toxicity
USDA	United States Department of Agriculture

3. INTRODUCTION

The Clean Water Act (CWA) and 40 Code of the Federal Register (CFR) Part 131 require states and authorized Tribes[a] to adopt water quality standards (WQS) consisting of three key components: designated uses, water quality criteria,[1] and an antidegradation policy.[b] This chapter describes ambient water quality criteria (AWQC). Specifically, Sections 3.1 and 3.2 provide background information on criteria and the general forms criteria can take. Section 3.3 describes human health criteria and the EPA's recommendations for developing such criteria. Section 3.4 describes criteria to protect recreation. Section 3.5 describes aquatic life criteria and the EPA's recommendations for developing such criteria. Section 3.6 describes nutrient (e.g., nitrogen and phosphorus) criteria, and Sections 3.7 through 3.12 describe special considerations for biological criteria, hydrologic flow, sediment, temperature, wildlife, and wetlands. Section 3.13 provides a discussion of special considerations for priority pollutants. Section 3.14 describes criteria to protect agricultural and industrial designated uses.

[a] Hereafter referred to as "states and authorized Tribes." "State" in the CWA and this document refers to a state, the District of Columbia, the Commonwealth of Puerto Rico, the United States Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands. "Authorized Tribes" refers to those federally recognized Indian Tribes with authority to administer a CWA WQS program.

[b] The CWA specifies that WQS must consist of designated uses and criteria to protect such uses. In 1987, Congress amended the CWA to recognize that antidegradation requirements are also part of WQS (see Section 303(d)(4)(B)). The EPA's regulation at 40 CFR 131.3(i) provides that WQS "are provisions of State or Federal law" that consist of designated uses and water quality criteria. 40 CFR 131.5(a)(3), 131.6(d), and 131.12 further reinforce that antidegradation requirements are part of WQS.

3.1. WATER QUALITY CRITERIA

Under Section 303(c)(2)(A) of the CWA, states and authorized Tribes are responsible for adopting WQS that "...consist of the designated uses of the navigable waters involved and the water quality criteria for such waters based upon such uses." These standards shall "...protect the public health or welfare, enhance the quality of water and serve the purposes of this Act." 40 CFR 131.3(b) further defines criteria as "...elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use." Criteria represent the conditions (e.g., concentrations of particular chemicals, levels of certain parameters) sufficient to restore and maintain the chemical, physical, and biological integrity of water bodies and protect applicable designated uses. Generally, criteria provide for the protection and propagation of fish, shellfish, and wildlife as well as recreation in and on the water. If a criterion is exceeded, exceeded, the water quality may pose a human health or ecological risk, and protective or remedial action may be needed.

To provide scientific guidance to states and authorized Tribes, the EPA publishes, and from time to time revises, criteria for water quality under CWA Section 304(a) that accurately reflect the latest scientific knowledge. The EPA's Section 304(a) national criteria recommendations (sometimes referred to as "304(a) criteria")

TOXIC AND PRIORITY POLLUTANTS

Section 307(a)(1) of the CWA establishes a list of **toxic pollutants**, originally contained in a House of Representatives committee report and subsequently promulgated by the EPA at 40 CFR 401.15. When this chapter refers to toxic pollutants, it is referring specifically to the pollutants regulated under CWA Section 307(a)(1). When the chapter refers to **pollutants with toxic effects**, it is including all pollutants that may have toxic properties, not just those specifically regulated under CWA Section 307(a)(1).

To prioritize action on the pollutants on the toxic pollutant list and to make the list more usable, the EPA created its list of **priority pollutants** at 40 CFR Part 423, Appendix A. The priority pollutant list identifies, among other things, individual chemical names, as opposed to the toxic pollutant list which identified general classes of pollutants. In this chapter, the terms priority pollutants and toxic pollutants are used interchangeably.

For more information see section 3.13 of this chapter and the EPA's *Toxic and Priority Pollutants Under the CWA* webpage.

provide quantitative concentrations or levels and/or qualitative measures of pollutants that, if not exceeded, will generally ensure adequate water quality for protection of a designated use.[2] The EPA's supporting documentation for 304(a) criteria recommendations also includes evaluations of available scientific data on the effects of the pollutants such as effects on public health and welfare, aquatic life, and recreation. The EPA develops 304(a) criteria recommendations based on the best available science, scientific literature review, established procedures for risk assessment, EPA policies, external scientific peer review, and public input. Because the purpose of the EPA's 304(a) criteria recommendations, as set out in the CWA, is solely to identify levels of pollutants in water that will ensure adequate water quality protection of designated uses, the recommendations are made independent of other considerations. The EPA's 304(a) criteria recommendations do not impose legally binding requirements. Therefore, they do not substitute for the CWA or regulations, and they are not regulations themselves.

In accordance with 40 CFR 131.11, states and authorized Tribes must adopt water quality criteria that "...protect the designated use." The EPA recommends that states and authorized Tribes consider the Agency's national recommended water quality criteria when developing their criteria. However, states and authorized Tribes may adopt, where appropriate, other scientifically defensible criteria that differ from the EPA's recommendations (section 3.2.1 of this chapter describes the options for deriving numeric water quality criteria). Per 40 CFR 131.11(a)(1), state and authorized Tribal criteria must meet the requirements presented in Figure 3.1.

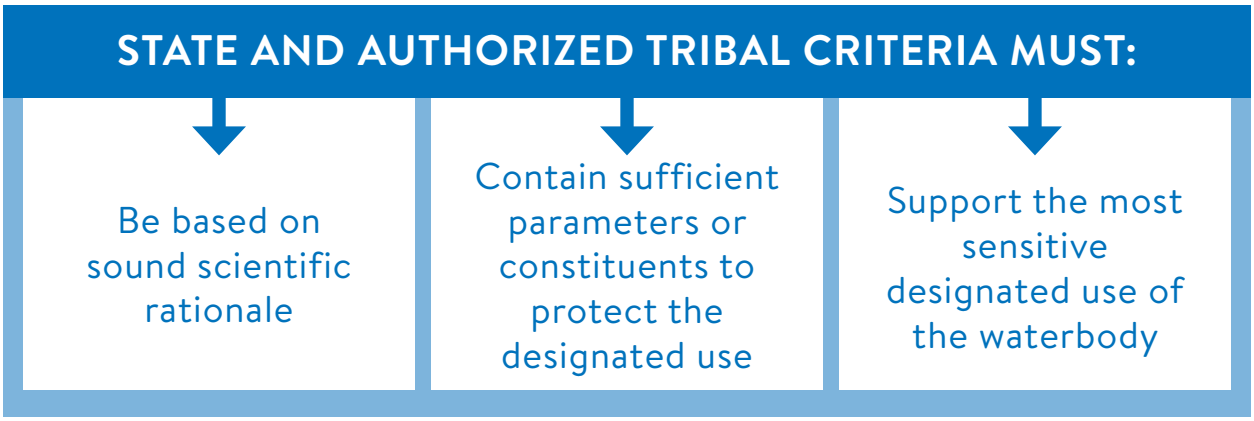

Figure 3.1. Requirements of State and Authorized Tribal Criteria under 40 CFR 131.11(a)(1).

While most 304(a) criteria recommendations represent specific levels of chemicals in the water that are not expected to pose significant human health or ecological risks, certain pollutants primarily exert their toxic effects by accumulating in fish tissue. For such cases, a fish tissue-based criterion may be appropriate. Water column-based criteria can be derived from fish tissue-based criteria using chemical-specific translation methods. As an example, the EPA's *aquatic life criterion for selenium* includes both fish tissue-based components as well as a translation to water column-based components.[3] It also includes methods that a state or authorized Tribe can use to derive a site-specific water column translation of the fish tissue component. Another example of a chemical-specific translation method can be found in the EPA's *Guidance for Implementing the January 2001 Methylmercury Water Quality Criterion* (2010).[4]

Under Section 303(c) of the CWA, the EPA reviews and approves or disapproves state and authorized Tribal WQS to ensure that the above requirements, among others, are met. The EPA recommends states and authorized Tribes develop a record describing the scientific justification for their adopted criteria and the public participation process. If a state or authorized Tribe relies on 304(a) criteria recommendations (or other up-to-date EPA guidance documents), they may reference and rely on the data in those documents and may not need to create duplicative or new material for inclusion in their records. However, where the state or authorized Tribe adopts site-specific criteria or uses an approach that differs from that of the EPA's current recommendations, the approach must meet the requirements of 40 CFR 131.11(a) and should be clearly documented and transparent. In the case where a state or authorized Tribe has chosen not to adopt a new criterion or update a criterion for a parameter for which the EPA has provided new or updated CWA Section 304(a) criteria recommendations, the EPA's provision at 40 CFR 131.20(a) requires states and authorized Tribes to provide an explanation for why it is choosing not to adopt new or revised criterion at that time. This explanation must be provided to the EPA when the state or authorized Tribe submits the results of its triennial review, consistent with 40 CFR 131.20(c). This explanation, while not approved or disapproved by the EPA, is an important method for a state or authorized Tribe to use to explain its rationale to the public and be transparent in its decision-making process. Please see Chapter 7 of this Handbook for additional information on the requirements at 40 CFR 131.20.

The EPA recommends that states and authorized Tribes coordinate with the EPA before beginning activities to adopt new or revised WQS long before they formally submit the WQS for EPA review.

Reasons for early coordination with the EPA prior to adopting new or revised WQS include:

- Early identification of potential areas of scientific or programmatic concern that require resolution between the EPA and the state or authorized Tribe, or with the federal agencies responsible for any relevant threatened or endangered species.
- Discussion and resolution of any such concerns before the EPA receives a formal review request from the state or authorized Tribe.
- Increased likelihood that state or authorized Tribal WQS meet the requirements of the CWA and 40 CFR Part 131 at the time of submission to the EPA.

While not a regulatory requirement, states and authorized Tribes may send draft WQS to the EPA for early feedback. The EPA will then provide comments on the proposed revisions to assist the state or authorized Tribe in developing WQS that are approvable. Coordination between the state or authorized Tribe and the EPA throughout the review process may assist in the EPA's timely review of state and authorized Tribal WQS.

States and authorized Tribes implement their criteria in the context of the water quality management activities they conduct under the CWA. For example, they utilize their

criteria when deriving appropriate water quality-based effluent limits (WQBELs) for National Pollutant Discharge Elimination System (NPDES) permits. They also use their criteria when determining whether a waterbody is attaining its WQS.

In making water quality management decisions such as Section 303(d) listing decisions, the EPA recommends that states and authorized Tribes apply each criterion independently to the particular waterbody. "Independent application" means that, where different types of assessment information are available (e.g., monitoring data for toxicity, water chemistry, and biology), any one assessment is sufficient to identify an existing or potential impairment regardless of the results from other types of assessment. For example, available information might not indicate an exceedance of a chemical-specific criterion to protect aquatic life, but the biological assessment at the site indicates the aquatic life use is not being met. In that case, for purposes of making a listing decision under Section 303(d), the state would list the water as impaired for the aquatic life use. For additional information on independent application, see the EPA's *Transmittal of Final Policy on Biological Assessments and Criteria*, Memorandum from Rick Brandes (1991), Section III.G of the EPA's *Water Quality Standards Regulation*, Advance Notice of Proposed Rulemaking (1998), and Section IV.K of the EPA's *2006 Integrated Reporting Guidance*, Memorandum from Diane Regas (2005).[5, 6]

Additionally, when implementing WQS, if a waterbody has multiple designated uses with different criteria for the same pollutant, states and authorized Tribes protect the most sensitive use, in accordance with 40 CFR 131.11(a).

The federal regulation at 40 CFR 131.10(b) requires that, when designating uses and associated criteria, states and authorized Tribes consider "the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters." For more information, see Chapter 2 of this Handbook, as well as the EPA's *Protection of Downstream Waters in Water Quality Standards: Frequently Asked Questions* (2014)[7] and the EPA's *Decision Tool for Downstream Water Quality Protection* webpage, which is an interactive interface designed to direct states and authorized Tribes to resources and methodologies when developing criteria that provide for the attainment and maintenance of downstream WQS. The EPA has also developed Templates for Narrative Downstream Protection Criteria in State Water Quality Standards that states and authorized Tribes can use to develop narrative criteria to address downstream protection.[8, 9]

3.2. FORMS OF WATER QUALITY CRITERIA

3.2.1. Numeric Water Quality Criteria

In accordance with 40 CFR 131.11(b)(1), in adopting water quality criteria, states and authorized Tribes should adopt numeric criteria based on one of the methods provided in Figure 3.2. The majority of this chapter discusses the EPA's recommended approaches for developing numeric criteria.

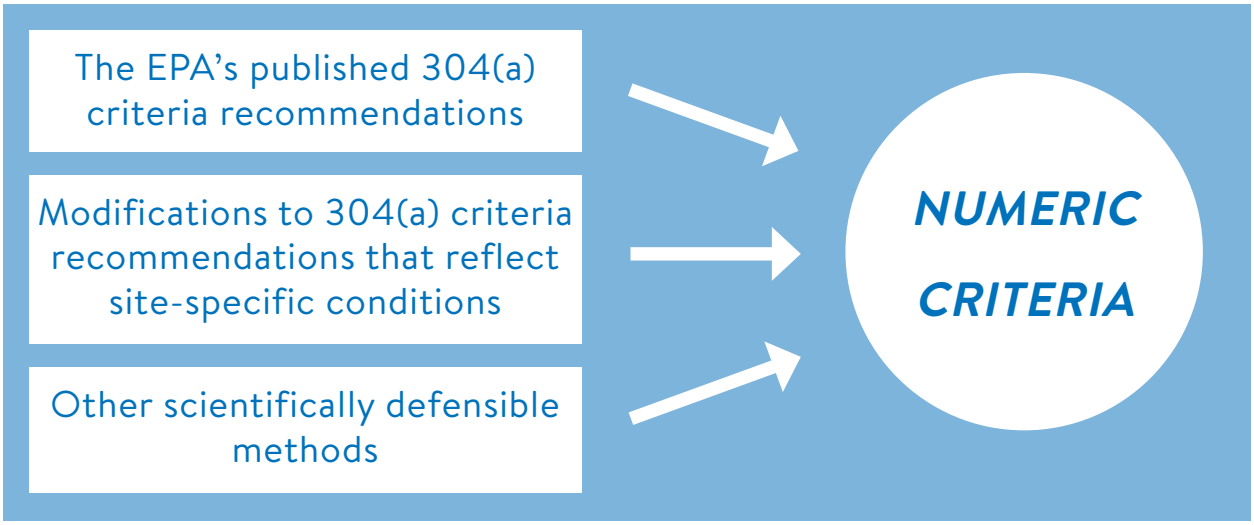

Figure 3.2. Methods for States and Authorized Tribes to Derive Numeric Criteria According to 40 CFR 131.11(b)(1).

3.2.2. Narrative Water Quality Criteria

In accordance with 40 CFR 131.11(b)(2), in adopting water quality criteria, states and authorized Tribes should "establish narrative criteria or criteria based on biomonitoring methods where numeric criteria cannot be established or to supplement numeric criteria."

Example of a Narrative Criterion (adapted from the EPA's *Model Water Quality Standards Template for Waters on Indian Reservations* (2016)):[10]

All waters shall be free from toxic, radioactive, conventional, non-conventional, deleterious or other polluting substances in amounts that will prevent attainment of the designated uses specified.

All waters shall be free from substances, attributable to wastewater discharges or other pollutant sources that do one or more of the following:

1. *Settle to form objectionable deposits.*
2. *Float as debris, scum, oil, or other matter forming nuisances.*
3. *Produce objectionable color, odor, taste, or turbidity.*
4. *Cause injury to, are toxic to, or produce adverse physiological responses in humans, animals, or plants.*
5. *Produce undesirable or nuisance aquatic life.*

Narrative criteria for pollutants with toxic effects can be established in state and authorized Tribal WQS in various forms. In addition to item four in the above example narrative criterion, a narrative toxic pollutant criterion can take the following (or similar) form:

Waters shall be free from toxic pollutants in toxic amounts.

Such narrative criteria can serve as the basis for establishing pollutant or chemical-specific WQBELs for wastewater or stormwater discharges where the state or authorized Tribe has not adopted chemical-specific numeric criteria for a specific pollutant. They can also serve as a basis for establishing whole-effluent toxicity (WET) controls.[11] See the EPA's NPDES permitting regulations at 40 CFR 122.44(d).

Consistent with 40 CFR 131.11(a)(2), where a state or authorized Tribe adopts narrative criteria for priority pollutants to protect designated uses, it must also provide information identifying the method by which it intends to regulate point source discharges of priority pollutants in impaired waters based on such narrative criteria. Although not specifically required for non-priority pollutants, providing the same information for those other pollutants will help the EPA's review of criteria submitted by states and authorized Tribes. These implementation methods are often called "implementation procedures" or "translator procedures" or simply "translators." Such information may be included as part of the WQS or may be included in the documents generated by the state or authorized Tribe in accordance with the Water Quality Planning and Management Regulations at 40 CFR Part 130. Procedures for the review and revision of WQS are discussed in depth in Chapter 7 of this Handbook. The EPA recommends that states and authorized Tribes include the following components in their implementation methods for translating narrative criteria for both priority pollutants and other pollutants with toxic effects:

- Specific, scientifically defensible technical methods for implementing the narrative criteria such as the following:
  - Methods for deriving chemical-specific values using available toxicity data, including methods for applying such values in developing WQBELs, and calculating site-specific values based on local water chemistry or biology.
  - Methods for developing and implementing WET criteria and controls
  - Methods for developing and implementing biological criteria.
- Statements or procedures describing how the state or authorized Tribe intends to integrate the methods into its pollutant control program (e.g., procedures for addressing conflicting or inconsistent results).
- Information necessary to apply the narrative criteria as numeric values, for example:
  - Methods the state or authorized Tribe will use to identify pollutants it will regulate in a specific discharge.
  - A lifetime cancer risk level for carcinogens.
  - Methods for identifying compliance thresholds in permits where calculated WQBELs are below the levels of detection.
  - Methods for selecting appropriate hardness, pH, and temperature variables for criteria expressed as functions.
  - Methods or policies controlling the size and in-zone water quality of mixing zones.
  - Calculated critical low-flow values for translating chemical-specific numeric criteria for aquatic life and human health into WQBELs.
  - Other methods and information needed to apply WQS on a case-by-case basis.

The EPA has developed administrative and scientific recommendations for states and authorized Tribes to implement narrative criteria to comply with Section 303(c)(2)(B) of the CWA. See the discussion in section 3.13 of this chapter.

Wetlands are an example of a type of waterbody that states and authorized Tribes may want to develop narrative criteria for to provide a more relevant scientific basis for applying the provisions of the CWA to these unique waters. Wetlands criteria can be derived and supported using measurements of wetland function or condition. This typically involves intensive data collection dependent on a successful wetland monitoring and assessment program.[12] Due to the unique characteristics of wetlands relative to flowing surface waters, WQS for wetlands may differ from other WQS. For example, they may rely less on water chemistry parameters and more on diversity of vegetation or macroinvertebrate communities. Wetlands criteria may also differ from other criteria by relying on additional parts of state laws and regulations that do not apply to instream water quality.

The EPA has developed Templates for Developing Wetland Water Quality Standards that states and authorized Tribes may use as model language for including WQS specifically for wetlands.[13]

3.3. HUMAN HEALTH WATER QUALITY CRITERIA

Human health water quality criteria protect any designated uses related to ingestion of water, ingestion of aquatic organisms, or other waterborne exposure from surface waters.[14] Such designated uses can include, but are not limited to, consumption of fish or shellfish (including consumption associated with fishing or shellfish harvesting) and protection of sources of drinking water. Note that recreational water criteria are covered in Section 3.4 of this chapter. Some states and authorized Tribes include criteria intended to protect human health from consumption of fish or shellfish from recreational fishing activities under their recreational designated uses.

The EPA's current recommended approach for deriving 304(a) criteria recommendations for protection of human health is the *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (2000) (hereafter referred to as the "2000 Human Health Methodology").[15] It also provides states and authorized Tribes with scientifically sound options for developing their own human health criteria that consider local conditions. If states and authorized Tribes choose to derive their own human health criteria or modify the EPA's 304(a) criteria recommendations, the EPA recommends that they use the 2000 Human Health Methodology and consider any updated and scientifically defensible data to guide their actions. In addition, the 2000 Human Health Methodology defines the default factors that the EPA uses in evaluating the soundness and consistency of state and authorized Tribal WQS in accordance with Section 303(c) of the CWA.

The derivation of human health criteria requires information about both the toxicological endpoints of concern for water pollutants and the pathways of human exposure to those pollutants. The two primary pathways of human exposure to pollutants present in a particular waterbody that the EPA considers in deriving human health 304(a) criteria recommendations are as follows:

1. Direct and indirect ingestion of water obtained from the waterbody.
2. Consumption of fish/shellfish obtained from the waterbody.

The EPA's human health 304(a) criteria recommendations are designed to minimize the risk of adverse effects occurring to humans from chronic (i.e., lifetime) exposure to pollutants through the ingestion of drinking water and consumption of fish obtained from surface water.[16] Information on deriving human health criteria is included in subsection 3.3.1 and 3.3.2. In contrast, the Safe Drinking Water Act (SDWA) controls the presence of contaminants in finished ("at-the-tap") drinking water.

In situations where states and authorized Tribes do not develop their own criteria and the EPA has not developed human health 304(a) criteria recommendations, states and authorized Tribes have looked to maximum contaminant levels (MCL) and maximum contaminant level goals (MCLG) under the SDWA to protect public water supply designated uses. MCLGs, like human health 304(a) criteria recommendations, are health-based. MCLs, on the other hand, are developed with consideration given to the costs and technological feasibility of reducing contaminant levels in water to meet those WQS. In addition, MCLs do not consider exposure pathways beyond drinking water, e.g., exposures via fish consumption. the EPA recommends that states and authorized Tribes do not use MCLs as WQS where consideration of available treatment technology, costs, or availability of analytical methodologies has resulted in an MCL that is less protective than an MCLG. For more information, see Section II.H of the EPA's *Revisions to the Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health*, Notice of Availability (2000).

In 2015, the EPA revised 94 of the existing CWA Section 304(a) recommended water quality criteria for human health to reflect the latest scientific information, including updated exposure factors (body weight, drinking water consumption rates, fish consumption rate), bioaccumulation factors, and toxicity factors (reference dose, cancer slope factor). The criteria have also been updated to follow the 2000 Human Health Methodology. The EPA's National Recommended Human Health Water Quality Criteria website provides more information on the final updated criteria and supporting documents.[17]

For detailed information about how to derive human health criteria, including the equations, please see the EPA's 2000 Human Health Methodology.

3.3.1 Toxicological Endpoints – Reference Dose and Cancer Slope Factor

For non-cancer toxicological effects, the EPA typically uses a reference dose (RfD) to derive human health criteria. In general, an RfD is the amount of a chemical that a person can ingest every day for a lifetime that is not anticipated to cause harmful noncancer health effects. For cancer toxicological effects, the EPA typically uses an oral cancer slope factor (CSF) to derive human health criteria.

The EPA considers toxicity factors from the EPA program offices, other national and international programs, and state and authorized Tribal programs. The EPA recommends that states and authorized Tribes use the most up-to-date, scientifically sound toxicity data when deriving human health criteria. The EPA follows a systematic process, detailed in the *EPA Response to Scientific Views from the Public on Draft Updated National Recommended Water Quality Criteria for the Protection of Human Health* (2015), to search for and select the toxicity values used to derive the human health criteria for noncarcinogenic and carcinogenic effects.[18]

3.3.2 Human Exposure Considerations Used in Water Quality Criteria Derivation

This subsection describes the parameters chosen by the EPA for use in the human health criteria derivation equations in order to protect the general population over a lifetime. States and authorized Tribes may modify the EPA's recommendations, as appropriate, to protect specific sensitive populations. For example, if pregnant women or young children are the target populations, then the EPA recommends criteria development using specific exposures for those groups. For more information on exposure considerations for children and sensitive target populations, see the 2000 Human Health Methodology.[19] Updated exposure parameters for sensitive populations may also be found in the EPA's *Exposure Factors Handbook 2011 Edition (Final)* (2011) (hereafter referred to as the "2011 Exposure Factors Handbook") and the EPA's updated fish consumption report *Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010)* (2014).[20, 21]

Body Weight

The EPA's 2015 updated recommended exposure assumption for body weight is 80 kilograms (kg), which represents the mean weight for adults 21 years of age and older based on data derived from the Center for Disease Control and Prevention's National Health and Nutrition Examination Survey (NHANES) 1999–2006 data.[22] This recommendation is found in Table 8.1 in the 2011 Exposure Factors Handbook. This updated body weight assumption replaced the EPA's previously recommended weight for adults of 70 kg that was described in the 2000 Human Health Methodology, which was approximated from the mean body weight of adults from the NHANES III database (1988-1994) and a 1989 study by the National Cancer Institute (see the 2000 Human Health Methodology for additional information). Chapter 8 of the 2011 Exposure Factors Handbook also contains recommendations for body weights of pregnant women, children, and infants.

Drinking Water Intake

Based on NHANES 2003-2006 data, the EPA's 2015 updated recommended exposure assumption for drinking water intake is 2.4 liters per day (L/d), rounded from 2.414 L/d for per capita estimate of combined direct and indirect "community water" ingestion at the 90th percentile for adults 21 years of age and older. For this estimate, direct water is defined as water ingested directly as a beverage (from community water sources); indirect water is defined as water added in the preparation of food or beverages but not water intrinsic to purchased foods. Community water includes direct and indirect use of tap water and excludes bottled water and other sources such as water from wells and springs. This recommended value is found in Chapter 3 (Table 3-23) of the 2011 Exposure Factors Handbook. This updated drinking water rate replaces the drinking water intake assumption of 2 L/d described in the 2000 Human Health Methodology, which represented the 86th percentile for adults 20 years and older in the United States Department of Agriculture's (USDA) Continuing Survey of Food Intake by Individuals 1994-96 analysis, or the 88th percentile of adults in the National Cancer Institute study of the 1977-78 Nationwide Food Consumption Survey (see the 2000 Human Health Methodology for additional information). Chapter 3 of the 2011 Exposure Factors Handbook also contains drinking water intake recommendations for women of childbearing age and children.

Fish Consumption Rate

In 2014, the EPA updated its recommended default fish consumption rate (FCR) for the general adult population and sport fishers and incorporated this updated rate into its 2015 updated 304(a) recommended human health criteria. This updated default FCR for the general adult population and sport fishers is 22 grams per day (g/d) (0.022 kg/d). The updated FCR of 22 g/d represents the 90th percentile consumption rate of freshwater and estuarine fish for the United States adult population that is 21 years of age and older based on NHANES 2003-2010 data (see the EPA's *Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010)* (2014)).[23] This updated FCR replaces the previously recommended default of 17.5 g/d, which represented an estimate of the 90th percentile consumption rate of freshwater and estuarine fish for the adult population based on the USDA's Continuing Survey of Food Intake by Individuals 1994-96 data (see the EPA's *Estimated Per Capita Fish Consumption in the United States* (2002)).[24]

As identified in the 2000 Human Health Methodology, the level of fish intake varies by geographic location. Therefore, the EPA recommends a hierarchy for states and authorized Tribes to follow that encourages use of the best data available to derive fish consumption rates (illustrated in Figure 3.3). The EPA recommends that states and authorized Tribes consider developing water quality criteria to protect highly exposed population sub-groups and use local or regional data, as they should be more representative of target population group(s) than the EPA's default values.

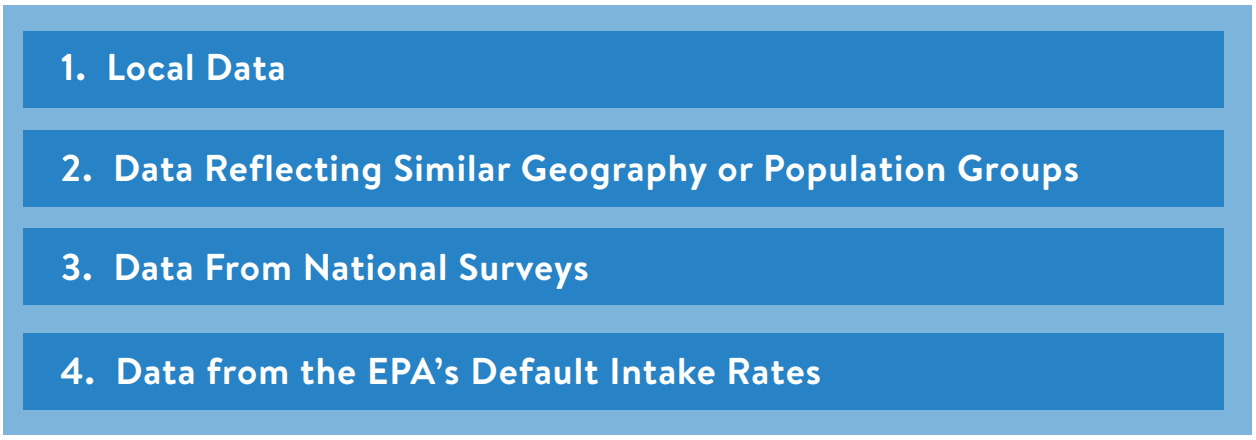

Figure 3.3. The EPA's Recommended Four-Preference Hierarchy for Collecting the Data Used to Derive Fish Consumption Rates.

Consumption of locally harvested fish and shellfish by American Indian Tribes or other groups engaged in subsistence fishing is likely to be higher than it is for the general United States population. For subsistence fishers, the EPA's default FCR is 142 g/d. The EPA recommends that states and authorized Tribes consider site-specific and Tribal-specific factors when determining FCRs for highly exposed populations. Local data may include data from a variety of contexts, including consumption by the general population state-wide, by a specific subpopulation within the state or region, consumption of fish taken from a specific waterbody or within a specific community, or a traditional baseline heritage rate. Depending on the data used, it may be appropriate to adjust the contemporary rate to account for suppression effects. A suppression effect occurs when a fish consumption rate for a given subpopulation reflects a current level of consumption that is artificially diminished from an appropriate baseline level of consumption for that subpopulation. The more robust baseline level of consumption is "suppressed," as it does not get captured by the fish consumption rate. Suppression effects may arise as a result of contaminated aquatic ecosystems, depleted aquatic ecosystems and fisheries, or both. When agencies set environmental standards using a fish consumption rate based upon an artificially diminished consumption level, they may set in motion a downward spiral whereby the resulting standards permit further contamination and/or depletion of the fish and aquatic resources.

It is important for states and authorized Tribes to account for the suppression effect by documenting a heritage or unsuppressed rate with additional literature-based research (for Tribes, for instance), or by evaluating recent past rates through a survey, and subsequently adjusting the contemporary rate. Because the CWA is meant not merely to maintain the status quo, but to restore and maintain the chemical, physical, and biological integrity of the Nation's waters, deriving criteria using an unsuppressed FCR furthers the restoration goals of the CWA and ensures protection of human health-related designated uses (i.e., as pollutant levels decrease, fish habitats are restored, and fish availability increases over time). The EPA's *Guidance for Conducting Fish Consumption Surveys (2016)* provides advice on how to conduct surveys to estimate fish consumption. [25]

The *EPA Policy on Consultation and Coordination with Indian Tribes* (2011) and the accompanying *EPA Guidance for Discussing Tribal Treaty Rights* (2016) describe how the EPA is to consult and coordinate on a government-to-government basis with federally recognized Tribal governments when the EPA's actions and decisions may affect Tribal interests in areas where Tribal treaties exist.[26, 27] Specifically, the 2016 Guidance for Discussing Tribal Treaty Rights provides assistance on consultation and coordination with respect to the EPA's decisions that are focused on specific geographic areas when Tribal treaty rights, or other reserved rights relating to the protection or use of natural resources, or an environmental condition necessary to support natural resources, may exist.

The EPA recommends that states or authorized Tribes establishing WQS (or planning fish consumption surveys that may inform environmental regulatory actions) for geographic areas that include Tribal lands, rights, or populations consider the potential relevance of Tribes' treaty and/or other reserved rights to such WQS actions to ensure that the actions are protective of Tribal fishers exercising those rights, as applicable.

For additional information, see the EPA's *Human Health Ambient Water Quality Criteria and Fish Consumption Rates: Frequently Asked Questions* (2013) and the National Environmental Justice Advisory Council's report, *Fish Consumption and Environmental Justice* (2002).[28, 29]

Bioaccumulation

Bioaccumulation refers to the uptake and retention of a chemical by an aquatic organism from all surrounding media (e.g., water, food, sediment) whereas bioconcentration refers to the uptake and retention of a chemical by an aquatic organism from water only. For some chemicals, particularly those that are persistent and hydrophobic, the magnitude of bioaccumulation by aquatic organisms can be substantially greater than the magnitude of bioconcentration. Thus, an assessment of bioconcentration alone may underestimate the extent of accumulation in aquatic biota for these chemicals.

The magnitude of bioaccumulation by aquatic organisms varies widely depending on the chemical, but can be extremely high for some persistent and hydrophobic chemicals. For such bioaccumulative chemicals, concentrations in aquatic organisms

may pose unacceptable human health risks from fish and shellfish consumption even when concentrations in water are too low to cause unacceptable health risks from drinking water consumption alone. These chemicals may also biomagnify in aquatic food webs, a process whereby chemical concentrations increase in aquatic organisms of each successive trophic level due to increasing dietary exposures (e.g., increasing concentrations from algae, to zooplankton, to forage fish, to predatory fish).

The EPA's 2000 Human Health Methodology recommends the use of bioaccumulation factors (BAFs), where available, to reflect the uptake of a contaminant from all sources (e.g., ingestion, sediment) by fish and shellfish, rather than only from the water column as reflected by the use of bioconcentration factors (BCFs) in the 1980 Human Health Methodology.[a] Criteria developed using BAFs better represent exposures to pollutants that affect human health than do criteria developed using BCFs. The EPA's *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (2000); *Technical Support Document Volume 2: Development of National Bioaccumulation Factors* (2003) contains procedures for calculating BAFs.[30] The EPA also recommends that states and authorized Tribes calculate site-specific BAFs, where possible, for use in developing their state and authorized Tribal human health water quality criteria. The EPA's *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (2000); *Technical Support Document Volume 3: Development of Site-Specific Bioaccumulation Factors* (2009) contains procedures for calculating site-specific BAFs.[31] The EPA applied the methodologies from Volumes 2 and 3 above in its 2015 human health criteria updates. More information on the development of national BAFs for the 2015 update is available in the *Development of National Bioaccumulation Factors: Supplemental Information for EPA's 2015 Human Health Criteria Update* (2016).[32] A spreadsheet of national BAFs developed for the 2015 update is also available.[33]

Relative Source Contribution

For non-carcinogens and non-linear carcinogens, the EPA includes a relative source contribution (RSC) component in human health criteria calculations. The RSC represents the appropriate portion of the RfD to be attributed to ambient water and freshwater and estuarine fish consumption. This is usually expressed as a percentage of the RfD but can also be expressed as an absolute value after subtracting an allowance to reflect exposures that may come from sources not considered in the criterion derivation. The rationale for this approach is that, for pollutants exhibiting threshold effects (i.e., pollutants which exhibit toxicity above a certain level of that pollutant), the objective of the human health criterion is to ensure that an individual's total exposure from all sources does not exceed a threshold level. These sources include, but are not limited to, exposure to a particular pollutant from ocean fish consumption (not included in the fish consumption rate), non-fish food consumption (fruits, vegetables, grains, meats, poultry), dermal exposure, and respiratory exposure.

[c] United States Environmental Protection Agency. 1980. Appendix C–Guidelines and methodology used in the preparation of health effect assessment chapters of the consent decree water criteria documents. Federal Register 45:79347-79357

The EPA recommends following the Exposure Decision Tree in Figure 4-1 of the 2000 Human Health Methodology to determine the appropriate RSC. A default RSC of 20% is recommended and used by the EPA in deriving Section 304(a) recommended criteria for non-carcinogens and non-linear carcinogens where data are insufficient to characterize the likelihood of exposure to relevant sources. The 20% default RSC should only be replaced where sufficient data are available to develop a scientifically defensible alternative value. For example, in the 2015 updated criteria recommendations for the protection of human health, the EPA defined a RSC of 0.5 or 0.8 for several pollutants based on currently available data regarding human exposure to these pollutants.[34]

Cancer Risk Levels

For deriving human health 304(a) criteria recommendations based on the 2000 Human Health Methodology, the EPA uses the 10^{-6} (i.e., 1 chance in 1,000,000) risk level. However, when states and authorized Tribes develop their criteria, 10^{-5} (i.e., 1 chance in 100,000) may be acceptable for the general target population depending on the particular circumstances. It is important to note that the incremental cancer risk levels are relative, meaning that any given criterion associated with a particular cancer risk level is also associated with specific exposure parameter assumptions (i.e., fish consumption rate, drinking water intake, body weight). Selection of a cancer risk level to derive human health criteria should involve careful consideration of the associated exposure parameter assumptions, and whether the resulting criteria would expose the target population consuming fish at unsuppressed rates to no more than a 10^{-5} cancer risk (or sensitive subpopulations consuming fish at unsuppressed rates to no more than a 10^{-4} cancer risk). See the Fish Consumption Rate discussion in subsection 3.3.2 for more information on the suppression effect.

Additional information is available in the EPA's *Human Health Ambient Water Quality Criteria and Fish Consumption Rates: Frequently Asked Questions* (2013) and the National Environmental Justice Advisory Council's report, *Fish Consumption and Environmental Justice* (2002).[35, 36]

3.4. RECREATIONAL WATER QUALITY CRITERIA

In 2012, the EPA issued updated AWQC recommendations for recreational waters for two bacterial indicators of fecal contamination: Escherichia coli and enterococci.[37] The new criteria are designed to protect primary contact recreational uses including swimming, bathing, surfing, water skiing, tubing, water play by children, and similar water contact activities where a high degree of bodily contact with the water, immersion and ingestion are likely. These recommendations rely on the latest research and science including studies that show a link between gastrointestinal and respiratory illnesses and fecal contamination in recreational waters. Although the 2012 criteria apply to both coastal and non-coastal primary contact recreation waters, the 2012 criteria were developed to meet statutory obligations under the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000, which amended the CWA. The BEACH Act includes specific requirements related to coastal recreational waters and water quality criteria for those waters.

In addition, in 2019, the EPA issued *Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin*.[38] These are recommended concentrations of the cyanotoxins in recreational waters to protect primary contact recreational uses.

As a general guideline, the EPA recommends that states and authorized Tribes avoid situations in which recreational waters contain chemicals in concentrations that are toxic or otherwise harmful to humans if ingested or irritating to the skin or mucous membranes of the human body upon brief immersion. Protection from these types of effects is the subject of the human health criteria discussed in Section 3.3 of this chapter. For example, the EPA's human health 304(a) criteria recommendations for pollutants with toxic effects, which are designed to protect direct human drinking water intake and fish consumption, might provide useful guidance in these circumstances. Additionally, such criteria may be used to support the designated use where fishing is included in the state or Tribal definition of "recreation." In this latter situation, where consumption of aquatic life is possible, the state or authorized Tribe should use only the portion of the criterion based on fish consumption unless drinking water supply is also a designated use.

The EPA notes that criteria to protect human health when aquatic organisms are consumed may also be applied in association with aquatic life designated uses. See the EPA's *Use of Fish and Shellfish Advisories and Classifications in 303(d) and 306(b) Listing Decisions, WQSP-00-03* (2000).[39]

If a waterbody is not designated as a drinking water supply source, a state or authorized Tribe can adopt human health criteria for consumption of organisms only, instead of for consumption of water and organisms. The EPA recommends, however, that the state or authorized Tribe evaluate whether organism-only AWQC for non-bioaccumulative chemicals pose a risk to swimmers in those water bodies. For an example, see the EPA's *Update of Human Health Ambient Water Criteria: Cyanide* (2015).[40]

States and authorized Tribes may also include other provisions in their WQS to protect the physical parameters necessary for the protection of recreational uses such as a narrative criterion stating that stream flows shall support recreational uses.

The EPA has developed and published online a technical support document and an overview document that provide information for states and authorized Tribes on flexible approaches for developing site-specific recreational criteria that reflect the latest science:

- *Overview of Technical Support Materials: A Guide to the Site-Specific Alternative Recreational Criteria TSM Documents* (2014) is an overarching guide designed to help water quality managers evaluate their site information and choose the best technical approach for developing site-specific recreational criteria.[41]
- *Site-Specific Alternative Recreational Criteria Technical Support Materials for Alternative Indicators and Methods* (2014) describes how to evaluate and compare alternative methods for measuring microbes in water using an existing EPA-approved method.[42]
- *Microbial Risk Assessment (MRA) Tools, Methods, and Approaches for Water Media* (2014) assists risk assessors and scientists in developing rigorous and scientifically defensible risk assessments for waterborne pathogens.[43]

3.5. AQUATIC LIFE WATER QUALITY CRITERIA

Aquatic life water quality criteria are necessary to support any designated uses related to protection and propagation of fish, shellfish, and wildlife.[44]

The EPA uses *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (1985) (commonly referred to as the "1985 Guidelines" or "Aquatic Life Guidelines" and hereafter referred to in this document as "Aquatic Life Guidelines") to derive 304(a) criteria recommendations to protect aquatic life from the effects of toxic pollutants.[45] These guidelines describe an objective way to estimate the highest concentration of a substance in water that will not present a significant risk to the aquatic organisms in the water. This EPA method relies primarily on acute and chronic laboratory toxicity data for aquatic organisms from eight taxonomic groups reflecting the distribution of aquatic organisms' taxa that are intended to be protected by water quality criteria. Acute criteria are derived using short-term (48- to 96-hour) toxicity tests on aquatic plants and animals. Chronic criteria can be derived using longer-term (seven-day to greater than 28-day) toxicity tests, if available, or by using an acute-to-chronic ratio procedure if there are insufficient chronic data. If justified, acute and chronic aquatic life criteria may be related to other water quality characteristics such as pH, temperature, or hardness. Separate criteria are typically developed for freshwater and saltwater organisms. Other information from mesocosms (controlled field experiments) and field data are considered when available and as appropriate. The Aquatic Life Guidelines recommend that criteria are lowered to protect commercially or recreationally important species, where appropriate.

As mentioned above, the EPA's aquatic life 304(a) criteria recommendations represent specific levels of chemicals or conditions in a waterbody that are not expected to cause adverse effects to aquatic life.[46] For metals, such recommendations are typically in the form of dissolved concentrations, with some exceptions (see the EPA's *Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria*, Memorandum from Martha Prothro (1993)).[47]

3.5.1 Water Quality Criteria Expression

Aquatic life water quality criteria are typically expressed in two forms, with different recommended magnitude and duration: (1) as acute criteria to protect against mortality or effects that occur due to a short-term exposure to a chemical and (2) as chronic criteria to protect against mortality, growth, and reproductive effects that may occur due to a longer-term exposure to a chemical. Where appropriate, the calculated criteria may be made more stringent to protect commercially or recreationally important species, and criteria may also be made more stringent to protect endangered or threatened species.

Both the acute and chronic criteria have three components: criterion magnitude (i.e., the criterion maximum concentration (CMC) for acute criteria and criterion continuous concentration (CCC) for chronic criteria), duration of the CMC and CCC (i.e., averaging period), and a maximum allowable frequency of exceedance of the CMC and CCC. For aquatic life criteria based on standard laboratory toxicity tests, the EPA typically recommends average durations of one hour for the CMC and four days for the CCC. There are some exceptions to reflect unique characteristics of individual pollutants. For example, the EPA's 304(a) criteria recommendations for ammonia and selenium are expressed with 30-day averaging periods.[48, 49] The EPA typically recommends a maximum frequency of exceedance of not more than once in three years, on average, to allow for ecosystem recovery. For additional discussion of duration and frequency, see Appendix D of the EPA's *Technical Support Document for Water Quality-based Toxics Control (1991)*.[50]

3.5.2 Site-Specific Aquatic Life Water Quality Criteria

The EPA's regulation at 40 CFR 131.11(b)(1)(ii) provides that states and authorized Tribes may adopt criteria that are "modified to reflect site-specific conditions." Site-specific criteria, as with all criteria, must be based on a sound scientific rationale and protect designated uses and are subject to EPA review and approval or disapproval under Section 303(c) of the CWA. A site-specific criterion is developed to protect aquatic life at a particular site, usually by taking into account a site's physical, chemical, and/or biological conditions (i.e., water quality characteristics or species composition).

The EPA's aquatic life 304(a) criteria recommendations could be under- or over-protective if one or both of the following occur:

1. Physical and/or chemical characteristics of the site alter the biological availability and/or toxicity of the chemical (e.g., alkalinity, hardness, pH, suspended solids, and salinity influence the concentration(s) of the toxic form(s) of some heavy metals, ammonia, and other chemicals).
2. The species at the site are more or less sensitive than those included in the national criteria dataset (e.g., the national criteria dataset contains data for trout, salmon,

penaeid shrimp, and other aquatic species that have been shown to be especially sensitive to some materials, and those species are not found at a site or downstream).

To appropriately protect the aquatic community under such circumstances, a state or authorized Tribe may want to develop site-specific criteria. The EPA has developed the following procedures to derive site-specific aquatic life criteria:

- The Recalculation Procedure takes into account relevant differences between the sensitivities of the aquatic organisms in the national dataset and the sensitivities of organisms that occur at the site. For more information, refer to the EPA's *Revised Deletion Process for the Site-specific Recalculation Procedure for Aquatic Life Criteria* (2013), which updates and supersedes the deletion process step of the Recalculation Procedure contained within Appendix B of the EPA's *Interim Guidance on Determination and Use of Water-Effect Ratios for Metals* (1994) and *EPA's Modifications to Guidance Site-Specific Criteria* (1997).[51, 52, 53]
    - It should be noted that tested species present in the national criteria database are intended to serve as surrogates for other sensitive taxa that may occur at a site. Thus, care should be taken when considering removing any species from the national criteria database, such that continued protection of sensitive, untested species at the site is still ensured. Because some tested species might be needed to represent untested species that occur at the site, the deletion procedure does not provide for simplistic deletion of all species that do not occur at the site. Rather the concept is to consider which tested species are most closely related to those occurring at the site, and delete those for which another tested species would better represent the species occurring at the site.
- For copper, the biotic ligand model (BLM) approach takes into account the effects of all of the water chemistry parameters that have a major influence on copper toxicity including temperature, pH, dissolved organic carbon, alkalinity, and the presence of specific cations and anions in the water.[54] This approach allows the BLM-based criteria to be customized to the particular waterbody under

consideration using the methodology described in the EPA's *Aquatic Life Ambient Freshwater Quality Criteria – Copper (2007)*.[55] Given the broad geographical range over which the BLM is likely to be applied, and the limited availability of data for input parameters in many areas, the EPA developed default values that can be used to fill in missing water quality input parameters.

- For metals other than copper, the Water-Effect Ratio (WER) procedure takes into account relevant differences between the toxicities of a metal in laboratory dilution water and in the site water. In performing a WER, care must be taken to ensure that samples and tests are representative of the potential conditions at a site, such that the WER-derived criteria continue to be protective under conditions when the metals are highly bioavailable. For more information, refer to the EPA's *Interim Guidance on Determination and Use of Water-Effect Ratios for Metals (1994) and Modifications to Guidance Site-Specific Criteria* (1997).

Additional Resource: The EPA's *Metals Aquatic Life Criteria and Chemistry Map (MetALiCC Map)*:[56]

This GIS application provides access to an interactive nationwide database to support states, Tribes, and stakeholders with the derivation of bioavailability-based 304(a) freshwater aquatic life criteria values when site-specific water chemistry data are not available. Specifically, this map-based application provides access to 1) water chemistry parameter values necessary for the derivation of bioavailability based criteria values for metals, 2) aquatic life criteria values for selected metals (currently copper and aluminum), 3) USGS NWIS water quality monitoring station locations, and 4) Major National Pollution Discharge Elimination System (NPDES) discharges for the conterminous United States.

Freshwater aquatic life criteria for certain metals are expressed as a function of hardness because hardness can affect the toxicities of these metals. Increasing hardness has the effect of decreasing the toxicity of metals. As described in *National Recommended Water Quality Criteria: 2002*, the EPA recommends that hardness not have a low end cap (or floor) at 25 milligrams per liter (mg/L) or any other hardness value on the low end for metal criteria calculations.[57] If a state or authorized Tribe has a regulatory requirement to cap (at the low end) hardness at 25 mg/L or a situation-specific question about the applicability of the hardness-toxicity relationship, a WER procedure should be used to provide the level of protection intended by the EPA's Aquatic Life Guidelines.[58] For hardness over 400 mg/L, the EPA recommends two options: (1) calculate the criterion using a default WER of 1.0 and using a hardness of 400 mg/L in the hardness equation; or (2) calculate the criterion using a WER and the actual ambient hardness of the surface water in the equation.

Several states and authorized Tribes include provisions in their WQS that allow adjustment of aquatic life numeric criteria to reflect the natural condition of the waterbody. In *Establishing Site Specific Aquatic Life Criteria Equal to Natural*

Background, Memorandum from Tudor T. Davies (1997), the EPA described how states and authorized Tribes could develop site-specific criteria to protect aquatic life designated uses based on natural background conditions.[59] The memorandum recommends the following three basic elements that a state or authorized Tribe should include in their WQS, at a minimum:

1. A definition of natural background describing the condition of water quality that would exist in the absence of human-caused pollution or disturbance.
2. A provision allowing for criteria to be set equal to natural conditions.
3. A written procedure for determining natural background or a reference in WQS to a binding procedure that the state or authorized Tribe will use.

In recognition of the inherent challenges involved in identifying natural conditions, the EPA developed the *Framework for Defining and Documenting Natural Conditions for Development of Site-Specific Natural Background Aquatic Life Criteria for Temperature, Dissolved Oxygen, and pH: Interim Document* (2015) to provide clarity and direction for states and authorized Tribes that want to establish site-specific criteria for temperature, dissolved oxygen, and pH that take into account natural background conditions.[60] This Framework assists states and authorized Tribes by providing an approach for successfully characterizing and identifying natural conditions for these three parameters, which then informs the development of site-specific criteria to protect aquatic life. It is important to note that this document only pertains to dissolved oxygen, pH, and temperature, not criteria for toxic pollutants. Chapter 2 of this Handbook discusses how natural conditions may be addressed by refining designated uses.

The EPA encourages states or authorized Tribes that are interested in developing site-specific criteria to involve the appropriate EPA regional office early in the process to identify and resolve any potential concerns prior to the EPA receiving a formal submittal of adopted WQS revisions for review. States, authorized Tribes, and the EPA should judiciously consider all approaches, the complexity of the problem, and the extent of knowledge available concerning the fate and effects of the pollutant under consideration, to ensure that aquatic life are protected and the designated use(s) can be met.

States and authorized Tribes are encouraged to examine their administrative and rulemaking procedures to identify opportunities to streamline adoption of site-specific criteria. One way to do this is through adoption of a "performance-based" approach. This approach relies on adoption of a process (i.e., a criterion derivation methodology) rather than a specific outcome (e.g., numeric criterion or concentration of a pollutant) consistent with 40 CFR 131.11 and 131.13. The performance-based approach is particularly well suited for translating narrative criteria into quantifiable measures and for the derivation of site-specific numeric criteria. Proper development and implementation of such an approach can result in consistent application of state and authorized Tribal narrative criteria and scientifically defensible site-specific adjustments to numeric criteria. When such a "performance-based" approach is sufficiently detailed and has

suitable safeguards to ensure predictable, repeatable outcomes, EPA approval of such an approach can also serve as approval of the outcomes as well. If a particular state or authorized Tribe's approach is not sufficiently detailed or lacks appropriate safeguards, then EPA review of a specific outcome is still necessary. However, even a more general performance-based approach would still help guide EPA review of specific outcomes. See 65 FR 24648.

Once the state or authorized Tribe adopts and the EPA approves a set of procedures that qualify under the performance-based approach, subsequent site-specific criteria developed pursuant to that approved procedure do not need to be submitted to or approved by the EPA. This does not affect state-specific administrative processes that may require approval by different levels within the state. The EPA encourages the state or authorized Tribe to maintain a list of the resulting site-specific criteria on its publicly accessible website. The EPA also encourages states and authorized Tribes to coordinate closely with the EPA when developing any such approach. More information on the performance-based approach can be found in the EPA's *Review and Approval of State and Tribal Water Quality Standards*, Final Rule (2000). For example, the EPA approved Oregon's statewide copper criteria, described as a performance-based provision, whereby copper criteria would be calculated at each site based on the site's water chemistry.[61]

3.6. NUTRIENT WATER QUALITY CRITERIA

Nutrient pollution is a widespread and growing environmental problem in the United States. Nutrient pollution can cause numerous adverse effects to aquatic life, impair recreational designated uses, and threaten human health by polluting drinking water supplies. For example, nutrient pollution is known to increase algal biomass (and specifically cause algal blooms), which can, in turn, deplete oxygen to levels that are harmful to other aquatic organisms, decrease the aesthetic and recreational value of a waterbody, and produce toxins that can harm humans and animals if inhaled or consumed, including during recreation in the water.

Updated Information: *Ambient Water Quality Criteria to Address Nutrient Pollution in Lakes and Reservoirs* (2021):[62]

In 2021, the EPA issued final recommended ambient water quality criteria to address nutrient pollution in lakes and reservoirs. These recommendations replace those published by EPA in 2000 and 2001 for lakes and reservoirs.

Visit the EPA's *Ambient Water Quality Criteria to Address Nutrient Pollution in Lakes and Reservoirs website* to view the final recommended criteria in addition to interactive statistical models that relate nutrient concentrations to endpoints that quantify protection of different designated uses (aquatic life use, drinking water source, and recreation).[63]

The EPA encourages states and authorized Tribes to develop numeric nutrient water quality criteria to create effective tools to help prevent and manage nutrient pollution. Specifically, the EPA recommends that states and authorized Tribes adopt numeric criteria into WQS for both total nitrogen and total phosphorus to help prevent eutrophication and the proliferation of harmful algal blooms in rivers and streams, lakes and reservoirs, and estuaries and coastal areas.

In addition to the EPA's Numeric Nutrient Water Quality Criteria website, see the following documents for more information:[64]

- *Renewed Call to Action to Reduce Nutrient Pollution and Support for Incremental Actions to Protect Water Quality and Public Health*, Memorandum from Joel Beauvais (2016).[65]
- *Preventing Eutrophication: Scientific Support for Dual Nutrient Criteria* (2015).[66]
- *Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions*, Memorandum from Nancy K. Stoner (2011).[67]
- *Nutrient Pollution and Numeric Water Quality Standards*, Memorandum from Benjamin H. Grumbles (2007).[68]
- *Development and Adoption of Nutrient Criteria into Water Quality Standards*, Memorandum from Geoffrey Grubbs (2001).[69]
- *National Strategy for the Development of Regional Nutrient Criteria* (1998).[70]

To develop numeric nutrient criteria, the EPA recommends a variety of approaches such as the reference condition approach, empirical stressor-response models, and mechanistic water quality models. The EPA has published technical guidance describing the techniques for developing numeric nutrient criteria for different waterbody types, including nationally recommended CWA Section 304(a) numeric nutrient criteria on an ecoregional basis for most rivers/streams and lakes/reservoirs across the country.[71] Additionally, the EPA's Nutrient Scientific Technical Exchange Partnership and Support program (N-STEPS) provides technical support to states and authorized Tribes for the development of scientifically sound numeric nutrient criteria.[72] N-STEPS provides the EPA, states, and authorized Tribes a mechanism to work in partnership in addressing scientific issues related to numeric nutrient criteria derivation. See the EPA's Technical Support for Numeric Nutrient Criteria Development webpage.[73]

The following technical support documents describe the techniques that the EPA recommends to develop numeric nutrient criteria for use in state and authorized Tribal WQS:

- *Using Stressor-response Relationships to Derive Numeric Nutrient Criteria* (2010)[74] Describes a four-step approach to state, local, authorized Tribal, and regional scientists for estimating and interpreting nutrient stressor-response relationships to derive numeric nutrient criteria.
- *Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Waters* (2001)[75] Provides scientifically defensible technical guidance to assist states and authorized Tribes in developing numeric nutrient criteria for estuaries and coastal waters.
- *Nutrient Criteria Technical Guidance Manual: Lakes and Reservoirs* (2000)[76] Provides states and authorized Tribes with a scientifically defensible method to develop ecoregion-specific nutrient criteria for lakes and reservoirs.
- *Nutrient Criteria Technical Guidance Manual: Rivers and Streams* (2000)[77] Provides background information on classifying rivers and streams, selecting

criteria background information on classifying rivers and streams, selecting criteria variables, designing monitoring programs, building a database analyzing nutrient and algal data, deriving regional criteria, and implementing management practices.

- *Nutrient Criteria Technical Guidance Manual: Wetlands* (2008)[78] Provides background information on how to develop nutrient criteria for wetlands. It does not contain specific numeric nutrient criteria recommendations for wetlands, but it does present the EPA's scientific recommendations on defensible approaches for developing regional nutrient criteria that apply to wetlands.

In addition to technical guidance documents for developing nutrient criteria, the EPA has provided a toolkit of additional resources.[79] This toolkit compiles available EPA resources to facilitate state and authorized Tribal adoption of numeric nutrient criteria. It includes information on criteria and WQS development; water quality monitoring, assessment, reporting, and planning; WQBELs and water quality trading; economics and financing; and communications materials.

3.7. BIOLOGICAL WATER QUALITY CRITERIA (BIOCRITERIA)

Biological water quality criteria are numeric values or narrative expressions that describe the desired biological condition of an aquatic community within a waterbody with an aquatic life use designation. Biological data can be used to verify improvement in water quality in response to regulatory and other improvement efforts and to detect new or continuing degradation of waters. Biological criteria also provide a framework for evaluating the effectiveness of best management practices and management measures for nonpoint source impacts. Numeric biological criteria can provide effective monitoring criteria for evaluation of the health of an aquatic ecosystem.

Evaluation of the biological condition of a waterbody should include measures of the structure and function of the aquatic community within a specified habitat. Expert knowledge of the system is required for the selection of appropriate biological components and measurement indices. The development and implementation of biological criteria involves the following:

- Selection of surface waters to use in developing reference conditions for each designated use.
- Measurement of the structure and function of aquatic communities in reference surface waters to establish biological criteria.
- Measurement of the physical habitat and other environmental characteristics of the water resource.
- Establishment of a protocol to compare the biological criteria to biota in comparable test waters to determine whether impairment has occurred.

In addition, the EPA supports use of biological data to refine aquatic life designated uses and the development of biological water quality criteria as part of state and authorized Tribal WQS. This effort will help states, authorized Tribes, and the EPA achieve the biological integrity objective in Section 101 of the CWA and comply with the statutory requirements under Sections 303 and, for the EPA, Section 304 (see *A Primer on Using Biological Assessments to Support Water Quality Management* (2011) and *Practitioner's Guide to the Biological Condition Gradient: A Framework to Describe Incremental Change in Aquatic Ecosystems* (2016)).[80, 81]

Biological assessments are an evaluation of the condition of a waterbody using surveys of the structure and function of a community of resident biota (e.g., fish, benthic macroinvertebrates, periphyton, amphibians). See the EPA's *Biological Assessments: Key*

Terms and Concepts (2011).[82] Assessments of habitat condition, both instream and riparian, are typically conducted simultaneously. Such information can reflect the overall ecological integrity of a waterbody and provide a direct measure of both present and past effects of stressors on the biological integrity of an aquatic ecosystem. The benefit of biological assessment information is based in its capability to do the following:

- Characterize the biological condition of a waterbody relative to WQS.
- Integrate the cumulative effects of different stressors from multiple sources, thus providing a holistic measure of their aggregate effect.
- Detect aquatic life impairment from unmeasured stressors and unknown sources of impairment.
- Provide field data on biotic response variables to support development of empirical stressor response models.
- Inform water quality and natural resource managers, stakeholders, and the public on the environmental outcomes of the actions taken.

For more information, see the EPA's *Biological Assessment Program Review: Assessing Level of Technical Rigor to Support Water Quality Management* (2013) and other technical support documents included on the EPA's Biological Water Quality Criteria webpage.[83, 84]

3.8. FLOW CONSIDERATIONS

The natural flow regime, defined as the characteristic pattern of flow magnitude, timing, duration, frequency, and rate of change, plays a central role in supporting the chemical, physical, and biological integrity of streams and rivers and the services they provide. Hydrologic alteration is a change to a natural flow regime and can include an increase or decrease in water volume, seasonal pulse flow disruption, dramatic variation in water temperature, and other factors. Hydrologic alteration can affect aquatic species' ability to spawn, gather nutrients from a stream system, access high-quality habitat, and more. In contrast, maintaining normal flow regimes may help increase a river's or stream's resilience to a variety of stressors including climate change. CWA programs can incorporate strategies to protect aquatic ecosystems from the harmful effects of hydrologic alteration, and WQS programs in particular can include water quality criteria for flow to protect designated uses such as aquatic life, recreation, fishing, or shellfish harvesting. Several states and authorized Tribes have adopted a narrative form of flow criteria in their WQS. The following provides an example narrative criterion for flow:

> *Stream or waterbody flows shall support the designated aquatic life use.*

In 2016, the EPA and the United States Geological Survey finalized the technical report *Protecting Aquatic Life from Effects of Hydrologic Alteration* (2016) that provides information on protecting aquatic life from the effect of hydrologic alteration in flowing waters for interested water quality managers and other stakeholders.[85] The report discusses the natural hydrologic flow regime and potential effects of flow alteration on aquatic life, examples of states that have adopted narrative flow WQS, and a flexible, non-prescriptive framework that could be considered by water quality managers and other stakeholders to establish targets for flow that are protective of aquatic life.

3.9. SEDIMENT BENCHMARKS

Sediments are loose particles of sand, clay, silt, and other substances that settle at the bottom of a waterbody. They come from eroding soil and from decomposing plants and animals. Wind, water, and ice often carry these particles great distances. Many of the sediments in our rivers, lakes, and oceans have been contaminated by pollutants.

Suspended and bedded sediments (SABS) are defined by the EPA as particulate organic and inorganic matter that suspends in or is carried by the water and/or accumulates in a loose, unconsolidated form on the bottom of natural waterbodies. This includes the frequently used terms of clean sediment, suspended sediment, total suspended solids, bedload, turbidity, or eroded materials. SABS in excessive amounts constitute a major ecosystem stressor and are a leading cause of waterbody impairment.

Contaminated sediments are soils, sand, organic matter, or minerals that accumulate on the bottom of a waterbody and contain toxic or hazardous materials that may adversely affect human health or the environment. The EPA has dealt directly with the toxicity of chemicals in sediments in fresh and marine waters through equilibrium partitioning sediment benchmarks (ESBs).

The equilibrium partitioning approach focuses on predicting the chemical interaction between sediments and contaminants. ESBs are the EPA's recommendation of the concentration of a substance in sediment that will not unacceptably affect benthic organisms or their associated designated uses. The EPA chose the equilibrium partitioning approach because it accounts for the varying biological availability of chemicals in different sediments and allows for the incorporation of the appropriate biological effects concentration. This provides for the derivation of benchmarks that are causally linked to the specific chemical, applicable across sediments, and appropriately protective of benthic organisms. ESBs may be useful as a complement to existing sediment assessment tools to help assess the extent of sediment contamination, identify chemicals causing toxicity, and serve as targets for pollutant loading control measures.

The EPA has published technical guidance for developing SABS criteria and technical guidance describing several approaches for developing ESBs for different chemical classes for the protection of aquatic life:

- *Developing Water Quality Criteria for Suspended and Bedded Sediments (SABS): Potential Approaches* (2003) is a discussion paper prepared for the EPA Science Advisory Board consultation on potential approaches for developing water quality criteria for SABS.[86] The paper introduces SABS and criteria. In addition, it discusses the types and status of criteria that have been or are being used by states and authorized Tribes.

- *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures* (2003) describes an approach for summing the toxicological contributions of mixtures of 34 polycyclic aromatic hydrocarbons (PAHs) to derive concentrations of PAH mixtures in sediment that protect against potential effects to benthic organisms.[87]
- *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBS) For The Protection of Benthic Organisms: Dieldrin* (2003) describes procedures to derive ESBs for the insecticide dieldrin.[88]
- *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Endrin* (2003) describes procedures to derive ESBs for the insecticide endrin.[89]
- *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Metal Mixtures (Cadmium, Copper, Lead, Nickel, Silver, and Zinc)* (2005) describes procedures to derive concentrations of metal mixtures in sediment that protect against potential effects on benthic organisms.[90] A procedure for addressing chromium toxicity in sediments is included in an appendix.
- *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compendium of Tier 2 Values for Nonionic Organics* (2008) describes procedures to derive concentrations for 32 nonionic organic chemicals in sediment that protect against potential effects on benthic organisms.[91]
- *Estimation of Biota Sediment Accumulation Factor (BSAF) from Paired Observations of Chemical Concentrations in Biota and Sediment* (2009) provides information on methodologies to estimate Biota Sediment Accumulation Factor (BSAF) for nonionic organic chemicals.[92] BSAF is a parameter describing bioaccumulation of sediment-associated organic compounds or metals into tissues of ecological receptors.
- *Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Procedures for the Determination of the Freely Dissolved Interstitial Water Concentrations of Nonionic Organics* (2012) provides guidance on procedures to determine the freely dissolved water concentration limits of nonionic organics that protect against potential effects on benthic organisms in sediment interstitial waters.[93]

Achieving water quality goals and maintaining public health and environmental improvements at contaminated sediment sites requires cross-program collaboration, as well as close collaboration with stakeholders. As such, *Promoting Water, Superfund and Enforcement Collaboration on Contaminated Sediments*, Memorandum from Cynthia Giles, Mathy Stanislaus, and Ken Kopocis (2015) encourages improvements in communication, coordination, and collaboration among water, Superfund, and enforcement programs when addressing contaminated sediments.[94]

3.10. TEMPERATURE WATER QUALITY CRITERIA

Water temperature is an important aspect of protecting aquatic life, such as in cold water habitats where certain species may require cold water to survive. Some waters are naturally warm at certain times of the year due to factors including increased solar radiation and warm air temperature. However, human activities (e.g., removal of streamside vegetation that provides shade, discharges of heat from municipal and industrial facilities, and water withdrawals) can also increase water temperature by increasing the heat load into the waterbody, reducing the waterbody's capacity to absorb heat, and eliminating or reducing the amount of groundwater flow, which helps to moderate temperatures. Some human activities can also decrease water temperatures, for example, when cold water is released from the bottom of a thermally stratified reservoir behind a dam.

State and authorized Tribal water quality criteria for temperature can play an important role in meeting the CWA Section 101(a)(2) goal of "protection and propagation of fish, shellfish, and wildlife" by protecting the habitat in which such aquatic life live. The EPA's current 304(a) criteria recommendations for temperature are found in *Quality Criteria for Water 1986* (1986), commonly known as the "Gold Book."[95] In addition, the EPA's Region 10 office has developed guidance on the development of temperature criteria for the protection of salmonids as well as other supporting materials and technical products, including a primer for identifying cold water refuges to protect and restore thermal diversity in riverine landscapes.[96, 97]

3.11. WILDLIFE WATER QUALITY CRITERIA

Development of water quality criteria to protect wildlife may be important because terrestrial and avian wildlife species that are dependent on the aquatic food web may be exposed to aquatic contaminants via dietary exposure. This exposure pathway can be particularly important for bioaccumulative pollutants, which accumulate in tissues of aquatic organisms at levels greater than water column concentrations. Bioaccumulation is defined as the accumulation of chemicals in the tissue of organisms through any route including ingestion or direct contact with contaminated water. The Aquatic Life Guidelines are typically used by the EPA to derive 304(a) criteria recommendations intended to protect aquatic life (e.g., fish, benthic invertebrates, zooplankton) from the effects of toxic contaminants, as described in Section 3.5 of this chapter.[98] Those guidelines include a provision intended to protect wildlife that consume aquatic organisms from the bioaccumulation potential of a compound. The Aquatic Life Guidelines recommend deriving final wildlife residue values based on available data.

In 1995, the EPA published the *Water Quality Guidance for the Great Lakes System at 40 CFR Part 132* in which Appendix D describes a methodology applicable to the Great Lakes System for developing criteria for the protection of avian and mammalian wildlife from "adverse effects resulting from the ingestion of water and aquatic prey." That methodology is similar to the methodology used to derive non-cancer human health criteria. Separate wildlife values are derived for birds and mammals using taxonomic class-specific toxicity data and exposure data for five representative Great Lakes wildlife species (bald eagle, herring gull, belted kingfisher, mink, and river otter), which are likely to experience the highest exposures to bioaccumulative contaminants through the aquatic food web in the Great Lakes. In addition, the EPA published the *Great Lakes Water Quality Initiative Technical Support Document for Wildlife Criteria* (1995), which includes the methodology for deriving wildlife values for pollutants with limited toxicological data to derive a value for only one of the two taxonomic classes specified (birds and mammals).[99]

3.12. WATER QUALITY CRITERIA FOR WETLANDS

Numeric aquatic life 304(a) water quality criteria recommendations are designed to be protective of aquatic life for surface waters and are generally applicable to most wetland types. The EPA's *An Approach for Evaluating Numeric Water Quality Criteria for Wetlands Protection* (1991) provides an approach, based on the site-specific guidelines, for detecting wetland types that might not be protected by direct application of 304(a) criteria recommendations.[100] The evaluation can be simple for those wetland types for which sufficient water chemistry and species assemblage data are available but will be less useful for wetland types for which these data are not readily available. States and authorized Tribes can use the results of this type of evaluation, combined with information on local or regional environmental threats, to prioritize wetland types (and individual criteria) for further site-specific evaluations and/or additional data collection. The EPA recommends close coordination among regulatory agencies, wetland scientists, and criteria experts in developing criteria for wetlands.

In 2008, the EPA published a wetland-specific Nutrient Criteria Technical Guidance Manual to assist states and authorized Tribes in developing numeric nutrient criteria for wetlands.[101] Additionally, the EPA developed narrative templates for wetlands WQS including a 2016 frequently asked questions document to simplify development of protective WQS for wetlands.[102, 103] States and authorized Tribes may choose to develop different types of criteria for wetlands protection, including site-specific numeric or narrative criteria, as long as they are scientifically defensible and protective of the designated uses, and otherwise consistent with 40 CFR 131.11 and CWA Section 303(c)(2)(B).

3.13. WATER QUALITY CRITERIA FOR PRIORITY POLLUTANTS

Section 303(c)(2)(B) of the CWA and 40 CFR 131.11 require states and authorized Tribes to adopt numeric water quality criteria for Section 307(a) "toxic pollutants," as necessary, to support state and authorized Tribal designated uses where the discharge or presence of such pollutants in the affected waters could reasonably be expected to interfere with those designated uses adopted by the state or authorized Tribe.[104] Where numeric criteria are not available, the state or authorized Tribe must adopt criteria based on biological monitoring or assessment methods consistent with EPA guidance published pursuant to Section 304(a)(8). See Section 3.2.2 of this chapter.

For regulatory purposes, the EPA has translated the 65 compounds and families of compounds listed under Section 307(a) (which potentially include thousands of specific compounds) into 126 specific toxic substances, which the EPA refers to as "priority pollutants," and has published national criteria recommendations for most of these pollutants consistent with the authority provided in Section 304(a).[105] The Section 307(a)(1) list of "toxic pollutants" is codified at 40 CFR 401.15. Both the list of priority pollutants and the EPA's 304(a) criteria recommendations for those pollutants are subject to change.

When reviewing applicable WQS during their triennial reviews, in addition to reviewing all applicable criteria, states and authorized Tribes must ensure that they have adopted criteria for certain toxic pollutants, as required by Section 303(c)(2)(B). It is important to note that, although a state or authorized Tribe may have previously adopted numeric criteria for certain priority pollutants, it may need to adopt numeric criteria for additional priority pollutants in the following situations:

- The EPA has published new or updated 304(a) criteria recommendations for a priority pollutant; and/or
- New information on existing water quality and pollution sources indicates that a priority pollutant for which a state or authorized Tribe had not previously adopted criteria could now be reasonably expected to interfere with applicable designated uses.

For additional information and recommendations for implementing Section 303(c)(2)(B), see the following documents:

- *Guidance for State Implementation of Water Quality Standards for CWA Section 303(c)(2)(B)* (1988).[106]
- *Compliance with CWA Section 303(c)(2)(B)*, Memorandum from Martha Prothro (1989).[107]
- *Option 3 of Section 303(c)(2)(B) Guidance*, Memorandum from David K. Sabock (1990).[108]
- Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance, Final Rule (1992) (57 FR 60848).[109]

3.13.1 Water Quality Criteria for Priority Pollutants Based on Biological Monitoring

For priority pollutants for which the EPA has not published 304(a) numeric water quality criteria, CWA Section 303(c)(2)(B) requires states and authorized Tribes to adopt criteria based on biological monitoring or assessment methods consistent with information published by the EPA in accordance with Section 304(a)(8). The phrase "biological monitoring or assessment methods" includes the following:

- Whole effluent toxicity (WET) control methods.
- Biological criteria methods (discussed in Section 3.7 of this chapter).
- Other methods based on biological monitoring or assessment.

The phrase "biological monitoring or assessment methods" in its broadest sense includes numeric values developed through translator procedures. This broad interpretation of the phrase is consistent with the EPA's policy of applying chemical-specific, biological, and WET methods independently in an integrated pollutant control program. See the *Technical Support Document for Water Quality-based Toxics Control (1991)* for more information about the integrated approach.[110]

States and authorized Tribes should also consider developing protocols to derive and adopt numeric criteria for priority pollutants (or other pollutants) where the EPA has not issued 304(a) criteria recommendations. The state or authorized Tribe should consider available laboratory toxicity test data that may be sufficient to support derivation of chemical-specific criteria. Existing data do not necessarily need to be as comprehensive as those recommended in the EPA's Aquatic Life Guidelines in order for a state or authorized Tribe to use its own protocols to derive numeric values.[111] The EPA has described such protocols in the *Water Quality Guidance for the Great Lakes System: Supplementary Implementation Document (SID)* (1995) and in Appendices A and C of 40 CFR Part 132 (Water Quality Guidance for the Great Lakes System).[112] This is particularly important where other components of a state's or authorized Tribe's narrative criterion implementation procedure (e.g., WET controls or biological criteria) may not ensure full protection of designated uses. For some pollutants, a combination of chemical-specific and other approaches may be necessary (e.g., pollutants where bioaccumulation in fish tissue or water consumption by humans is a primary concern).

Biologically based monitoring or assessment methods serve as the basis for control where no specific numeric criteria exist or where calculation or application of pollutant-by-pollutant criteria is infeasible. Also, these methods may serve as a supplemental measurement of WQS attainment in addition to numeric and narrative criteria. The requirement for both numeric criteria and biologically based methods reflects that Section 303(c)(2)(B) requires that states and authorized Tribes develop a comprehensive priority pollutant control program regardless of the status of the EPA's 304(a) criteria recommendations.

The WET procedure is a means of assessing and protecting against the aggregate toxic effect of the discharge of pollutants, including point source dischargers of priority pollutants. The procedure is particularly useful for monitoring and controlling the toxicity of complex effluents that may not be well controlled through chemical-specific numeric criteria. For additional information, see the EPA's WET methods webpage.[113]

3.14. WATER QUALITY CRITERIA FOR AGRICULTURAL AND INDUSTRIAL DESIGNATED USES

Generally, water quality criteria developed for human health and aquatic life will be sufficiently stringent to protect agricultural and industrial designated uses because those uses are generally less sensitive than human health and aquatic life designated uses. There could, nevertheless, be situations where such designated uses may require more stringent criteria to protect them. Salts could be a problem in crop water, for example. Hardness or other contaminants could cause issues at industrial facilities. States and authorized Tribes may also establish criteria specifically designed to protect such designated uses and should ensure that they apply the criteria that are protective of the most sensitive use of the waterbody, as required by 40 CFR 131.11(a).

Endnotes

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