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Office of Water
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Draft Technical Support Document:

Implementing the 2019 Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin

Notice: This technical support document contains several questions and answers relating to the Environmental Protection Agency's (EPA) *Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin*.[1] Microcystins and cylindrospermopsin are two types of cyanotoxins that are produced from photosynthetic bacteria, called cyanobacteria. Exposure to the microcystins and cylindrospermopsin can pose health risks to humans and animals. Symptoms reported after recreational exposure to cyanobacterial blooms included skin irritations, gastrointestinal illnesses, hepatomegaly and kidney damage.

The information in this document is primarily intended to support states, authorized tribes, and territories (collectively referred to as "states and authorized tribes") interested in adopting the recommended criteria into their state or tribal water quality standards (WQS) or using the recommended values as the basis for swimming advisories and related public notification purposes.[2] EPA envisions that if states or authorized tribes decide to use the values for issuing swimming advisories they might do so in a manner similar to their current recreational water advisory programs.

Chemical and physical factors in a waterbody can play a role in the composition and production of cyanotoxins associated with a toxigenic cyanobacterial bloom (such factors include, but are not limited to, levels of nitrogen and phosphorus, the availability of organic matter, turbidity, turbulence or flushing of a waterbody, light attenuation, water temperature and pH). The recommended criteria and swimming advisory values were derived based on data related to exposure factors, including the rate of incidental consumption of water while swimming and the duration of time spent recreating in water, and are recommended for waters designated for primary contact recreation. Some states and authorized tribes may experience other hazards associated with cyanobacterial blooms that are not addressed in this document (e.g., with respect to cytokines or other cyanotoxins), therefore a more holistic approach to monitoring waterbodies may be necessary to ensure public health protection.

Exposure to cyanobacteria and their toxins can also occur through non-recreational pathways such as consumption of cyanotoxin-contaminated drinking water and food (including fish), and during bathing or showering. This document does not address or provide recommendations for non-recreational exposures. Although there are no national level recommended criteria for cyanotoxins in public water supply designated uses, in 2015, EPA published health advisories for the cyanotoxins, microcystins and cylindrospermopsin in finished drinking water. For information related to the drinking water health advisories for microcystins and cylindrospermopsin, see https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisory-documents-cyanobacterial-toxins.

This document provides background information on the factors that contribute to cyanobacterial growth and toxin production; recommendations on how to monitor for cyanobacteria and two of their known cyanotoxins (microcystins and cylindrospermopsin) in waterbodies; and information on how to complete assessments, list impaired or threatened waters, and develop Total Maximum Daily Load (TMDLs), based

[1] USEPA (U.S. Environmental Protection Agency). 2019. *Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin 2019.* EPA 822-R-18-004. U.S. Environmental Protection Agency, Office of Water, Washington, DC. https://www.epa.gov/wqc/recommended-human-health-recreational-ambient-water-quality-criteria-or-swimming-advisories.

[2] When a bloom or the presence of cyanotoxins is confirmed, the recreational waterbody manager usually issues a public notification (either a swimming advisory or a closure of swimming areas) to raise awareness of the potential risks associated with contact with the cyanobacterial bloom or its toxins in recreational waters. Swimming advisories are recommendations to limit swimming or other recreational water-contact activities, due to an increased health risk from contact with or ingestion of the cyanobacteria or cyanotoxins; whereas, a closure notification or posting typically means that the waterbody is officially closed to the public. Decisions to post an advisory or closure for a waterbody or a beach are local decisions. Information about communicating swimming advisories or closures to the public, including sample templates, is available at Communicating about Cyanobacterial Blooms and Toxins in Recreational Waters (webpage).

on WQS that adhere to EPA's 2019 recommended criteria for total microcystins and cylindrospermopsin. While this document cites statutes and regulations that contain requirements applicable to these programs, it does not impose legally binding requirements on EPA, states, authorized tribes, other regulatory authorities, or the regulated community. EPA, states, authorized tribes and other decision makers may adopt approaches on a case-by-case basis that differ from those provided in this document, as appropriate and consistent with statutory and regulatory requirements. Also, EPA may update this document as new scientific and technical information becomes available. In addition to this document, EPA has prepared the following information to support states and authorized tribes in their efforts to monitor and respond to cyanobacterial blooms and cyanotoxins in recreational waters:

- Cyanobacterial Harmful Algal Blooms in Water (website): https://www.epa.gov/cyanohabs
- Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Waters
- Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters

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General Questions about Cyanotoxin Water Quality Criteria

1. What are EPA's recommended recreational water quality criteria for total microcystins and cylindrospermopsin?

In 2019, EPA issued its recreational water quality criteria recommendations for the cyanotoxins, microcystins and cylindrospermopsin, reflecting the latest scientific knowledge, public comments, and external scientific peer review. The criteria are designed to protect the public from incidental exposure to harmful levels of these cyanotoxins while participating in water-contact activities where immersion and incidental ingestion of water are likely. Such activities include but are not limited to swimming, water skiing, tubing, skin diving, water play by children, or similar water-contact activities in all waterbodies designated for such recreational uses.[3] EPA issues such recommendations under the statutory authority of the Clean Water Act (CWA), Section 304(a).

EPA's recommended recreational water quality criteria for total microcystins and cylindrospermopsin consist of three components:

- *Magnitude* — The numeric expression of the maximum amount of a pollutant that may be present in a waterbody while also protecting the designated use(s) of the waterbody. In this case, the magnitude represents the concentration of total microcystins (8 µg/L) or cylindrospermopsin (15 µg/L) in the water column that is not expected to result in adverse human health effects from short-term recreational exposure to the cyanotoxins via incidental ingestion while recreating (e.g., swimming), based on children's exposure parameters.
- *Duration* — Duration is the period of time over which the magnitude is calculated. Exposure to recreational waters containing microcystins or cylindrospermopsin at or below the recommended magnitude concentrations over the short-term ten-day duration would not be expected to result in the adverse health effects discussed in health effects assessment (Section 5) of the criteria document.
- *Frequency* of excursion — The number of times the contaminant may be present above the recommended criteria concentration (magnitude) over the specified period (duration). For these criteria, the frequency corresponds to how often (within a single recreational season, *and across* multiple recreational seasons) the concentration of total microcystins or cylindrospermopsin in a waterbody may exceed the magnitude concentration and be protective of the designated use. The recommended frequency within a single recreational season is no more than three excursions. The number of years that a pattern of more than three excursions can occur *across* recreational seasons and still deemed to be protective of the designated use—referred to in Question 3 as the *recurrence frequency*—is a risk management decision, to be made by a state or authorized tribe. If a state or authorized tribe chooses to adopt the recommended criteria into its state or tribal WQS, EPA recommends that the state or authorized tribe include this recurrence frequency number in its WQS (see Table 1, note b).

EPA developed the following criteria values for total microcystins and cylindrospermopsin concentrations for states and authorized tribes to consider as the basis for human health protection in primary contact recreational waters (see Table 1 for a summary of the magnitude, duration and frequency).

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[3] For information about the scope and applicability of recreational criteria, see EPA's 2012 *Recreational Water Quality Criteria*, (Section 2.0 Applicability and Scope). Office of Water 820-F-12-058. https://www.epa.gov/sites/production/files/2015-10/documents/rwqc2012.pdf

Table 1. Recreational Water Quality Criteria Recommendations for Microcystins and Cylindrospermopsin [a]

Total Microcystins Magnitude (µg/L)	Cylindrospermopsin Magnitude (µg/L)	Duration	Frequency
8	15	1 in 10-day assessment period across a recreational season	Not more than 3 excursions in a recreational season in more than one year [b]

[a] States and authorized tribes can choose to adopt one or both criteria recommendations.

[b] An excursion is defined as a 10-day assessment period with any toxin concentration higher than the criteria magnitude. When more than three excursions occur within a recreational season and that pattern reoccurs in more than one year, it is an indication the water quality has been or is becoming degraded and is not supporting its recreational use. As a risk management decision, states and authorized tribes should include in their WQS an upper-bound frequency stating the number of years that pattern can reoccur and still support its recreational use.

Cyanobacterial blooms can occur naturally but can be an uncommon event due to a convergence of climatic and other environmental factors that result in a single short-term bloom lasting days or a couple of weeks. In some cases, multiple blooms can occur in a single year. Alternatively, longer-term cyanobacterial blooms can occur regularly in some waters lasting for a few weeks, months, or possibly all year. Cyanobacterial blooms can occur while conditions conducive to cyanobacterial proliferation exist and limit the use of the waterbody for primary recreation. The criteria components listed in Table 1, above, can help to identify a short- or long-term temporal trend or a spatial distribution pattern of cyanotoxin excursions that can be used to evaluate a waterbody.

EPA recognizes there are multiple environmental factors that can cause variability in bloom formation and toxin production, and that some years may produce HABs that occur for long periods, or HABs of shorter duration that occur repeatedly throughout a single recreational season, but such events may not occur every year. Therefore, EPA concludes that it is appropriate to consider a pattern of multiple excursions within a recreational season as well as a pattern of excursions in multiple years (i.e., more than one year) when determining whether the use is attained. It is important to note that the years with multiple excursions do not have to be consecutive to indicate a water-quality problem. The upper bound frequency (e.g., one year out of three years) is a risk management decision that states and authorized tribes need to determine when developing their WQS. States and authorized tribes should include the number of years a pattern of cyanotoxin excursions can occur for the recreational use to be supported.

EPA recommends that if toxin concentrations are higher than the criterion magnitude in a sample collected during a ten-day assessment period, then that period should be considered an excursion from the recreational criteria. A short-term cyanobacterial bloom that does not reoccur can result in a small number of excursions of the criteria but is not expected to result in impairment of the recreational use. Such cyanobacterial blooms may result from conditions that occur naturally (e.g., as a result of unusually hot conditions), but not frequently. EPA recommends that when more than three excursions (an exceedance during the ten-day assessment period) occur within a recreational season *and* that pattern reoccurs in more than one year, it is an indication that the water quality is or may be becoming degraded such that the waterbody may no longer support the recreational use. Multiple excursions over a single recreation season indicates that a waterbody may not support a recreational use for a significant proportion of the season. EPA recommends that a concentration of 8 µg/L total microcystins or 15 µg/L cylindrospermopsin not be exceeded in more than three ten-day assessment periods over the course of a recreation season in more than one year. EPA does not recommend averaging sampling data to determine an excursion, because averaging does not give a clear picture of the pattern of cyanobacterial bloom formation and cyanotoxin exposure to the population using the waterbody for recreational purposes.

The number of years over which time an observed pattern (of three or more ten-day excursions during a recreational season) can occur across recreational seasons is a risk management decision that states and authorized tribes should consider when developing their criteria. States and authorized tribes should include the number of years a pattern of cyanotoxin excursions can occur for the use to be supported in their WQS. Furthermore, states and authorized tribes may make different risk management decisions for different types of waterbodies. EPA recommends states and authorized tribes clarify these differences in their WQS. For more information about how the criteria were developed, see: https://www.epa.gov/wqc/recommended-human-health-recreational-ambient-water-quality-criteria-or-swimming-advisories.

2. How can EPA's recommended recreational water quality criteria values for total microcystins and cylindrospermopsin be used for swimming advisories?

State, tribal or local governments can use swimming advisories to provide information to recreators on their potential exposure to cyanobacteria and their toxins. EPA envisions that if states or authorized tribes decide to use the values as swimming advisory values, they can manage a cyanotoxin monitoring and advisory program in the same way as they manage any already existing recreational water advisory programs (i.e., those for *E. coli* or enterococci). States and authorized tribes may choose to apply either or both recommended magnitude values as the basis for swimming advisories (i.e., public notifications) for recreational waterbodies. For this purpose, EPA recommends that the magnitude (i.e., 8 µg/L total microcystins or 15 µg/L cylindrospermopsin) not be exceeded on any given day.

Table 2. Swimming Advisory Recommendations for Microcystins and Cylindrospermopsin[a]

Total Microcystins Magnitude (µg/L)	Cylindrospermopsin Magnitude (µg/L)	Duration	Frequency
8	15	One day	Not to be exceeded

EPA recognizes that some states and authorized tribes may handle swimming advisories through their health departments and not through their environmental quality departments. As a result, inter-departmental coordination may be helpful to implement an advisory program which can also serve to inform drinking water providers and water quality practitioners. EPA has provided an example Cyanobacteria Bloom Response Contact List on its website to help state or tribal employees consider who to contact in the event of a cyanobacterial bloom.

Swimming advisories can be used to provide information to recreators on their potential exposure to cyanobacteria and their toxins. Some local and state governments currently post notifications for swimmers, in the form of advisories or warnings, when a cyanobacterial bloom is reported in recreational waters or when cyanotoxin levels exceed swimming advisory thresholds.

If using the recommended values for public notification purposes (swimming advisory or beach closure), EPA recommends that the relevant authority (typically a local health department official or environmental protection agency) notify the public whenever a sample exceeds the recommended criteria concentration value. EPA also recommends that an exceedance of the recommended criteria concentration result in a swimming advisory being issued until subsequent sampling results show that the toxin concentration has fallen below the recommended magnitude value of the criteria. By increasing the monitoring frequency at a site where a swimming advisory is issued, recreational waterbody managers will get a clearer understanding of the temporal and spatial nature of toxins that can be useful in making management decisions to protect the recreational use, including when to remove an advisory.

EPA also recognizes that environmental conditions may change rapidly from one sample period to the next, depending on the frequency of samples taken. For an example of how the state of Ohio uses toxin concentration results to make swimming advisory decisions, see the Example 1 text box below. Appendix B of the criteria document summarizes available information on state recreational water guidelines for cyanotoxins and cyanobacteria (see: https://www.epa.gov/wqc/recommended-human-health-recreational-ambient-water-quality-criteria-or-swimming-advisories.

Example 1: State of Ohio example of a tiered approach to public notifications

The Ohio Environmental Protection Agency collaborated with the Department of Natural Resources and the Department of Health to develop a tiered notification system which takes different actions based on different numeric thresholds for cyanotoxin concentrations in recreational waters. That is, the state takes various actions—such as posting information about harmful algal blooms (HABs), issuing a recreational public health advisory, or temporarily closing recreational waters through a no contact advisory—depending on the severity of the bloom event.

Toxin of concern	Informational sign postings about HABs at recreational waters	Recreational public health advisory	Elevated recreational public health advisory (e.g. no contact)
Microcystin-LR	< 6 µg/L	6 µg/L	20 µg/L
Cylindrospermopsin	< 5 µg/L	5 µg/L	20 µg/L

Once an advisory is posted, Ohio conducts a standard sampling protocol for cyanotoxins and lifts the advisory once two consecutive samples taken at least one week apart show cyanotoxins have decreased below the advisory threshold. For more information, see the *State of Ohio Harmful Algal Bloom Response Strategy for Recreational Waters* (Ohio EPA, 2016).

EPA has published materials for recreational waterbody managers responsible for monitoring and responding to cyanobacterial blooms. These materials include a communication toolbox with examples of public messages, press releases, and warning and posting signage that recreational waterbody managers may use to inform the public of increased health risks associated with exposure to cyanobacteria and their toxins. In addition, EPA has provided recommendations for public health officials or waterbody managers (or relevant state, local or tribal officials) to consider various water monitoring, sampling and testing methods to determine whether a cyanobacterial bloom is producing toxins, whether the bloom presents an increased risk to water-contact recreators and human health, and whether immediate actions should be taken to notify the public if a closure is recommended based on waterbody test results.

- Communicating about Cyanobacterial Blooms and Toxins in Recreational Waters
- Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Waters
- Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters

3. What flexibilities do states and authorized tribes have when they choose to adopt recreational water quality criteria for total microcystins and cylindrospermopsin?

When states or authorized tribes choose to adopt EPA's *Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin*, states and authorized tribes have flexibility to accommodate specific water quality-related circumstances while meeting the requirements of the CWA and the WQS regulation. In addition to considering the Agency's national recommended water quality criteria when revising their WQS, states and authorized tribes may adopt, where appropriate, other scientifically defensible criteria that differ from EPA's recommendations. For example, states and authorized tribes can:

- *Define the length of the recreational season.* States and authorized tribes can adopt seasonal designated uses of a waterbody with respect to various 304(a) recommended criteria, including the recommended criteria for total microcystins and cylindrospermopsin. Therefore, for states and authorized tribes that have adopted seasonal uses, the recommended cyanotoxin criteria would apply only to the primary contact recreation season. 40 CFR 131.10(f) specifies that states and authorized tribes "may adopt seasonal uses as an alternative to reclassifying a waterbody or segment thereof to uses requiring less stringent water quality criteria. If seasonal uses are adopted, water quality criteria should be adjusted to reflect the seasonal uses, however, such criteria shall not preclude the attainment and maintenance of a more protective use in another season." The length of a "recreational season" is an important consideration because states and authorized tribes would likely monitor the quality of their highest-priority recreational waters throughout the recreational season (for more on prioritizing waterbodies for assessments, see Question 6). For purposes of establishing seasonal WQS, a change to the recreational season constitutes a change to the state's or authorized tribe's designated use in their WQS under 40 CFR 131.10(f) and would need to be reviewed and approved by EPA pursuant to section 303(c) of the CWA. Because local health departments or departments of parks and recreation may define the recreational seasons for inland waterbodies, it is important for states and authorized tribes to coordinate with these local authorities when identifying the length of the state's or tribe's recreational season in WQS.

- *Define a recurrence frequency.* The criteria for total microcystins and cylindrospermopsin recommend that the magnitude values should not be exceeded in *more than three ten-day periods per recreational season in more than one year*, but the criteria do not specify an upper-bound number of years that pattern can occur across recreational seasons (i.e., a recurrence frequency). This provides states and authorized tribes the flexibility to define a recurrence frequency. For example, some states or authorized tribes might count the recurrence frequency over a rolling 5-year period while others choose to count over a rolling 10-year period.

> If a state or authorized tribe chooses to adopt the recommended criteria, EPA expects the state or tribe to also include this recurrence frequency in its WQS. A state or authorized tribe may achieve this with a written statement in its standards. An example written statement could say, *"The concentration of total microcystins shall not exceed 8 µg/L in more than three ten-day periods per recreational season, for more than one recreational season, over a 5-year period."*

- *Derive site-specific criteria elements*. States and authorized tribes may adopt EPA recommended criteria or may modify the criteria to fit their unique situation based on site-specific data and information. For example, a state or tribe may derive site-specific criteria based, in part, on information about the exposure variables among the population that uses the waterbody (e.g., age and incidental ingestion rates) or to allow for specific cultural or land use practices at or near the site. The site-specific criteria must be scientifically defensible and protective of the designated use of the state's or tribe's waterbodies and approved by EPA pursuant to section 303(c) of the CWA.
- *Revise the designated uses of waterbodies within their state*. If a state or authorized tribe finds that attaining one of the designated CWA section 101(a)(2) uses[4] in its standards is not feasible, the state or authorized tribe may remove or modify the designated use based on appropriate use attainability analysis and documentation subject to EPA's review and approval. Therefore, if the recreational criteria for total microcystins or cylindrospermopsin cannot be attained, the state or authorized tribe can consider whether to modify or remove the designated use.

[4] Uses that provide for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, as well as for the protection of human health when consuming fish, shellfish, and other aquatic life (e.g. recreation use, aquatic life use).

4. What is the relationship between cyanobacterial blooms and the recommended criteria?

Cyanobacteria, commonly referred to as blue-green algae, are photosynthetic bacteria that occur naturally in waters, including waters used for primary contact recreation. Under certain conditions, cyanobacteria may grow rapidly to form accumulations known as cyanobacterial blooms. When the proliferation of cells making up the bloom also contains toxin-producing strains of cyanobacteria, there is the potential to have elevated concentrations of the cyanotoxins, microcystins and cylindrospermopsin, present. Generally referred to as a harmful algal blooms (HABs), these toxin-producing cyanobacterial blooms can cause harm to animals, people, or the environment. Accumulations of cyanobacteria have been associated with outbreaks of inflammatory illness (e.g., rashes) unrelated to the production of cyanotoxins.

Some states have chosen to adopt a value based on cell density as a screening tool, with further tests for specific toxins after confirming that a bloom is present. EPA did not develop recommended criteria or swimming advisories based on cyanobacterial cell density; however, the Agency summarized available information on adverse effects that may result from exposure to cyanobacterial cells and estimated a cell density value corresponding to the toxin-based criteria magnitude. For more information on the health effects from exposure to cyanobacterial cells, go to:

- Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin (see section 7.5 Cyanobacterial Cells)

Exposure to the toxins, microcystins and cylindrospermopsin, can pose additional health risks to humans and animals. Symptoms reported after recreational exposure to cyanobacterial blooms (including microcystin-producing genera) included skin irritations, allergic reactions or gastrointestinal illnesses. Symptoms of exposure to cylindrospermopsin have been reported to include fever, headache, vomiting, bloody diarrhea, hepatomegaly and kidney damage with the loss of water, electrolytes and protein.

For more information on the health effects from exposure to microcystins and cylindrospermopsin, go to:

- Health Effects Support Document for the Cyanobacterial Toxin Microcystins
- Health Effects Support Document for the Cyanobacterial Toxin Cylindrospermopsin

The presence of cyanobacteria does not necessarily mean that cyanotoxins are being produced, and conversely, cyanotoxins can be present at levels above the criteria magnitude when accumulations of cyanobacteria were not observed.[5] Benthic cyanobacteria, occurring at the bottom of the waterbody, may not be visible from the surface, but may still produce toxins.

For information on identifying blooms and specific cyanobacteria, go to:

- USGS Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities.

[5] Lahti K, Rapala J, Färdig M, Niemelä M, & Sivonen K (1997b). Persistence of cyanobacterial hepatotoxin, microcystin-LR in particulate material and dissolved in lake water. *Water Research*, 31(5), 1005-1012.
Zastepa A, Pick F, & Blais J (2014). Fate and persistence of particulate and dissolved microcystin-LA from Microcystis blooms. *Human and Ecological Risk Assessment: An International Journal, 20*(6), 1670-1686.

5. Why should I consider nutrient pollution if I am implementing criteria for cyanotoxins?

Nitrogen and phosphorus loadings, or nutrient pollution input into recreational waterbodies from agricultural, industrial, and urban sources can provide optimal conditions for cyanobacterial blooms and cyanotoxin production. Preventing nutrient input and reducing nitrogen and phosphorus levels in a waterbody can help to reduce the occurrence of cyanobacterial blooms or the levels of cyanotoxins in blooms containing toxin-producing strains of cyanobacteria.[6]

The relationships between nutrients and other physical, chemical or environmental conditions is complex and can present an added challenge to recreational waterbody managers responsible for monitoring and responding to cyanobacterial blooms. In addition to nutrient concentrations, factors such as the availability of organic matter, turbidity, turbulence or flushing of a waterbody, light attenuation, temperature and pH can play a role in the composition and cyanotoxin production associated with a cyanobacterial bloom.

The sources of nutrients present in waterbodies are both natural and anthropogenic. Soil and erosion of phosphorus-containing rocks are the most significant natural sources of the phosphorus in surface waters, while bed sediment resuspension can be the major source of phosphorus to the lower water column. Significant natural sources of nitrogen include fixation of nitrogen gas, N_2, and dry and wet deposition of nitrogen compounds from the atmosphere. Human-induced nutrient pollution comes from several sources:

1. Stormwater runoff (e.g., urban and rural) contains nitrogen and phosphorus from fertilizers (especially those applied in excess or before a rain storm), yard clippings, leaves, and pet wastes that are washed away to local waterbodies or conveyed through storm sewer systems.
2. Municipal wastewater discharges (including septic systems) process billions of gallons of wastewater every day. Municipal wastewater contains nitrogen and phosphorus from human waste, food, and certain soaps and detergents.
3. Industrial wastewater discharges from industrial facilities, such as food processing and fertilizer manufacturing facilities, are sources of nitrogen and phosphorus.
4. Agricultural practices, including concentrated animal feeding operations and row crops, are sources of nitrogen and phosphorus. Other sources include: animal waste, gaseous nitrogen-based compounds like ammonia and nitrogen oxides released to the atmosphere from ventilated production houses, manure storage structures, or fields where manure (or other fertilizers) is applied and re-deposited onto land and eventually washes into surface waters.

Reductions in nutrient pollution help to reduce the occurrence of cyanobacterial blooms and waterbody eutrophication. Studies have shown that excess nitrogen can stimulate the growth of the cyanobacteria, *Microcystis*.[7] Elevated concentrations of total and dissolved phosphorus and soluble phosphates and nitrates provide optimal conditions for the increased production of microcystins. Controlling phosphorus and nitrogen inputs could reduce the biomass of cyanobacteria in the system, and the frequency and concentration of microcystins produced.

The World Health Organization: Guidelines for Safe Recreational Water Environments (PDF) contains a

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[6] For the results of a study on how the experimental limitation of nutrient supplies aided in the diminishing of a cyanobacterial bloom, see:
Pace, M. et al. Reversal of a cyanobacterial bloom in response to early warnings. *Proceedings of the National Academy of Science. USA* 114, 352–357; DOI:10.1073/pnas.1612424114 (2017).

[7] See Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin, Section 3.0 Nature of the Stressors.

chapter on algae and cyanobacteria in fresh water, which includes short- and long-term management options—including nutrient management and implementation of control and abatement technologies, among other practices—with the goal of preventing or reducing the occurrence of cyanobacterial blooms in recreational waters.

As a long-term strategy to address eutrophication and cyanobacteria blooms, states and authorized tribes may consider adopting numeric nutrient criteria into their WQS or, alternatively, develop a numeric target to implement a narrative nutrient criterion that has already been adopted into their WQS. Numeric nutrient criteria or targets are useful as efficient and effective tools to support water quality assessments, watershed protection or restoration, TMDL development and permitting programs, where applicable. Specifically, numeric nutrient criteria or targets sets the foundation for states and authorized tribes to develop environmental baselines, manage water quality more effectively, measure progress, and support broader implementation initiatives (such as water quality trading, best management practices (BMPs), land stewardship, wetlands protection, voluntary collaboration, and stormwater runoff control strategies). EPA stands ready to provide technical assistance to states and authorized tribes who are developing numeric nutrient criteria or targets for different waterbody types through EPA's N-STEPS program.[8]

EPA continues to provide scientific and technical assistance to states and authorized tribes who are working to reduce nutrient pollution as a means of reducing the occurrence of cyanobacterial blooms. For more information on what EPA is doing to help reduce nutrient pollution and for tools to assist states and authorized tribes, refer to:

- Preventing Eutrophication: Scientific Support for Dual Nutrient Criteria Factsheet (PDF)
- Managing Microcystin: Identifying National-Scale Thresholds for Total Nitrogen and Chlorophyll a
- Deriving Nutrient Targets to Prevent Excessive Cyanobacterial Densities in U.S. Lakes and Reservoirs (PDF)
- Renewed Call to Action to Reduce Nutrient Pollution and Support for Incremental Actions to Protect Water Quality and Public Health (September 2016 EPA Memo) (PDF)
- Nutrient Pollution Policy and Data
- Toolkit of Resources to Assist States with Adopting and Implementing Numeric Nutrient Criteria
- Water Quality Standards Handbook
- A Compilation of Cost Data Associated with the Impacts and Control of Nutrient Pollution (PDF)

Implementation Questions about Monitoring, Assessment and Listing

6. What information should states and authorized tribes consider when prioritizing which waterbodies to monitor based on risk of elevated levels of cyanotoxins?

Recognizing the potential risks of exposure to cyanotoxins, states and authorized tribes across the country are monitoring for cyanobacteria (as a potential precursor to blooms), microcystins, cylindrospermopsin, or other algal toxins. Some states and authorized tribes have reported microcystins data through the Water Quality Portal, an interagency website that provides public access to water quality data.[9] Reporting data on cyanobacterial blooms and toxin levels can improve transparency with the public and help to provide a regional or national understanding of where blooms are taking place.

[8] https://www.epa.gov/nutrient-policy-data/n-steps
[9] https://www.waterqualitydata.us/

States and authorized tribes are encouraged to upload microcystins data to the Water Quality Portal (see: https://www.waterqualitydata.us/).

EPA recommends that states and authorized tribes prioritize their waterbodies, for monitoring purposes, based on risk factors relevant to the likelihood of a cyanotoxin or HABs event and its relative impact to recreational users of each waterbody. Prioritizing which waterbodies to monitor can help to direct often limited resources where they will be most effective.

States and authorized tribes may also consider their capacity to include cyanobacterial indicators as part of a robust monitoring and assessment program necessary to evaluate the condition of their waterbodies. Some states and authorized tribes consider existing phytoplankton data or use satellite imagery as a screening tool to identify waters that may need additional sampling.[10] States and authorized tribes may also use field test kits to screen for waters with elevated toxins before collecting a sample. States and authorized tribes are encouraged to collaborate with a range of state, tribal and local agencies, waterbody managers and citizen science/volunteer monitoring organizations to monitor local waterbodies, leveraging the presence of local resources to collect and analyze samples in a timely and appropriate manner for risk management and response activities.

CWA practitioners, public health officials, and other waterbody managers may consider a variety of information when prioritizing which waterbodies to monitor for potential cyanotoxins. Some of the factors listed below may help state, tribal and local officials to identify which waterbodies are most vulnerable:

- the type of waterbody, and types and numbers of recreational users;
- past/historical occurrence of HABs and cyanotoxin production;
- seasonal patterns of cyanobacterial blooms (influenced by temperature and precipitation, among other factors);
- point and nonpoint sources of contamination (especially nutrients) in the waterbody and in the watershed;
- physical and hydrologic factors (e.g., depth, fetch,[11] light attenuation, availability of organic matter, turbidity, pH and nutrients);
- chlorophyll-a and phycocyanin[12] levels (e.g., cell densities);
- other water quality limitations or impairments; and,
- any other information gathered as part of source water assessments or sanitary surveys.

EPA has developed materials to assist recreational waterbody managers interested in monitoring for and responding to cyanobacteria and cyanotoxins in recreational waters. In addition, EPA has provided recommendations for various water sampling and testing methods to determine whether a cyanobacterial bloom is producing cyanotoxins, whether the bloom presents a risk to human health, and whether actions should be taken to notify the public and reduce public health risks from various recreational uses of a waterbody, including if a closure is recommended.

- Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Waters.

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[10] For a list of state recreational water guidelines relating to cyanobacteria or cyanotoxins, see Appendix B of the criteria document, https://www.epa.gov/wqc/recommended-human-health-recreational-ambient-water-quality-criteria-or-swimming-advisories.

[11] Fetch refers to the area of a lake surface over which the wind blows in an essentially constant direction, thus generating waves. The term also is used as a synonym for fetch length, which is the horizontal distance over which wave-generating winds blow.

[12] Phycocyanin is a pigment present in cyanobacteria.

- Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters (PDF).

The following additional sources of information may inform states and authorized tribes when taking a risk-based approach to prioritizing recreational waterbodies.

- Cyanobacteria Assessment Network, CyAN: EPA's Office of Research and Development, the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA) and United States Geological Survey (USGS) are collaborating to provide interactive maps based on satellite imagery and data on chlorophyll-a levels in large waterbodies nationwide.[13]
- Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities: This 2015 guide, produced by the USGS, provides field images to help differentiate between cyanobacterial blooms (some of which produce toxins), non-toxic algal blooms, and floating plants that might be confused with algae.
- Water Quality Portal: The National Water Quality Monitoring Council, USGS and EPA sponsor the Water Quality Portal, an interagency website that provides public access to water quality data collected by over 400 federal, state, tribal, and local agencies.
- Other resources may be found in pages 5 through 7 of EPA's document, Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters (PDF).

7. How frequently and over what time period should states and authorized tribes collect data on cyanotoxin levels?

States and authorized tribes have discretion and flexibility when establishing a monitoring program for cyanotoxins. For example, states and authorized tribes may prioritize which waterbodies they monitor and how frequently they monitor those waterbodies (for information on prioritization, see Question 6). Baseline monitoring could include routine monitoring (e.g., weekly monitoring over the course of a recreation season), responsive/episodic monitoring (e.g., initiating sampling in response to a physical bloom or reported potential negative health impact to animals or humans), or a combination of the two. EPA recommends that states and authorized tribes use their monitoring strategy or annual workplans to identify the monitoring approach that will be implemented for the recreational season, considering available resources and the potential use of tools, such as remote sensing and citizens' volunteer monitoring.

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[13] Algorithms to assess bloom frequency and severity have been developed; however, current satellite resolution and sensing capabilities limit the ability to apply the CyAN assessment methods on a national scale. Satellites with the highest resolution, such as Landsat, can capture 62% of lakes greater than 1 ha (2.47 acres) and 95% of the lakes with public drinking water intake locations. Unfortunately, these satellites make less frequent flyovers and are not equipped with sensors capable of distinguishing CyanoHABs from other types of HABs. Lower resolution satellites capture less than 1% of waterbodies and only 33% of drinking water intakes but make more frequent flyovers and can identify CyanoHABs. For more information, see:

Urquhart et al. *A method for examining temporal changes in cyanobacterial harmful algal bloom spatial extent using satellite remote sensing*. Harmful Algae, 67 (2017), pp. 144-152. https://doi.org/10.1016/j.hal.2017.06.001

Clark et al. *Satellite monitoring of cyanobacterial harmful algal bloom frequency in recreational waters and drinking water sources*. Ecological Indicators, 80 (2017), pp. 84-95. https://doi.org/10.1016/j.ecolind.2017.04.046

Stumpf et al. Challenges for mapping cyanotoxin patterns from remote sensing of cyanobacteria. Harmful Algae, 54 (2016), pp. 160-173. https://doi.org/10.1016/j.hal.2016.01.005

Following initial detection and confirmation of microcystins or cylindrospermopsin in waterbodies designated for primary contact recreation, EPA recommends more frequent monitoring until the bloom subsides or the cyanotoxin levels no longer exceed the cyanotoxin criteria magnitude level. Once the cyanotoxins have subsided, EPA suggests that regular monitoring of prioritized waterbodies continue for the duration of the recreation season.

For more information about monitoring for cyanotoxins, see EPA document:

- Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters

8. How should states and authorized tribes analyze and interpret cyanotoxin monitoring data and information to evaluate ambient conditions and recreational use support?

The recommended ten-day duration component of the criteria naturally translates into use of ten-day assessment periods over the course of a recreation season to evaluate ambient waterbody condition and recreational use attainment. EPA recognizes that some states and authorized tribes have routine daily, weekly, biweekly, or monthly sampling schedules in place for different water bodies and recreational areas. Monitoring at other waterbodies may be event driven in response to a bloom. EPA recommends more frequent sampling if a bloom is detected, particularly if it is documented to have toxin levels that exceed the criteria magnitude.

Weekly monitoring may provide two samples within the ten-day assessment period, or weekly monitoring may provide data for two consecutive ten-day assessment periods (depending on how the weeks and ten-day periods align). If one or more samples are collected within the ten-day assessment period that exceed the criteria magnitude, these are counted as a single excursion. Biweekly or monthly sampling schedules can also be considered with respect to ten-day assessment periods, recognizing that some states and authorized tribes may choose to use fixed, *a priori* intervals while others may begin a ten-day period with the first sample that exceeded the criteria magnitude.

States and authorized tribes have flexibility delineating the ten-day assessment periods within their recreational season. The Example 2 text box is provided to illustrate how exceedances can count towards excursions when assessing use attainment. For the application of these criteria, an exceedance is defined as an instance when the monitoring data indicates a concentration of microcystins or cylindrospermopsin that is higher than the recommended magnitude value, and an excursion is defined as an instance of one or more exceedances within a ten-day assessment period that corresponds to the duration. The calendar figures in Example 2 illustrate two ways states and authorized tribes could set up their ten-day assessment periods, either by blocking out ten-day periods before the start of the recreation season (Example 2A) or by marking ten-day assessment periods from the date a bloom is detected and an exceedance is confirmed (Example 2B).

Example 2: Examples of How a State or Tribe Might Count Exceedances and Excursions

The following examples illustrate two hypothetical scenarios describing the evaluation of exceedances and determination of excursions for the ten-day duration period. These scenarios are intended to demonstrate how the number of excursions can be counted within a given recreation season. The red X shown on the example calendars denote days where cyanotoxin monitoring results were above the recommended cyanotoxin magnitude (exceedances). The shaded boxes represent ten-day assessment periods. An assessment period with one or more exceedances is counted as an excursion.

Example 2A: Predetermined Monitoring Schedule

June

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8 X	9 X	10 X	11 X	12	13	14
15	16	17	18	19	20	21 X
22 X	23 X	24	25	26	27 X	28 X
29	30					

Example 2A. In this example, the state or authorized tribe establishes regularly-scheduled monitoring to begin on June 1, and on June 8 monitoring results showed an exceedance of the cyanotoxin magnitude. Subsequent monitoring showed exceedances June 9, 10 and 11, and later in the month on June 21, 22 and 23, and June 27 and 28. <u>In this case, the nine exceedances equate to three excursions because the exceedances were detected across three separate ten-day assessment periods</u>.

Example 2B: Responsive Ten-Day Periods

June

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8 X	9 X	10 X	11 X	12	13	14
15	16	17	18	19	20	21 X
22 X	23 X	24	25	26	27 X	28 X
29	30					

Example 2B. In this example, the state or authorized tribe monitors for cyanotoxins in response to a suspected bloom, once the monitoring data indicates a concentration of microcystins or cylindrospermopsin that is higher than the recommended magnitude. On June 8 a suspected bloom was confirmed and monitoring results showed an exceedance of the cyanotoxin magnitude. Subsequent monitoring showed exceedances June 9, 10 and 11. A second bloom was suspected later in the month and confirmed through additional monitoring showed exceedances on June 21, 22, 23, 27 and 28. In this case, the nine exceedances equate to two excursions because the exceedances were detected across two separate ten-day periods.

9. What should states and authorized tribes consider when selecting an analytical method and sampling locations?

When selecting a method to monitor for cyanotoxins, states and authorized tribes should consider cost and practicality of various monitoring methods, and reliability and comparability of results, among other factors. More than 100 microcystin congeners are known to exist, although the majority of toxicological data on the effects of microcystins are available for microcystin-LR (a frequently monitored congener). Therefore, EPA established its recommended criterion for microcystins based on microcystin-LR and used it as a surrogate for other microcystin congeners. Two congeners of cylindrospermopsin have been identified. Analytical methods must be sufficiently sensitive to detect the cyanotoxins in question at concentrations below the criteria magnitude. Analytical results may vary depending on the analytical methods used.

Methods vary widely in sensitivity, rapidity, cost, and ease of use. As described below, there are both rapid screening tests and laboratory methods used to detect and identify cyanobacterial cells; determine the presence, absence, or count of individual congeners; or measure the concentration of total cyanotoxins in a water sample. In waterbodies that have been prioritized for monitoring, it may be cost effective to use field test kits at several locations throughout the waterbody prior to selecting samples for lab-based analysis (see below for description of field test kits). Some analytical methods measure the sum of all congeners while other methods measure specific congeners of interest. Each method has specific requirements for sample preparation/processing and analytical standards. These should also be considered when planning monitoring programs. EPA does not recommend any single method to monitor for cyanotoxins and refers readers to the National Environmental Methods Index (https://www.nemi.gov/home/) for information on analytical methods.

Methods for quantifying cyanotoxins (total or individual congener concentrations) include:

- Lab-based enzyme–linked immunosorbent assay (ELISA) methods, to measure cyanotoxins in question. The ELISA method is typically run with only a microcystin-LR standard for comparison but can quantify a broad range of microcystin congeners (especially if using an ADDA-based antibody) and other compounds that are similar to microcystin congeners (e.g., nodularin).
- Field test kits (e.g., Abraxis test strip, Envirologix QualiTube). These field-based methods do not require laboratory instrumentation and can produce semi-quantitative results within about an hour; however, their relatively high limit of quantification (approximately 1-10 µg/L) may better suit these methods for screening purposes.
- Protein phosphatase inhibition assay (PPIA). This method has varying degrees of specificity depending on its substrate composition and may react to compounds in the sample, other than microcystins.
- High performance liquid chromatography (HPLC) combined with ultraviolet/photodiode array detectors (UV/PDA). This method requires known toxin standards to be run alongside the water sample(s) to quantify the toxin concentration(s) and its results are limited to only those congeners for which standards are available and analyzed. LC-UV methods are based on a non-selective detector and co-eluting interferents can prevent accurate identification of components and quantitation. It is less sensitive than mass spectrometry methods (see below).
- Liquid chromatography/tandem mass spectrometry (LC/MS/MS).[14] Like HPLC-PDA, this method typically requires known toxin standards to be run alongside the water sample(s) to quantify the toxin concentration(s) and its results are limited to only those congeners for which standards are available and analyzed. It is, however, the most precise method for quantitation of analytes (such as specific microcystin variants) if standards are available. May require use of solid phase extraction for analytes with weak product ion abundance (microcystins). The LC-MS/MS MMPB (2-methyl-3(methoxy)-4-phenylbutyic acid) method, however, analyzes the chemically cleaved ADDA group common to all microcystin variants and provides an alternative LC-based approach for analyzing total microcystins. The MMPB method may also detect microcystins break-down products and could potentially overestimate total microcystins concentrations in some settings.

EPA recognizes that several states or authorized tribes may monitor for cyanobacterial cell densities in addition to, or in lieu of, monitoring for cyanotoxins. Two methods for quantifying cyanobacterial cells include microscopy and quantitative polymerase chain reaction (qPCR) and microarrays/DNA chips.

Like other aspects of monitoring programs, decisions on sample location are guided by the management questions being addressed. For example, when monitoring recreational waters for public health protection, it's reasonable to target sample collection toward capturing the highest potential exposure risks; therefore, EPA recommends that states and authorized tribes collect single grab samples from designated swimming areas, near the shoreline, or composite samples from points within the splash zones where children play. Monitoring for other objectives may result in sampling at other areas of a waterbody (e.g., if sampling for source water protection, rather than the protection of recreational

[14] For more information on single laboratory validated methods for detecting cyanotoxins in freshwaters by LC/MS/MS, see (1) https://www.epa.gov/water-research/single-laboratory-validated-method-determination-cylindrospermopsin-and-anatoxin to detect cylindrospermopsin and anatoxin-a, and (2) https://www.epa.gov/water-research/single-laboratory-validated-method-determination-microcystins-and-nodularin-ambient to detect microsystins and nodularin (combined intracellular and extracellular).

uses).

EPA has produced technical materials to aid in the development of cyanobacteria and cyanotoxin monitoring programs, including information on available testing methods and sampling logistics. See materials at:

- For recommendations related to establishing a sampling and monitoring program, see: https://www.epa.gov/cyanohabs/recommendations-cyanobacteria-and-cyanotoxin-monitoring-recreational-waters;
- For a summary of methods used to detect cyanobacteria and cyanotoxins in water, see: Determination of Cyanotoxins in Drinking and Ambient Freshwaters; and,
- For a set of frequently asked questions related to laboratory analysis for microcystins in drinking water, see: Frequently Asked Questions: Laboratory Analysis for Microcystins in Drinking Water.

10. What data and information should states and authorized tribes assemble and evaluate to complete CWA water quality assessments with EPA's recommended cyanotoxin criteria?

States and authorized tribes are required under 40 CFR 130.7(b)(5) to assemble and evaluate all existing and readily available water quality-related data and information when determining which waterbodies belong on the state's or authorized tribe's CWA section 303(d) list of impaired and threatened waters. For states and authorized tribes that have adopted the recommended recreational criteria for total microcystins and cylindrospermopsin and are interested in assessing against the criteria, "readily available data and information" would include observed concentration levels for microcystins and cylindrospermopsin collected by the state, authorized tribe, or other stakeholders (e.g., citizen science water monitoring groups).

In addition to observed concentration levels of microcystins and cylindrospermopsin, EPA considers advisories to be existing and readily available data and information. Hence, for states and authorized tribes that implement the recommended swimming advisory levels but do not adopt the recommended criteria, advisories can be used to support water quality assessments using other applicable WQS (e.g., designated uses and narrative criteria). EPA recommends that states and authorized tribes include within their assessment methodologies information about how the state or tribe will use advisories to evaluate attainment of narrative water quality criteria and associated designated uses.

11. Should states and authorized tribes update their assessment methodology to include the evaluation of cyanotoxin data and information? If so, what should be considered in these updates?

States and authorized tribes should consider updating their water quality assessment methodology to address any water quality standard adopted by the state or authorized tribe. An assessment methodology constitutes the decision process that a state or authorized tribe employs to determine the water quality attainment status of waters in the state or on tribal lands. Under 40 CFR 130.7(b)(6), states and authorized tribes are required to provide documentation to EPA to support their determination to include or not include waters on its impaired and threatened waters list. States and authorized tribes are required to include a description of the methodology used to develop the list; a description of the data and information used to identify waters for the list, including a description of the data and information used by the jurisdiction; and, a rational for any decisions to not use existing and readily available data and information to develop the list.

EPA encourages states and authorized tribes to make the assessment methodology available to the public for review and comment prior to, or along with, solicitations for data and information. Such engagement helps facilitate stakeholder input to the state's or authorized tribe's assessment of water quality status, including recreational use assessments. If states and authorized tribes choose to adopt the recommended cyanotoxin recreational criteria, EPA recommends that they update their assessment methodologies to account for any criteria-specific considerations. For states and authorized tribes that use the swimming advisory recommendation, EPA also encourages them to describe in their assessment methodology how, if at all, the advisory information will be used to support water quality assessments using other applicable WQS (e.g., designated uses and narrative criteria).

12. What happens if a state or authorized tribe does not have sufficient data to make an assessment determination?

EPA recommends that states and authorized tribes submit an integrated water quality report that uses a five-category approach for classifying the WQS attainment status for each waterbody in their jurisdiction. Consistent with this approach, EPA recommends that waterbody segments be placed in waterbody assessment Category 3 of the Integrated Report when there is insufficient available data and/or information to make a use-support determination. Information on the appropriate use of Category 3 can be found in EPA's 2009 memo to assist states and authorized tribes in the preparation of the 2010 Integrated Water Quality Reports.[15]

13. What factors should be considered in defining waterbody segmentation (e.g., if dividing a waterbody into smaller assessment units for advisories and 303(d) listings)?

States and authorized tribes have flexibility to define the segmentation for waterbodies within their jurisdiction. Information on segmenting waters can be found in EPA's 2005 memo to assist states and authorized tribes in the preparation of the 2006 Integrated Water Quality Reports.[16]

14. How should states and authorized tribes approach waterbody assessments for a waterbody that is already on the CWA section 303(d) list?

Consistent with any applicable water quality standard, states and authorized tribes make future assessment decisions based on an evaluation of existing and readily available water quality-related data and information against the water quality standard and accompanying assessment method. The assessment decision informs whether a waterbody should be identified as impaired or threatened on the jurisdiction's Section 303(d) list.

States and authorized tribes can decide not to include a waterbody/pollutant combination that was previously identified as impaired or threatened on a state's or tribe's 303(d) list (also known as, "delist") for several reasons, including: (a) the water quality standard is now being met, (b) there were flaws in the

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[15] USEPA (U.S. Environmental Protection Agency). 2009. Information Concerning 2010 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions. U.S. Environmental Protection Agency, Office of Water, Washington, DC.
https://www.epa.gov/sites/production/files/2015-10/documents/2009_05_06_tmdl_guidance_final52009.pdf.

[16] USEPA (U.S. Environmental Protection Agency). 2005. Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act. U.S. Environmental Protection Agency, Office of Water, Washington, DC.
https://www.epa.gov/sites/production/files/2015-10/documents/2006irg-report.pdf

original listing, (c) a TMDL was developed and approved by EPA, or (d) other point sources or nonpoint source controls are expected to meet WQS as described in 40 CFR 130.7(a)(b)(1).

Implementation Questions about Water Quality Management Plans (e.g., TMDLs)

15. How should states and authorized tribes complete TMDLs for waterbodies that are listed under CWA section 303(d) as impaired or threatened due to cyanotoxins?

States and authorized tribes can develop TMDLs for the pollutant(s) that promote development of cyanobacterial blooms and elevated levels of microcystins and cylindrospermopsin above EPA's recommended criteria. As previously discussed in this document, nitrogen and phosphorus loadings can provide optimal conditions for the formation of cyanobacterial blooms and cyanotoxin production. Although accurately deriving the quantity of nutrient pollution reduction necessary to meet WQS for cyanotoxins (or cyanobacteria) is a complex process, states and authorized tribes can use tools EPA is currently developing to better understand the relationship between the causal variables—pollutant loads of nitrogen and phosphorus—and the response variables of the cyanotoxin microcystins.[17] States and authorized tribes may also want to conduct site-specific studies to help refine these relationships and should consider the state of the science as they prioritize and schedule TMDLs to address cyanotoxins.

[17] Additional research is currently being conducted by EPA and others to improve the understanding between cyanotoxins and nutrient pollution. For example, see:

1. Lester L. Yuan and Amina I. Pollard, Managing microcystin: identifying national-scale thresholds for total nitrogen and chlorophyll-*a*, *Freshwater Biology*, 59, 9, (1970-1981), (2014).
2. Lester L. Yuan and Amina I. Pollard, Deriving nutrient targets to prevent excessive cyanobacterial densities in U.S. lakes and reservoirs, *Freshwater Biology*, 60, 9, (1901-1916), (2015).
3. Lester L. Yuan and Amina I. Pollard, Using National-Scale Data to Develop Nutrient–Microcystin Relationships That Guide Management Decisions, *Environmental Science & Technology*, 51, 12, (6972), (2017).