

U.S. Environmental Protection Agency

# NPDES Permit Writers' Manual



U.S. Environmental Protection Agency  
Office of Wastewater Management, Water Permits Division  
State and Regional Branch

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Environmental Protection  
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Office of Water  
Washington, DC

# United States Environmental Protection Agency

## National Pollutant Discharge Elimination System (NPDES) Permit Writers' Manual

This guidance was developed by staff within the U.S. Environmental Protection Agency's (EPA's) Office of Wastewater Management and addresses development of wastewater discharge permits under the National Pollutant Discharge Elimination System (NPDES). NPDES permit development is governed by existing requirements of the Clean Water Act (CWA) and the EPA NPDES implementing regulations. CWA provisions and regulations contain legally binding requirements. This document does not substitute for those provisions or regulations. Recommendations in this guidance are not binding; the permitting authority may consider other approaches consistent with the CWA and EPA regulations. When EPA makes a permitting decision, it will make each decision on a case-by-case basis and will be guided by the applicable requirements of the CWA and implementing regulations, taking into account comments and information presented at that time by interested persons regarding the appropriateness of applying these recommendations to the situation. This guidance incorporates, and does not modify, existing EPA policy and guidance on developing NPDES permits. EPA may change this guidance in the future.

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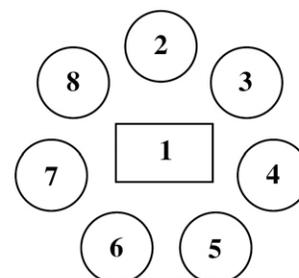
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## Introduction to the Manual

This manual reviews the statutory and regulatory framework of the National Pollutant Discharge Elimination System (NPDES) program and examines technical considerations for developing NPDES permits for wastewater discharges. The manual is designed, primarily, for new permit writers becoming acquainted with the NPDES program and the process of permit writing, but can also serve as a reference for experienced permit writers or anyone interested in learning about the legal and technical aspects of developing NPDES permits. This manual replaces the *1996 U.S. EPA NPDES Permit Writers' Manual*<sup>1</sup> <[www.epa.gov/npdes/pubs/owm0243.pdf](http://www.epa.gov/npdes/pubs/owm0243.pdf)>, which updated the *1993 Training Manual for NPDES Permit Writers*<sup>2</sup> <[www.epa.gov/npdes/pubs/owm0339.pdf](http://www.epa.gov/npdes/pubs/owm0339.pdf)>.

To assist the reader, acronyms and abbreviations are defined for the first use in each chapter and in Appendix A of the manual. Endnotes are provided at the end of each chapter.

## Purpose of this Manual

The purpose of this *NPDES Permit Writers' Manual* (manual) is to provide a general reference for permitting authorities that outlines and explains the core elements of the NPDES permit program. The core elements form the foundation of the NPDES program on which guidance for specific areas of the program (e.g., stormwater, concentrated animal feeding operations) can be built. While the guidance for these core program areas will be applicable in many cases, the U.S. Environmental Protection Agency (EPA) recognizes that each EPA Regional Office or authorized state, territory, or tribe (hereafter *state*) will tailor specific aspects of its NPDES permitting procedures to address state and local laws and site-specific concerns and conditions.

The specific objectives and functions of this manual are as follows:

- Provide an overview of the scope and the statutory and regulatory framework of the NPDES program.
- Describe the essential components of a permit and provide an overview of the permitting process.
- Describe the different types of effluent limitations and the legal and technical considerations involved in developing effluent limitations.
- Describe the legal and technical considerations involved in developing other permit conditions including
  - Monitoring and reporting requirements.
  - Special conditions.
  - Standard conditions.
- Describe other permitting considerations including
  - Variances.
  - Anti-backsliding.
  - Other applicable statutes.

- Explain the administrative process for issuing, modifying, revoking and terminating NPDES permits.

This manual is not intended to be a standalone reference document. Rather, it establishes the framework for NPDES permit development and should be supplemented, where necessary, by additional EPA and state regulations, policy, and detailed guidance applicable to specific types of dischargers and circumstances. To that end, this manual identifies and references relevant regulations, policy, and other guidance documents throughout the text.

## Publications Referenced

This manual provides links to publications available online that supplement the information in the manual. All documents available electronically were accessed and available as of the date of this manual's publication. Some documents are not available in an electronic format. In those instances, readers should check the following sources to determine the availability of and to obtain printed copies of the documents:

- Office of Water Resource Center (OWRC) <[www.epa.gov/safewater/resource/](http://www.epa.gov/safewater/resource/)>  
OWRC is a contractor-operated facility providing document delivery, information/referral, and reference services to public users and EPA staff interested in Office of Water Program information  
phone: 202-566-1729 or 800-832-7828, fax: 202-566-1736, e-mail: <[center.water-resource@epa.gov](mailto:center.water-resource@epa.gov)>.
- EPA Library Services and Repositories <[www.epa.gov/natlibra/libraries.htm](http://www.epa.gov/natlibra/libraries.htm)>  
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## Legislative and Regulatory Citations

There are a number of different conventions used to cite legislation and regulations. In this manual, the following conventions have been used:

- When citing the *United States Code*, the abbreviation U.S.C. is used. The abbreviation is preceded by the Title of the U.S.C. and then followed by the section number.  
Example: 16 U.S.C. 1531 *et seq.* and 33 U.S.C. §§ 1251-1387.

- When citing the Clean Water Act, the abbreviation CWA is used. The abbreviation is followed by the word *section* and then the section number.  
Example: CWA section 402 and CWA section 402(o).
- When citing the *Code of Federal Regulations* (CFR), the convention depends on the location of the reference. For first references, the abbreviation CFR is preceded by the title number of the CFR and followed either by the word *Part* (if it is a part—a whole number) or the number of the subsection (if it is a subpart/subsection). For subsequent references, the title and CFR are omitted and just the word *Part* or the section symbol (§) is used.  
Example: First citation: 40 CFR Part 136 or 40 CFR 122.44  
Subsequent citations: Part 136 or § 122.44.

Almost all the regulatory citations in this manual are for Title 40 of the CFR (with the exception of the other federal laws referenced in section 11.1 of this manual). Any other Titles are explicitly referenced and in the format for the first regulatory citation (e.g., 50 CFR Part 402).

## Electronic NPDES Information

Websites and electronically stored publications and data are available to help permit writers draft NPDES permits. Tools have been created to assist permit writers with specific aspects of permit development and are discussed in their respective sections. The electronic tools listed below apply to all aspects of permit development and serve as valuable references for the permit writer.

### NPDES Website and Resources

The Water Permits Division (WPD) within the EPA Office of Water (OW), Office of Wastewater Management, has developed a comprehensive NPDES Website <[www.epa.gov/npdes](http://www.epa.gov/npdes)> with technical and regulatory information about the NPDES permit program, information on related programs and initiatives, and documents published by WPD. Where applicable, this manual references the NPDES Website and provides links to relevant documents on that site. This manual also references other EPA and non-EPA websites that contain information that might be helpful to NPDES permit writers. Note, however, that EPA is not responsible for information provided on websites outside the EPA Website <[www.epa.gov](http://www.epa.gov)>.

WPD also has prepared several websites and other resources to help permit writers draft permits. This manual references those websites and resources in the appropriate section of this manual.

### Electronic Permitting Tools

Many EPA Regions and authorized states have developed tools to help them manage the permit issuance process. Electronic permitting tools range from spreadsheets and word processing applications to sophisticated Web-based systems that enable permitting authorities to manage their entire environmental program. For example, some states have built systems that enable dischargers to electronically sign and submit discharge reports; create, track, and store permit documents; and manage enforcement, compliance, and inspections related to permits. As technologies continue to evolve, many permitting authorities are likely to begin using more information technology applications to manage the process of permitting.

## ICIS-NPDES

Together with OW, the Office of Enforcement and Compliance Assurance (OECA) is responsible for oversight of implementation of the NPDES program. OW is responsible for the NPDES implementing regulations and oversight of permit issuance by states and EPA Regions. OECA, along with its regional, state, tribal and local counterparts, is responsible for tracking and maintaining enforcement and compliance activities, monitoring and enforcement and compliance status of the regulated community, and reviewing and evaluating program performance. OECA also maintains national data systems to support program management and oversight of the NPDES program.

The Permit Compliance System (PCS), one of two national NPDES electronic databases, supports the management and oversight of the NPDES program. Since the last modernization of PCS in 1985, the NPDES program has evolved significantly to include additional program requirements, such as the NPDES program for stormwater and implementation of the Combined Sewer Overflow Control Policy. Because of limitations to PCS, OECA is working to phase out this system and move to a more modern data management system described below.

### The Integrated Compliance Information System for NPDES permits (ICIS-NPDES)

<<https://icis.epa.gov/icis>>, the successor to PCS, provides an updated system that enables national program management and oversight activities such as

- Permit tracking and management.
- Compliance monitoring.
- NPDES program management.
- Enforcement actions.

ICIS-NPDES is a Web-based system with an electronic database capable of handling the large amount of data generated by and about the NPDES program. Section 11.5.1.1 of this manual provides more information on ICIS-NPDES as it relates to NPDES permit compliance.

## Hyperlinks in this Document

Where a website provides supplementary information or is referenced in this manual, the actual site or higher level site address appears in the symbols < > so that readers will have a reference to the address even in a printed version of this document. In the electronic version of the manual, the text in carats is also the hyperlink to the referenced website. Care has been taken to provide the correct Web addresses and hyperlinks; however, these references can change or become outdated after this manual's publication.

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<sup>1</sup> U.S. Environmental Protection Agency. 1996. *U.S. EPA NPDES Permit Writers' Manual*. EPA-833-B-96-003. U.S. Environmental Protection Agency, Office of Water, Washington, DC. <[www.epa.gov/npdes/pubs/owm0243.pdf](http://www.epa.gov/npdes/pubs/owm0243.pdf)>. Separate sections of this document are also available on the NPDES Website by going to <[www.epa.gov/npdes](http://www.epa.gov/npdes)>, clicking on Publications and entering NPDES Permit Writers' Manual in the Search box.

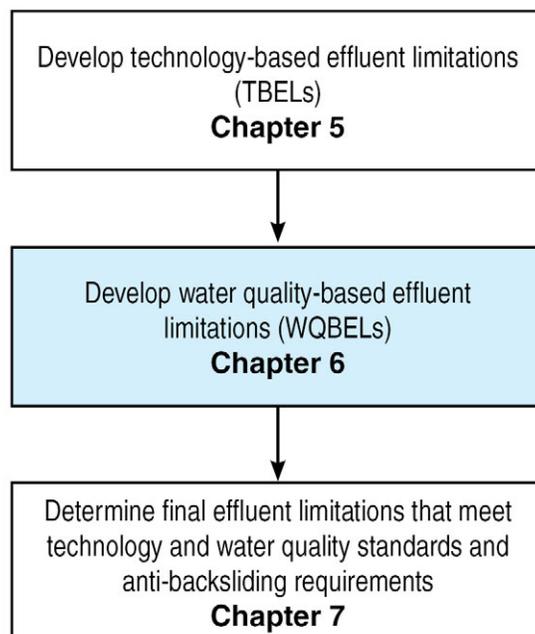
<sup>2</sup> U.S. Environmental Protection Agency. 1993. *Training Manual for NPDES Permit Writers*. EPA-833-B-93-003. U.S. Environmental Protection Agency, Office of Wastewater Management, Washington, DC. <[www.epa.gov/npdes/pubs/owm0339.pdf](http://www.epa.gov/npdes/pubs/owm0339.pdf)>.

## CHAPTER 6. Water Quality-Based Effluent Limitations

When drafting a National Pollutant Discharge Elimination System (NPDES) permit, a permit writer must consider the impact of the proposed discharge on the quality of the receiving water. Water quality goals for a waterbody are defined by state water quality standards. By analyzing the effect of a discharge on the receiving water, a permit writer could find that technology-based effluent limitations (TBELs) alone will not achieve the applicable water quality standards. In such cases, the Clean Water Act (CWA) and its implementing regulations require development of water quality-based effluent limitations (WQBELs). WQBELs help meet the CWA objective of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters and the goal of water quality that provides for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water (*fishable/swimmable*).

WQBELs are designed to protect water quality by ensuring that water quality standards are met in the receiving water. On the basis of the requirements of 40 CFR 125.3(a), additional or more stringent effluent limitations and conditions, such as WQBELs, are imposed when TBELs are not sufficient to protect water quality. Exhibit 6-1 illustrates the relationship between TBELs and WQBELs in an NPDES permit, as well as the determination of final effluent limitations.

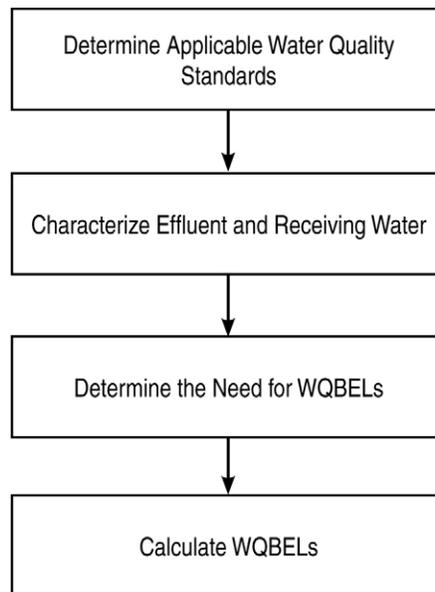
**Exhibit 6-1 Developing effluent limitations**



CWA section 301(b)(1)(C) requires that permits include any effluent limitations necessary to meet water quality standards. As illustrated above, to satisfy that requirement, permit writers implement a process to determine when existing effluent limitations (e.g., TBELs) and existing effluent quality are not sufficient to comply with water quality standards and to, where necessary, develop WQBELs. Exhibit 6-2 illustrates the four basic parts of the *standards-to-permits* process used to assess the need for and develop WQBELs.

After completing that process, the permit writer determines the final effluent limitations, includes any compliance schedules and interim effluent limitations, as appropriate, and documents all his or her decisions and calculations.

### Exhibit 6-2 Standards-to-permits process



This chapter provides basic information on the standards-to-permits process. For more detailed information on water quality standards and water quality-based permitting, and some of the specific topics discussed in this chapter, refer to the [NPDES Website](http://www.epa.gov/npdes) <[www.epa.gov/npdes](http://www.epa.gov/npdes)> and [Water Quality Standards Website](http://www.epa.gov/waterscience/standards) <[www.epa.gov/waterscience/standards](http://www.epa.gov/waterscience/standards)>.

## 6.1 Determine Applicable Water Quality Standards

CWA section 303(c) and Title 40 of the *Code of Federal Regulations* (CFR) Part 131 establish the framework for water quality standards. The CWA and implementing regulations require states to develop and, from time to time, revise water quality standards applicable to waters of the United States, or segments of such waterbodies, that are in the jurisdiction of the state. States must review their water quality standards at least once every 3 years and revise them as appropriate. Wherever attainable, water quality standards should protect water quality that provides for the protection and propagation of fish, shellfish and wildlife, and recreation in and on the water (i.e., the CWA section 101(a)(2) *fishable/swimmable* goal). In establishing standards, states must consider the use and value of their waters for public water supplies, propagation of fish and wildlife, recreation, agriculture and industrial purposes, and navigation. The U.S. Environmental Protection Agency (EPA) has provided information regarding procedures for developing water quality standards in the Water Quality Standards Regulation at Part 131 and EPA's *Water Quality Standards Handbook: Second Edition*<sup>1</sup> <[www.epa.gov/waterscience/library/wqstandards/handbook.pdf](http://www.epa.gov/waterscience/library/wqstandards/handbook.pdf)> (hereafter *WQS Handbook*). Under CWA section 510, states may develop water quality standards that are more stringent than those required by the CWA.

EPA Regions review and approve or disapprove new and revised water quality standards adopted by states. The purpose of EPA's review is to ensure that the new and revised water quality standards meet the requirements of the CWA and the Water Quality Standards Regulation. Water quality standards adopted and submitted to EPA after May 30, 2000, must be approved by EPA before they may be used to implement the CWA (e.g., used in NPDES permitting). If an EPA Region disapproves a submitted new or revised state water quality standard, and the state does not adopt the necessary changes within 90 days of notification of the disapproval, EPA must promptly propose and promulgate a replacement standard [see § 131.22(a)].

When writing an NPDES permit, the permit writer must identify and use the state water quality standards in effect for CWA purposes. EPA maintains a compilation of current state water quality standards on the Water Quality Standards: State, Tribal, & Territorial Standards Website <[www.epa.gov/waterscience/standards/wqslibrary/](http://www.epa.gov/waterscience/standards/wqslibrary/)>. In addition, EPA's Water Quality Standards: Laws and Regulations Website <<http://www.epa.gov/waterscience/standards/rules/>> provides federally promulgated standards applicable to specific states. The remainder of this section provides permit writers with a general overview of water quality standards and how they are implemented in NPDES permits.

### 6.1.1 Components of Water Quality Standards

Water quality standards comprise three parts:

- Designated uses.
- Numeric and/or narrative water quality criteria.
- Antidegradation policy.

Each of those three components, along with general policies that also may be included in state water quality standards, is described below.

#### 6.1.1.1 Designated Uses (§ 131.10)

The first part of a state's water quality standards is a classification system for waterbodies based on the expected uses of those waterbodies. The uses in this system are called *designated uses*. The regulations at § 131.10(a) describe various uses of waters that are considered desirable and that must be considered when establishing water quality standards. Those uses include public water supplies, propagation of fish, shellfish, and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation. The regulations allow states to designate more specific uses (e.g., cold water aquatic life) [see § 131.10(c)] or uses not specifically mentioned in the CWA, with the exception of waste transport and assimilation, which are not acceptable designated uses [see § 131.10(a)]. States must also consider and ensure the attainment and maintenance of the water quality standards of downstream waters when establishing designated uses [see § 131.10(b)].

The regulations in § 131.10(j) effectively establish a *rebuttable presumption* that the uses in CWA section 101(a)(2) (fishable/swimmable) are attainable. If a state fails to designate a given waterbody for such uses, or wishes to remove such uses, it must provide appropriate documentation demonstrating why such uses are not attainable. This analysis is commonly called a *Use Attainability Analysis* (UAA) (see § 131.3(g) and section 6.1.2.1 below).

### 6.1.1.2 Water Quality Criteria (§ 131.11)

The second part of a state's water quality standards is the set of water quality criteria sufficient to support the designated uses of each waterbody. EPA's Water Quality Standards Regulation at § 131.11(a) requires states to adopt water quality criteria using sound scientific rationale and to include sufficient parameters or constituents to protect the designated use. If a waterbody has multiple use designations, the criteria must support the most sensitive use. The regulation at § 131.11(b) allows states to adopt both numeric and narrative water quality criteria. Numeric water quality criteria are developed for specific parameters to protect aquatic life and human health and, in some cases, wildlife from the deleterious effects of pollutants. States establish narrative criteria where numeric criteria cannot be established, or to supplement numeric criteria. Criteria newly adopted or revised on or after May 30, 2000, do not become effective for purposes of the CWA until approved by EPA (see § 131.21(c)).

CWA section 304(a) directs EPA to develop, publish, and, from time to time, revise criteria for water quality accurately reflecting the latest scientific knowledge on the following:

- The kind and extent of all identifiable effects on health and welfare, including effects on aquatic life and recreational uses, that may be expected from the presence of pollutants in any body of water.
- The concentration and dispersal of pollutants or their byproducts through biological, physical, and chemical processes.
- The effects of pollutants on biological community diversity, productivity, and stability.

EPA's recommended criteria developed under CWA section 304(a) assist states in developing their water quality standards. EPA's numeric criteria are ambient levels of individual pollutants or parameters or they describe conditions of a waterbody that, if met, generally will protect the CWA section 101(a)(2) fishable and swimmable uses. EPA's recommended criteria developed under CWA section 304(a) do not reflect consideration of economic impacts or the technological feasibility of meeting the chemical concentrations in ambient water. EPA provides a table of the nationally recommended CWA section 304(a) criteria on the National Recommended Water Quality Criteria Website <[www.epa.gov/waterscience/criteria/wqctable/](http://www.epa.gov/waterscience/criteria/wqctable/)>. The regulation at § 131.11(b)(1) indicates that, in establishing numeric criteria, states may (1) adopt EPA's recommended criteria published under CWA section 304(a), (2) adopt those criteria modified to reflect site-specific conditions, or (3) adopt criteria based on other scientifically defensible methods.

CWA section 303(c)(2)(B) specifically requires states to adopt numeric criteria for CWA section 307(a) toxic (priority) pollutants for which EPA has published recommended criteria if the discharge or presence of the pollutant can reasonably be expected to interfere with designated uses. Furthermore, § 131.11(a)(2) requires states to review water quality data and information on discharges to identify specific water bodies where toxic pollutants might be adversely affecting water quality or attainment of designated uses or where levels of toxic pollutants would warrant concern and to adopt criteria for such toxic pollutants applicable to the waterbody that are sufficient to protect the designated use. As discussed in section 1.2 and presented in Exhibit C-1 in Appendix C of this manual, the CWA section 307(a) list contains 65 compounds and families of compounds, which EPA has interpreted to include 126 toxic (priority) pollutants.

## Numeric Criteria—Aquatic Life

Numeric criteria for the protection of aquatic life are designed to protect aquatic organisms, including both plants and animals. EPA's aquatic life criteria address both short-term (acute) and long-term (chronic) effects on both freshwater and saltwater species. Each of those criteria generally consists of three components:

- **Magnitude:** The level of pollutant (or pollutant parameter), usually expressed as a concentration, that is allowable.
- **Duration:** The period (averaging period) over which the in-stream concentration is averaged for comparison with criteria concentrations.
- **Frequency:** How often criteria may be exceeded.

### Are criteria and effluent limitations expressed in the same terms?

Generally, criteria and effluent limitations are not expressed in the same terms. As discussed above, criteria are generally expressed as a magnitude, duration and frequency. Effluent limitations in NPDES permits are generally expressed as a magnitude (e.g., milligrams per liter, micrograms per liter) and an averaging period (e.g., maximum daily, average weekly, average monthly). A permit writer should be aware of the procedures used by his or her permitting authority to appropriately reflect the magnitude, duration, and frequency components of aquatic life criteria when determining the need for and calculating effluent limitations for NPDES permits. Typically, the components of the criteria are addressed in water quality models through the use of statistically derived receiving water and effluent flow values that ensure that criteria are met under *critical conditions* (see section 6.2 below).

Exhibit 6-3 is an example of freshwater aquatic life criteria for cadmium from the National Recommended Water Quality Criteria Website <[www.epa.gov/waterscience/criteria/wqctable/](http://www.epa.gov/waterscience/criteria/wqctable/)> and at 66 FR 18935, April 12, 2001, Notice of Availability of 2001 Update: Aquatic Life Criteria Document for Cadmium <[www.epa.gov/EPA-WATER/2001/April/Day-12/w9056.htm](http://www.epa.gov/EPA-WATER/2001/April/Day-12/w9056.htm)>.

### Exhibit 6-3 Aquatic life criteria example: Cadmium (dissolved)

Except possibly where a locally important species is unusually sensitive, freshwater aquatic organisms and their uses should not be affected unacceptably if

#### Chronic criterion:

The 4-day average concentration (in micrograms per liter [ $\mu\text{g/L}$ ]) does not exceed the numerical value given by  $e^{(0.7409[\ln(\text{hardness})]-4.719)}$  (1.101672 – [( $\ln$  hardness)(0.041838)]) more than once every 3 years on average.

#### Acute criterion:

The 24-hour average concentration (in  $\mu\text{g/L}$ ) does not exceed the numerical value given by  $e^{(1.0166[\ln(\text{hardness})]-3.924)}$  (1.136672 – [( $\ln$  hardness)(0.041838)]) more than once every 3 years on average.

It is apparent that the acute and chronic aquatic life criteria for cadmium are not simply single numbers. Rather, they are expressed as a magnitude, a duration (4-day average or 24-hour average), and a frequency (not more than once every 3 years). Furthermore, the magnitude is expressed by a formula that is hardness-dependent, as is the case for most criteria for metals.

The magnitude of other aquatic life criteria can vary according to other conditions in the water or even based on the presence or absence of certain aquatic life. For example, EPA's 1999 recommended ammonia criteria vary according to pH, temperature, the presence or absence of salmonid species, and the presence or absence of early life stages of fish. A permit writer must be aware of the applicable criteria and any state regulations, policies, and procedures for interpreting numeric criteria and for implementing the criteria in NPDES permits. The durations of aquatic life criteria vary as well. For example, EPA's criteria recommendations for ammonia include a 30-day average chronic criterion. Also, many acute criteria for toxic pollutants are expressed as a 1-hour average. The frequency component of most aquatic life criteria specifies that they should be exceeded no more than once every three years.

Some states have adopted numeric criteria for nutrients as part of their water quality standards. EPA has developed nutrient criteria recommendations that are numeric values for both causative (phosphorus and nitrogen) and response (chlorophyll *a* and turbidity) variables associated with the prevention and assessment of eutrophic conditions. EPA's recommended nutrient criteria are different from most of its other recommended criteria, such as the criteria for cadmium and ammonia. First, EPA's recommended nutrient criteria are *ecoregional* rather than nationally applicable criteria, and they can be refined and localized using nutrient criteria technical guidance manuals. Second, the recommended nutrient criteria represent conditions of surface waters that have minimal impacts caused by human activities rather than values derived from laboratory toxicity testing. Third, the recommended nutrient criteria do not include specific duration or frequency components; however, the ecoregional nutrient criteria documents indicate that states may adopt seasonal or annual averaging periods for nutrient criteria instead of the 1-hour, 24-hour, or 4-day average durations typical of aquatic life criteria for toxic pollutants. The ecoregional nutrient criteria documents, technical guidance manuals, and other information on EPA's nutrient criteria recommendations, are available on the Water Quality Criteria for Nitrogen and Phosphorus Pollution Website <[www.epa.gov/waterscience/criteria/nutrient/](http://www.epa.gov/waterscience/criteria/nutrient/)>.

Water quality standards also typically include aquatic life criteria for parameters such as temperature and pH that are not chemical constituents. Criteria for pH generally are expressed as an acceptable pH range in the waterbody. Temperature criteria might be expressed as both *absolute temperature values* (e.g., temperature may not exceed 18 degrees Celsius [°C]) and restrictions on causing *changes in temperature* in the waterbody (e.g., discharges may not warm receiving waters by more than 0.5 °C).

In addition to criteria for individual pollutants or pollutant parameters, many states include in their water quality standards criteria for dissolved oxygen. Often, criteria for dissolved oxygen are addressed by modeling and limiting discharges of oxygen-demanding pollutants such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), and nutrients (phosphorus and nitrogen).

Finally, states could also include in their water quality standards numeric criteria to address the effect of mixtures of pollutants. For example, whole effluent toxicity (WET) criteria protect the waterbody from the aggregate and synergistic toxic effects of a mixture of pollutants. WET is discussed in detail later in this chapter.

### Numeric Criteria—Human Health

Human health criteria for toxic pollutants are designed to protect people from exposure resulting from consumption of fish or other aquatic organisms (e.g., mussels, crayfish) or from consumption of both water and aquatic organisms. These criteria express the highest concentrations of a pollutant that are not

expected to pose significant long-term risk to human health. Exhibit 6-4 is an example of human health criteria for dichlorobromomethane.

#### Exhibit 6-4 Human health criteria example: Dichlorobromomethane

For the protection of human health from the potential carcinogenic effects of dichlorobromomethane through ingestion of water and contaminated aquatic organisms, the ambient water criterion is determined to be 0.55 µg/L.

For the protection of human health from the potential carcinogenic effects of dichlorobromomethane through ingestion contaminated aquatic organisms alone, the ambient water criterion is determined to be 17 µg/L.

These values were calculated based on a national default freshwater/estuarine fish consumption rate of 17.5 grams per day.

Other criteria for protection of human health (e.g., bacteria criteria) consider a shorter-term exposure through uses of the waterbody such as contact recreation. EPA's current bacteria criteria recommendations use enterococci and *Escherichia coli* bacteria as indicators and include two components: a geometric mean value and a single sample maximum value. EPA has developed information on implementing those criteria in water quality standards on the [Microbial \(Pathogen\) Water Quality Criteria Website](http://www.epa.gov/waterscience/criteria/humanhealth/microbial/) <[www.epa.gov/waterscience/criteria/humanhealth/microbial/](http://www.epa.gov/waterscience/criteria/humanhealth/microbial/)>.

#### Other Numeric Criteria

In addition to aquatic life and human health criteria, some state water quality standards include other forms of numeric criteria, such as wildlife, sediment, and biocriteria.

Wildlife criteria are derived to establish ambient concentrations of chemicals that, if not exceeded, will protect mammals and birds from adverse impacts resulting from exposure to those chemicals through consumption of aquatic organisms and water. EPA established four numeric criteria to protect wildlife in the Great Lakes system in its *Final Water Quality Guidance for the Great Lakes System* <[www.epa.gov/EPA-WATER/1995/March/Day-23/pr-82.html](http://www.epa.gov/EPA-WATER/1995/March/Day-23/pr-82.html)> (60 FR 15387, March 23, 1995).

In a healthy aquatic community, sediments provide a habitat for many living organisms. Controlling the concentration of pollutants in the sediment helps to protect bottom-dwelling species and prevents harmful toxins from moving up the food chain and accumulating in the tissue of animals at progressively higher levels. For more information on this topic, see EPA's [Suspended and Bedded Sediments Website](http://www.epa.gov/waterscience/criteria/sediment/) <<http://www.epa.gov/waterscience/criteria/sediment/>>.

The presence, condition and numbers of types of fish, insects, algae, plants, and other organisms are data that, together, provide direct, accurate information about the health of specific bodies of water. Biological criteria (biocriteria) are narrative or numeric expressions that describe the reference biological integrity (structure and function) of aquatic communities inhabiting waters of a given designated aquatic life use. Biocriteria are based on the numbers and kinds of organisms present and are regulatory-based biological measurements. They are used as a way of describing the qualities that must be present to support a desired condition in a waterbody, and they serve as the standard against which biological assessment results are compared. EPA's [Biocriteria: Uses of Data in NPDES Permits Website](http://www.epa.gov/waterscience/biocriteria/watershed/npdes.html) <<http://www.epa.gov/waterscience/biocriteria/watershed/npdes.html>> provides more information on the use of bioassessment information.

## Narrative Criteria

All states have adopted narrative water quality criteria to supplement numeric criteria. Narrative criteria are statements that describe the desired water quality goal for a waterbody. Narrative criteria, for example, might require that discharges be “free from toxics in toxic amounts” or be “free of objectionable color, odor, taste, and turbidity.” Narrative criteria can be the basis for limiting specific pollutants for which the state does not have numeric criteria [§ 122.44(d)(1)(vi)] or they can be used as the basis for limiting toxicity using WET requirements where the toxicity has not yet been traced to a specific pollutant or pollutants [§ 122.44(d)(1)(v)]. For toxic pollutants, EPA’s Water Quality Standards Regulation at § 131.11(a)(2) requires states to develop implementation procedures for toxics narrative criteria that address how the state intends to regulate point source discharges of toxic pollutants to water quality limited segments.

### 6.1.1.3 Antidegradation Policy (§ 131.12)

The third part of a state’s water quality standards is its antidegradation policy. Each state is required to adopt an antidegradation policy consistent with EPA’s antidegradation regulations at § 131.12. A state’s antidegradation policy specifies the framework to be used in making decisions about proposed activities that will result in changes in water quality. Antidegradation policies can play a critical role in helping states protect the public resource of water whose quality is better than established criteria levels and ensure that decisions to allow reductions in water quality are made in a public manner and serve the public good. Along with developing an antidegradation policy, each state must identify the method it will use to implement the policy. It is important for permit writers to be familiar with their state’s antidegradation policy and how that policy is to be implemented in NPDES permits.

A state’s antidegradation policy provides three levels of protection from degradation of existing water quality:

- **Tier 1:** This tier requires that existing uses, and the level of water quality necessary to protect the existing uses, be maintained and protected.
- **Tier 2:** Where the quality of waters exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water (sometimes referred to as *high-quality waters*), Tier 2 requires that this level of water quality be maintained and protected unless the state finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the state’s continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area where the waters are located. In allowing any such degradation or lower water quality, the state must assure water quality adequate to protect existing uses fully and must assure that there will be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control.
- **Tier 3:** This tier requires that the water quality of outstanding national resources waters (ONRWs) be maintained and protected.

States take a variety of approaches to implementing antidegradation policies. Some states designate their waters as Tier 1, Tier 2 (high-quality water) or Tier 3 waters in their antidegradation implementation methods, while others designate a waterbody as a Tier 2 or high-quality water only when activities that would degrade water quality are proposed. In some cases, states may have classified the waterbody as

receiving a tier of protection for all pollutant-related parameters, whereas in other cases, tiers of protection have been determined on a parameter-by-parameter basis.

#### 6.1.1.4 General Policies (§ 131.13)

In addition to the three required components of water quality standards, states may, at their discretion, include in their standards policies that generally affect how the standards are applied or implemented. Examples of such policies include mixing zone policies, critical low flows at which criteria must be achieved, and the availability of variances. Some general policies are discussed in more detail later in this chapter. As with the other components of water quality standards, general policies are subject to EPA review and approval if they are deemed to be new or revised water quality standards (i.e., if they constitute a change to designated use(s), water quality criteria, antidegradation requirements, or any combination).

Additional and more detailed information on water quality standards is available in the WQS Handbook.

### 6.1.2 Water Quality Standards Modifications

Permit writers should be aware of several types of modifications to water quality standards that could permanently or temporarily change the standards and, thus, change the fundamental basis of WQBELs. Those modifications, described below, are as follows:

- Designated use reclassification.
- Site-specific water quality criteria modification.
- Water quality standard variance.

#### 6.1.2.1 Designated Use Reclassification

Once a use has been designated for a particular waterbody or segment, that use may not be removed from the water quality standards except under specific conditions. To remove a designated use, the state demonstrates that attaining that use is not feasible because of any one of the six factors listed in § 131.10(g). The regulations at § 131.10(j) specifically require a state to conduct a UAA if the designated uses for a waterbody do not include the uses in CWA section 101(a)(2) (i.e., fishable/swimmable uses); if the state wishes to remove designated uses included in CWA section 101(a)(2) from its water quality standards; or if the state wishes to adopt subcategories of CWA section 101(a)(2) uses with less stringent criteria. The WQS Handbook discusses UAAs and removing designated uses in detail. Reclassifying a waterbody's designated uses, as supported by a UAA, is a permanent change to both the designated use(s) and the water quality criteria associated with that (those) use(s).

States may conduct a UAA and remove a designated use but not if it is an existing use. Existing uses are defined in § 131.3 as those uses actually attained in the waterbody on or after November 28, 1975 (the date of EPA's initial water quality standards regulation at 40 *Federal Register* 55334, November 28, 1975). At a minimum, uses are deemed attainable if they can be achieved by the implementing effluent limits required under CWA sections 301(b) and 306 and by implementing cost effective and reasonable best management practices (BMPs) for nonpoint source control. EPA's Water Quality Standards: UAA Website <<http://www.epa.gov/waterscience/standards/uses/uaa/index.htm>> provides additional information and some example UAAs.

### 6.1.2.2 Site-Specific Water Quality Criteria Modification

As noted above, CWA sections 303(a)–(c) require states to adopt water quality criteria sufficient to protect applicable designated uses. In some cases, a state might find that the criteria it has adopted to protect a waterbody or segment of a waterbody do not adequately account for site-specific conditions. In such cases, states have the option of modifying water quality criteria on a site-specific basis. Setting site-specific criteria might be appropriate where, for example, a state has adopted EPA's CWA section 304(a) criteria recommendations and finds that physical or chemical properties of the water at a site affect the bioavailability or toxicity of a chemical, or the types of local aquatic organisms differ significantly from those actually tested in developing the EPA-recommended criteria. Site-specific criteria modifications change water quality criteria permanently while continuing to support the current designated uses.

Development of site-specific criteria for aquatic life is discussed in section 3.7 of the WQS Handbook for cases when (1) there might be relevant differences in the toxicity of the chemical in the water at the site and laboratory dilution water (Water-Effect Ratio Procedure) and (2) the species at the site are more or less sensitive than those used in developing the natural criteria (Species Recalculation Procedure). EPA's Office of Science and Technology (OST) has developed the Interim Guidance on Determination and Use of Water-Effect Ratios for Metals <[www.epa.gov/waterscience/standards/handbook/handbookappxL.pdf](http://www.epa.gov/waterscience/standards/handbook/handbookappxL.pdf)> in Appendix L of the WQS Handbook and the Streamlined Water-Effect Ratio Procedure for Discharges of Copper<sup>2</sup> <[www.epa.gov/waterscience/criteria/copper/copper.pdf](http://www.epa.gov/waterscience/criteria/copper/copper.pdf)>. In addition, pages 90-97 of Appendix L provide guidance for using the Species Recalculation Procedure. States may also consider establishing aquatic life criteria based on *natural background* conditions. Further information can be found in the memo Establishing Site Specific Aquatic Life Criteria Equal to Natural Background<sup>3</sup> <[www.epa.gov/waterscience/library/wqcriteria/naturalback.pdf](http://www.epa.gov/waterscience/library/wqcriteria/naturalback.pdf)>.

### 6.1.2.3 Water Quality Standard Variance

Water quality standard variances are changes to water quality standards and have similar substantive and procedural requirements and what is required to remove a designated use. Unlike use removal, variances are time-limited and do not permanently remove the current designated use of a waterbody. Variances are usually discharger- and pollutant-specific, though some states have adopted *general variances*. Where a state has adopted a general variance, the analyses necessary for the variance have been completed on a watershed-wide or statewide basis and, therefore, the process of obtaining a variance is simplified for individual dischargers in that watershed or state.

A variance might be appropriate where the state believes that the existing standards are ultimately attainable and that, by retaining the existing standards rather than changing them, the state would ensure that further progress is made in improving the water quality toward attaining the designated uses while the variance is in effect. State-adopted variances have been approved by EPA where, among other things, the state's standards allow variances and the state demonstrates that meeting the applicable criteria is not feasible on the basis of one or more of the factors outlined in § 131.10(g). A variance typically is granted for a specified period and must be reevaluated at least once every 3 years as reasonable progress is made toward meeting the standards [see section 5.3 of the WQS Handbook and § 131.20(a)].

Modifications of water quality standards could affect effluent limitations in permits in several ways. Specifically, the modifications can change the fundamental basis for WQBELs, potentially affecting an assessment of the need for WQBELs and possibly resulting in either more or less stringent WQBELs than

would otherwise be required. It is the permit writer's responsibility to ensure that any EPA-approved modification of water quality standards is properly reflected in an affected NPDES permit.

### 6.1.3 Water Quality Standards Implementation

As previously noted, CWA section 301(b)(1)(C) requires NPDES permits to establish effluent limitations as necessary to meet water quality standards. Effluent limitations and other conditions in NPDES permits may be based on a parameter-specific approach or a WET testing approach to implementing water quality standards. A third approach to implementing water quality standards, using biocriteria or bioassessment, is not directly accomplished through NPDES permit effluent limitations but can lead to effluent limitations for specific parameters or for WET. Each of those approaches to implementing water quality standards is discussed briefly below.

#### What procedures should permit writers use to implement water quality standards?

The terminology used and procedures described in this manual when discussing both assessing the need for and calculating WQBELs are based on the procedures in EPA's *Technical Support Document for Water Quality-Based Toxics Control*<sup>4</sup> <[www.epa.gov/npdes/pubs/owm0264.pdf](http://www.epa.gov/npdes/pubs/owm0264.pdf)> (hereafter *TSD*). Those procedures were developed specifically to address toxic pollutants but have been appropriately used to address a number of conventional and nonconventional pollutants as well. Permit writers should be aware that most permitting authorities have developed their own terminology and procedures for water quality-based permitting, often derived from, but with variations on, EPA's guidance. For example, EPA itself promulgated *Final Water Quality Guidance for the Great Lakes System* (60 FR 15387, March 23, 1995) with minimum water quality criteria, antidegradation policies, and implementation procedures, including permitting procedures based on the TSD. Under the CWA, Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin were required to adopt procedures for the Great Lakes system that are consistent with that guidance. Permit writers should always consult the applicable permitting regulations, policy, and guidance for the approved water quality-based permitting procedures in their state.

#### 6.1.3.1 Parameter-Specific Approach

The parameter-specific approach uses parameter-specific criteria for protection of aquatic life, human health, wildlife, and sediments, as well as any other parameter-specific criteria adopted into a state's water quality standards. The criteria are the basis for analyzing an effluent, deciding which parameters need controls, and deriving effluent limitations that will control those parameters to the extent necessary to achieve water quality standards in the receiving water. Parameter-specific WQBELs in NPDES permits involve a site-specific evaluation of the discharge (or proposed discharge) and its potential effect on the receiving water or an evaluation of the effects of multiple sources of a pollutant on the receiving water (e.g., through a total maximum daily load [TMDL] analysis). The parameter-specific approach allows for controlling individual parameters, (e.g., copper, BOD, total phosphorus) before a water quality impact has occurred or for helping return water quality to a level that will meet designated uses.

#### 6.1.3.2 Whole Effluent Toxicity (WET) Approach

WET requirements in NPDES permits protect aquatic life from the aggregate toxic effect of a mixture of pollutants in the effluent. WET tests measure the degree of response of exposed aquatic test organisms to an effluent. The WET approach is useful for complex effluents where it might be infeasible to identify

and regulate all toxic pollutants in the effluent or where parameter-specific effluent limitations are set, but the combined effects of multiple pollutants are suspected to be problematic. The WET approach allows a permit writer to implement numeric criteria for toxicity included in a state's water quality standards or to be protective of a narrative "no toxics in toxic amounts" criterion. Like the parameter-specific approach, the WET approach allows permitting authorities to control toxicity in effluents before toxic impacts occur or may be used to help return water quality to a level that will meet designated uses.

### 6.1.3.3 Bioassessment Approach

The biocriteria approach is used to assess the overall biological integrity of an aquatic community. As discussed in section 6.1.1 above, biocriteria are numeric values or narrative statements that describe the biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use. When incorporated into state water quality standards, biocriteria and aquatic life use designations serve as direct endpoints for determining aquatic life use attainment. Once biocriteria are developed, the biological condition of a waterbody can be measured through a biological assessment, or bioassessment.

A bioassessment is an evaluation of the biological condition of a waterbody using biological surveys and other direct measurements of resident biota in surface waters. A biological survey, or biosurvey, consists of collecting, processing, and analyzing representative portions of a resident aquatic community to determine the community structure and function. The results of biosurveys can be compared to the reference waterbody to determine if the biocriteria for the designated use of the waterbody are being met. EPA issued guidance on this approach in *Biological Criteria: National Program Guidance for Surface Waters*<sup>5</sup> <[www.epa.gov/bioindicators/html/biolcont.html](http://www.epa.gov/bioindicators/html/biolcont.html)>. As previously discussed, biocriteria generally are not directly implemented through NPDES permits but could be used in assessing whether a waterbody is attaining water quality standards. Nonattainment of biocriteria could lead to parameter-specific effluent limitations where the permitting authority is able to identify specific pollutant(s) and source(s) contributing to that nonattainment (see *EPA's Biocriteria: Uses of Data – Identify Stressors to a Waterbody Website* <<http://www.epa.gov/waterscience/biocriteria/uses/stressors.html>> or could lead to WET limitations where the permitting authority identifies sources of toxicity to aquatic life. EPA's *Biocriteria: Uses of Data - NPDES* <<http://www.epa.gov/waterscience/biocriteria/watershed/npdes.html>> provides examples on the use of bioassessment information in the NPDES permitting process.

Sections 6.2–6.4 below discuss, in detail, implementing water quality standards using the parameter-specific approach to assess the need for and develop effluent limitations in NPDES permits. Section 6.5 below provides additional detail on WET requirements in NPDES permits.

## 6.2 Characterize the Effluent and the Receiving Water

After identifying the most current, approved, water quality standards that apply to a waterbody, a permit writer should characterize both the effluent discharged by the facility being permitted and the receiving water for that discharge. The permit writer uses the information from those characterizations to determine whether WQBELs are required (section 6.3 below) and, if so, to calculate WQBELs (section 6.4 below). Characterizing the effluent and receiving water can be divided into five steps as shown in Exhibit 6-5 and discussed in detail below.

**Exhibit 6-5 Steps for characterizing the effluent and receiving water**

- Step 1. Identify pollutants of concern in the effluent
- Step 2. Determine whether water quality standards provide for consideration of a dilution allowance or mixing zone
- Step 3. Select an approach to model effluent and receiving water interactions
- Step 4. Identify effluent and receiving water critical conditions
- Step 5. Establish an appropriate dilution allowance or mixing zone

**6.2.1 Step 1: Identify Pollutants of Concern in the Effluent**

There are several sources of information for and methods of identifying pollutants of concern for WQBEL development. For some pollutants of concern, the permit writer might not need to conduct any further analysis and could, after characterizing the effluent and receiving water, proceed directly to developing WQBELs (section 6.4 below). For other pollutants of concern, the permit writer uses the information from the effluent and receiving water characterization to assess the need for WQBELs (section 6.3 below). The following subsections identify five categories of pollutants of concern for WQBEL development.

**6.2.1.1 Pollutants with Applicable TBELs**

One category of pollutants of concern includes those pollutants for which the permit writer has developed TBELs based on national or state technology standards or on a case-by-case basis using best professional judgment. By developing TBELs for a pollutant, the permit writer has already determined that there will be some type of final limitations for that pollutant in the permit and must then determine whether more stringent limitations than the applicable TBELs are needed to prevent an excursion above water quality standards in the receiving water (see Exhibit 6-1 above). A permit writer can determine whether the TBELs are sufficiently protective by either proceeding to calculate WQBELs as described in section 6.4 below and comparing them to the TBELs or by assuming that the maximum daily TBEL calculated is the maximum discharge concentration in the water quality assessments described in section 6.3 below.

**6.2.1.2 Pollutants with a Wasteload Allocation from a TMDL**

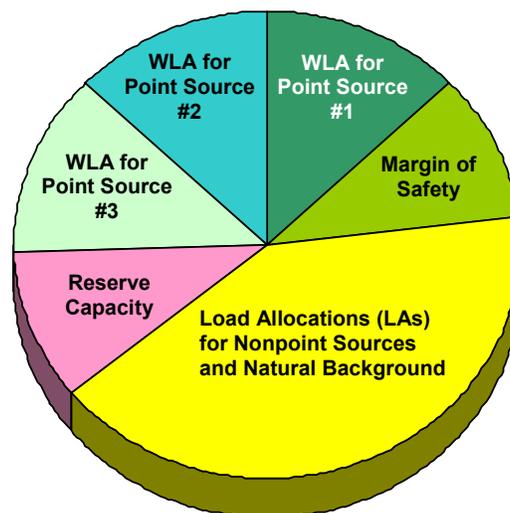
Pollutants of concern include those pollutants for which a *wasteload allocation* (WLA) has been assigned to the discharge through a TMDL. Under CWA section 303(d), states are required to develop lists of impaired waters. Impaired waters are those that do not meet the water quality standards set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that those jurisdictions establish priority rankings for waters on their CWA section 303(d) list and develop TMDLs for those waters.

**What is a WLA?**

The term WLA refers to the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution [see § 130.2(h)]. The WLA could be allocated through an EPA-approved TMDL, an EPA or state watershed loading analysis, or a facility-specific water quality modeling analysis.

A TMDL is a calculation of the maximum amount of a single pollutant that a waterbody can receive and still meet water quality standards and an allocation of that amount to the pollutant's sources. The portions of the TMDL assigned to point sources are WLAs, and the portions assigned to nonpoint sources and background concentrations of the pollutant are called *load allocations* (LAs). The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes designated in the water quality standards, to provide for the uncertainty in predicting how well pollutant reduction will result in meeting water quality standards, and to account for seasonal variations. A TMDL might also include a reserve capacity to accommodate expanded or new discharges in the future. Exhibit 6-6 depicts the parts of a TMDL.

**Exhibit 6-6 Parts of a TMDL**



$$\text{TMDL} = \Sigma \text{WLA} + \Sigma \text{LA} + \text{Margin of Safety} + \text{Reserve Capacity}$$

The NPDES regulations at § 122.44(d)(1)(vii)(B) require that NPDES permits include effluent limitations developed consistent with the assumptions and requirements of any WLA that has been assigned to the discharge as part of an approved TMDL. Thus, any pollutant for which a WLA has been assigned to the permitted facility through a TMDL is a pollutant of concern.

Permit writers might also choose to consider any pollutant associated with an impairment of the receiving water a pollutant of concern, regardless of whether an approved TMDL has been developed for that pollutant, a WLA has been assigned to the permitted facility, or the permitted facility has demonstrated that the pollutant is present in its effluent. Permitting authorities might consider monitoring requirements to collect additional data related to the presence or absence of the impairing pollutant in a specific discharge to provide information for further analyses.

### 6.2.1.3 Pollutants Identified as Needing WQBELs in the Previous Permit

Another category of pollutants of concern includes those pollutants that were identified as needing WQBELs in the discharger's previous permit. Permit writers must determine whether the conditions leading to a decision to include WQBELs for the pollutant in the previous permit continue to apply. Where those conditions no longer apply, the permit writer would need to complete an anti-backsliding

analysis to determine whether to remove the WQBELs from the reissued permit. Chapter 7 of this manual provides additional information on anti-backsliding requirements of the CWA and NPDES regulations. In addition, the permit writer might need to conduct an antidegradation analysis if the revised limitation would allow degradation of the quality of the receiving water.

#### 6.2.1.4 Pollutants Identified as Present in the Effluent through Monitoring

Pollutants of concern also include any pollutants identified as present in the effluent through effluent monitoring. Effluent monitoring data are reported in the discharger's NPDES permit application, discharge monitoring reports and special studies. In addition, the permitting authority might collect data itself through compliance inspection monitoring or other special study. Permit writers can match information on which pollutants are present in the effluent to the applicable water quality standards to identify parameters that are candidates for WQBELs.

#### 6.2.1.5 Pollutants Otherwise Expected to be Present in the Discharge

A final category of pollutants of concern includes those pollutants that are not in one of the other categories but are otherwise expected to be present in the discharge. There might be pollutants for which neither the discharger nor the permitting authority have monitoring data but, because of the raw materials stored or used, products or by-products of the facility operation, or available data and information on similar facilities, the permit writer has a strong basis for expecting that the pollutant could be present in the discharge. Because there are no analytical data to verify the concentrations of these pollutants in the effluent, the permit writer must either postpone a quantitative analysis of the need for WQBELs and generate, or require the discharger to generate, effluent monitoring data, or base a determination of the need for WQBELs on other information, such as the effluent characteristics of a similar discharge. A discussion on determining the need for WQBELs without effluent monitoring data is provided in section 6.3.3 below.

### 6.2.2 Step 2: Determine Whether Water Quality Standards Provide for Consideration of a Dilution Allowance or Mixing Zone

Many state water quality standards have general provisions allowing some consideration of mixing of effluent and receiving water when determining the need for and calculating WQBELs. Depending on the state's water quality standards and implementation policy, such a mixing consideration could be expressed in the form of a *dilution allowance* or *regulatory mixing zone*. A dilution allowance typically is expressed as the flow of a river or stream, or a portion thereof. A regulatory mixing zone generally is expressed as a limited area or volume of water in any type of waterbody where initial dilution of a discharge takes place and within which the water quality standards allow certain water quality criteria to be exceeded. Section 6.2.5 below discusses dilution allowances and mixing zones in greater detail.

State water quality standards or implementation policies might indicate specific locations or conditions (e.g., breeding grounds for aquatic species or bathing beaches) or water quality criteria (e.g., pathogens, pH, bioaccumulative pollutants, or narrative criteria) for which consideration of a dilution allowance or mixing zone is not allowed or is otherwise considered inappropriate.

### 6.2.3 Step 3: Select an Approach to Model Effluent and Receiving Water Interactions

Where consideration of a dilution allowance or mixing zone is not permitted by the water quality standards or is not appropriate, the relevant water quality criterion must be attained at the point of discharge. In such cases, there is no need for a water quality model to characterize the interaction between the effluent and receiving water. In this situation effluent limitations are based on attaining water quality criteria at the “end of the pipe.”

Where a dilution allowance or mixing zone is permitted, however, characterizing the interaction between the effluent and receiving water generally requires using a water quality model. In the majority of situations, and in all of the examples provided in this manual, permit writers will use a steady-state water quality model to assess the impact of a discharge on its receiving water. Steady-state means that the model projects the impact of the effluent on the receiving water under a single or *steady* set of design conditions. Because the model is run under a single set of conditions, those conditions generally are set at *critical conditions* for protection of receiving water quality as discussed in section 6.2.4 below. The permit writer would determine the amount of the dilution allowance or the size of the mixing zone that is available under these critical conditions as provided in section 6.2.5 below.

### 6.2.4 Step 4: Identify Effluent and Receiving Water Critical Conditions

Where steady-state models are used for water quality-based permitting, an important part of characterizing the effluent and receiving water is identifying the critical conditions needed as inputs to the water quality model. Permit writers should discuss selection of critical conditions with water quality modelers or other water quality specialists. Identifying the right critical conditions is important for appropriately applying a water quality model to assess the need for WQBELs and to calculate WQBELs. Some key effluent and receiving water critical conditions are summarized below.

#### What if I am not a water quality modeler?

Permit writers are not always water quality modelers, nor do they necessarily need to be experts in this field. Many permitting authorities have a team of water quality specialists who model point source discharges to provide data required for permit writers to assess the need for and develop WQBELs. In some cases, this team might even calculate WQBELs directly for the permit writers, who then only need to compare them to TBELs and determine the final effluent limitations for the NPDES permit. Permit writers should, at a minimum, familiarize themselves with water quality modeling concepts presented in this manual, particularly the identification of critical conditions input to a steady-state water quality model, and should consult water quality modelers or other water quality specialists as needed in the process of NPDES permit development.

#### 6.2.4.1 Effluent Critical Conditions

In most any steady-state water quality model there will be at least two basic critical conditions related to the effluent: flow and pollutant concentration.

## Effluent Flow

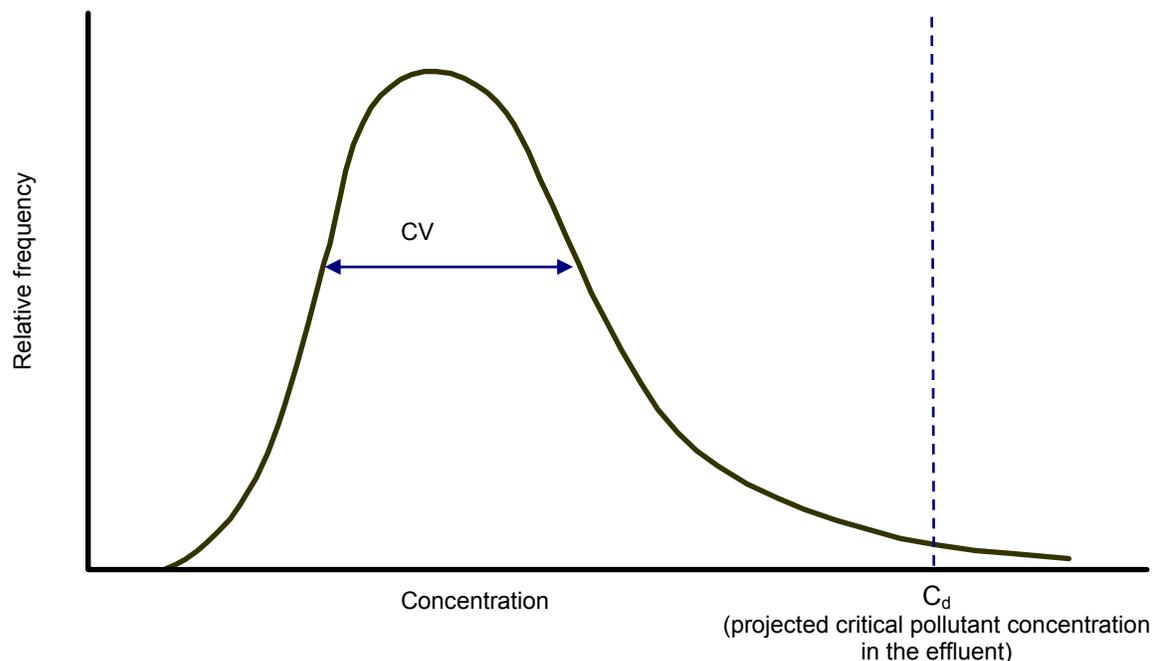
Effluent flow (designated  $Q_d$  in the water quality modeling equations used in this manual) is a critical design condition used when modeling the impact of an effluent discharge on its receiving water. A permit writer should be able to obtain effluent flow data from discharge monitoring reports or a permit application. Permitting authority policy or procedures might specify which flow measurement to use as the critical effluent flow value(s) in various water quality-based permitting calculations (e.g., the maximum daily flow reported on the permit application, the maximum of the monthly average flows from discharge monitoring reports for the past three years, the facility design flow). Permit writers should follow existing policy or procedures for determining critical effluent flow or, if the permitting authority does not specify how to determine this value, look at past permitting practices and strive for consistency.

## Effluent Pollutant Concentration

Permit writers can determine the critical effluent concentration of the pollutant of concern (designated  $C_d$ ) by gathering effluent data representative of the discharge. To establish the critical effluent pollutant concentration from the available data, EPA has recommended considering a concentration that represents something close to the maximum concentration of the pollutant that would be expected over time. In most cases, permit writers have a limited effluent data set and, therefore, would not have a high degree of certainty that the limited data would actually include the maximum potential effluent concentration of the pollutant of concern. In addition, the NPDES regulations at § 122.44(d)(1)(ii) require that permit writers consider the variability of the pollutant in the effluent when determining the need for WQBELs. To address those concerns, EPA developed guidance for permit writers on how to characterize effluent concentrations of certain types of pollutants using a limited data set and accounting for variability. This guidance is detailed in EPA's TSD.

By studying effluent data for numerous facilities, EPA determined that daily pollutant measurements of many pollutants follow a *lognormal distribution*. The TSD procedures allow permit writers to project a critical effluent concentration (e.g., the 99th or 95th percentile of a lognormal distribution of effluent concentrations) from a limited data set using statistical procedures based on the characteristics of the lognormal distribution. These procedures use the number of available effluent data points for the measured concentration of the pollutant and the coefficient of variation (or CV) of the data set, which is a measure of the variability of data around the average, to predict the critical pollutant concentration in the effluent. Exhibit 6-7 provides an example of a lognormal distribution of effluent pollutant concentrations and projection of a critical effluent pollutant concentration ( $C_d$ ). For additional details regarding EPA's guidance, see Chapter 3 of the TSD. Many permitting authorities have developed procedures for estimating a critical effluent pollutant concentration that are based on or derived from those procedures. For pollutants with effluent concentrations that *do not* follow a lognormal distribution, permit writers would rely on alternative procedures developed by their permitting authority for determining the critical effluent pollutant concentration.

### Exhibit 6-7 Example of lognormal distribution of effluent pollutant concentrations and projection of critical concentration ( $C_d$ )



#### 6.2.4.2 Receiving Water Critical Conditions

As with the effluent, flow (for rivers and streams) and pollutant concentration are receiving water critical conditions used in steady-state water quality models. In addition, depending on the waterbody and pollutant of concern, there could be additional receiving water characteristics that permit writers need to consider in a water quality model.

#### Receiving Water Upstream Flow

For rivers and streams, an important critical condition is the stream flow upstream of the discharge (designated  $Q_s$ ). That critical condition generally is specified in the applicable water quality standards and reflects the duration and frequency components of the water quality criterion that is being addressed. For most pollutants and criteria, the critical flow in rivers and streams is some measure of the low flow of that river or stream; however, the critical condition could be different (for example, a high flow, where wet weather sources are a major problem). If a discharge is controlled so that it does not cause water quality criteria to be exceeded in the receiving water at the critical flow condition, the discharge controls should be protective and ensure that water quality criteria, and thus designated uses, are attained under all receiving water flow conditions.

Examples of typical critical hydrologically based low flows found in water quality standards include the 7Q10 (7-day average, once in 10 years) low flow for chronic aquatic life criteria, the 1Q10 low flow for acute aquatic life criteria, and the harmonic mean flow for human health criteria for toxic organic pollutants. The permit writer might examine stream flow data from the state or the U.S. Geological

Survey to determine the critical flow at a point upstream of the discharge. The permit writer might also account for any additional sources of flow or diversions between the point where a critical low flow has been calculated and the point of discharge. EPA also has developed a biologically based flow method that directly uses the durations and frequencies specified in the water quality criteria.

### Climate Change Considerations

As noted in this section, the receiving water upstream flow is an important factor in modeling the interaction between the effluent discharge and a river or stream. In most instances, state water quality standards or implementation policies establish the critical low flows that should be used in modeling this interaction. The most common source of upstream flow data for water quality modelers is historical flow gage data available through the U.S. Geological Survey. Modelers should be aware that the effects of climate change could alter historical flow patterns in rivers and streams, making these historical flow records less accurate in predicting current and future critical flows. Where appropriate, water quality modelers should consider alternate approaches to establishing critical low flow conditions that account for these climatic changes.

### Receiving Water Background Pollutant Concentration

In addition to determining the critical effluent concentration of the pollutant of concern, the permit writer also should determine the critical background concentration of the pollutant of concern in the receiving water before the discharge (designated  $C_s$ ) to ensure that any pollutant limitations derived are protective of the designated uses. Permitting authority policies or procedures often address how to determine that critical background concentration value for the pollutant. For example, using ambient data or working with the discharger to obtain reliable ambient data, the permit writer might use the maximum measured background pollutant concentration or, perhaps, an average of measured concentrations as the critical condition. Ambient data will provide the most reliable characterization of receiving water background pollutant concentration. EPA encourages permitting authorities to collect and use actual ambient data, where possible. Where data are not available, however, the state might have other procedures, such as establishing that without valid and representative ambient data, no dilution or mixing will be allowed (i.e., criteria end-of-pipe), or using a percentage of an applicable water quality criterion or a detection, quantitation, or other reporting level. The permit writer should consult the permitting authority's policies and procedures or, if there are no policies or procedures available, look at past permitting practices and maintain consistency with those practices when determining the critical receiving water background concentrations.

### Other Receiving Water Characteristics

For waterbodies other than free-flowing rivers and streams, there might be critical environmental conditions that apply rather than flow (e.g., tidal flux, temperature). In addition, depending on the pollutant of concern, the effects of biological activity and reaction chemistry might be important in assessing the impact of a discharge on the receiving water. In such situations, additional critical receiving water conditions that might be used in a steady-state water quality model include conditions such as pH, temperature, hardness, or reaction rates, and the presence or absence of certain fish species or life stages of aquatic organisms, to name a few.

Sections 6.3 and 6.4 below provide further discussion of how critical conditions are applied in a water quality model to determine the need for and calculate WQBELs.

### 6.2.5 Step 5: Establish an Appropriate Dilution Allowance or Mixing Zone

Following verification of whether the applicable water quality standards allow any consideration of effluent and receiving water mixing and, for a steady-state modeling approach, the critical conditions that apply to the effluent and receiving water, permit writers can determine how the effluent and the receiving water mix under critical conditions. Based on this determination, permit writers can then establish the maximum dilution allowance or mixing zone allowed by the water quality standards for each pollutant of concern.

#### 6.2.5.1 Type of Mixing Under Critical Conditions

On the basis of requirements in the water quality standards, the dilution allowance or mixing zone used in water quality models and calculations are likely to vary depending on whether there is rapid and complete mixing or incomplete mixing of the effluent and receiving water under critical conditions. Thus, the permit writer needs to understand something about *how* the effluent and receiving water mix under critical conditions.

*Rapid and complete mixing* is mixing that occurs when the lateral variation in the concentration of a pollutant in the direct vicinity of the outfall is small. The applicable water quality standards might specify certain conditions under which a permit writer could *assume* that rapid and complete mixing is occurring, such as the presence of a diffuser. Some standards may also allow a *demonstration* of rapid and complete mixing in cases where the conditions for simply assuming rapid and complete mixing are not met. For example, the applicable water quality standards might specify a distance downstream of a discharge point by which the pollutant concentration across the stream width must vary by less than a certain percentage to assume that there is rapid and complete mixing.

If the permit writer cannot assume rapid and complete mixing and there has been no demonstration of rapid and complete mixing, the permit writer should assume that there is incomplete mixing. Under incomplete mix conditions, mixing occurs more slowly and higher concentrations of pollutants are present in-stream near the discharge as compared to rapid and complete mixing. Thus, an assumption of incomplete mixing is more conservative than an assumption of rapid and complete mixing. For waterbodies other than rivers and streams (e.g., lakes, bays, and the open ocean) the permit writer usually would assume incomplete mixing.

#### 6.2.5.2 Maximum Dilution Allowance or Mixing Zone Size

Once a permit writer determines whether the applicable water quality standards allows consideration of some ambient dilution or mixing and determines the type of mixing taking place (rapid and complete mixing versus incomplete mixing), he or she would again consult the water quality standards to determine the maximum size of the dilution allowance or mixing zone that may be considered in water quality modeling calculations.

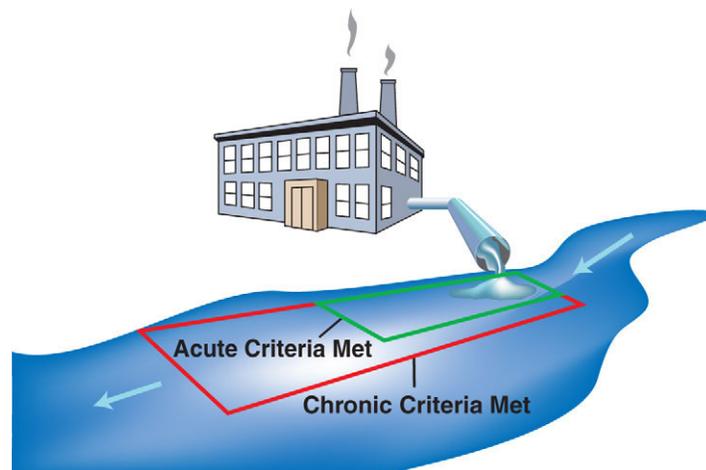
### Dilution Allowances in Rapid and Complete Mix Situations

The maximum permissible dilution allowance for rivers and streams under conditions of rapid and complete mixing should be indicated in the water quality standards or standards implementation policy. For example, some water quality standards allow a permit writer to use up to 100 percent of the critical low flow of a river or stream as a dilution allowance in water quality models and calculations when there is rapid and complete mixing. In some cases, water quality standards implement a factor of safety by permitting only a percentage of the critical low flow to be used as a dilution allowance, even when there is rapid and complete mixing under critical conditions. Water quality standards might incorporate such a factor of safety to account for any uncertainty related to other conditions in the waterbody or to ensure that some assimilative capacity is retained downstream of the discharge being permitted. Recall as well that for some pollutants (e.g., pathogens in waters designated for primary contact recreation, bioaccumulative pollutants), the water quality standards or implementing procedures might not authorize any dilution allowance even where the effluent and receiving water mix rapidly and completely.

### Dilution Allowances and Regulatory Mixing Zones in Incomplete Mix Situations

In an incomplete mixing situation, the water quality standards or implementation policies might allow some consideration of ambient dilution. Rather than permitting as much as 100 percent of the critical low flow as a dilution allowance, however, they will likely specify either a limited dilution allowance (such as a percentage of the critical low flow) or the maximum size of a regulatory mixing zone. A regulatory *mixing zone* is a limited area or volume of water where initial dilution of a discharge takes place and within which the water quality standards allow certain water quality criteria to be exceeded. While the criteria may be exceeded within the mixing zone, the use and size of the mixing zone must be limited such that the waterbody as a whole will not be impaired and such that all designated uses are maintained as discussed in section 6.2.5.3 below. Exhibit 6-8 is a diagram illustrating the concept of a regulatory mixing zone. The mixing zone often is a simple geometric shape inside of which a water quality criterion may be exceeded. The geometric shape does not characterize how mixing actually occurs. Actual mixing is described using field studies and a water quality model.

**Exhibit 6-8 Regulatory mixing zones for aquatic life criteria**



Note that Exhibit 6-8 above illustrates two different mixing zones, one for an acute aquatic life criterion and one for a chronic aquatic life criterion. The water quality standards could specify different maximum mixing zone sizes for different pollutants, different types of criteria, and different waterbody types. Exhibit 6-9 provides examples of different maximum mixing zone sizes and dilution allowances.

### Exhibit 6-9 Examples of maximum mixing zone sizes or dilution allowances under incomplete mixing conditions by waterbody type\*

**For rivers and streams:**

- Mixing zones cannot be larger than 1/4 of the stream width and 1/4 mile downstream
- Mixing must be less than 1/2 stream width with a longitudinal limit of 5 times the stream width
- Dilution cannot be greater than 1/3 of the critical low flow

**For lakes and the ocean:**

- Mixing zones for lakes cannot be larger than 5% of the lake surface
- A maximum of 4:1 dilution is available for lake discharges
- A maximum of 10:1 dilution is available for ocean discharges
- The maximum size mixing zone for the ocean is a 100-foot radius from the point of discharge

\* Examples were adapted from state standards and procedures and do not reflect EPA guidance or recommendations.

Permit writers should always check the applicable water quality standards to see if mixing zones are permitted and determine the maximum mixing zone size for the waterbody type, pollutant of concern, and specific criterion being considered.

#### 6.2.5.3 Restrictions on Dilution Allowance or Mixing Zone Size

In addition to specifying the maximum dilution allowance or mixing zone size allowed under both rapid and complete mixing conditions and incomplete mixing conditions, the water quality standards or implementation policies generally include constraints that could further limit the available dilution allowance or mixing zone size to something less than the absolute maximum allowed. For example, one restriction on the size of the acute mixing zone could be that it must be small enough to ensure that the potential time of exposure of aquatic organisms to a pollutant concentration above the acute criterion is very short, and organisms passing through that acute mixing zone will not die from exposure to the pollutant. Such a restriction might lead the permitting authority to give a discharger an acute mixing zone for a specific pollutant that is smaller than the maximum size allowed by the water quality standards or to not allow any acute mixing zone at all. Other possible restrictions on dilution and mixing zone size include preventing impairment of the integrity of the waterbody as a whole and preventing significant risks to human health. For example, a permitting authority might restrict the size of a mixing zone for a human health criterion to prevent the mixing zone from overlapping a drinking water intake.

### 6.3 Determine the Need for WQBELs

After determining the applicable water quality standards and characterizing the effluent and receiving water, a permit writer determines whether WQBELs are needed. This section provides an overview of that process.

### 6.3.1 Defining Reasonable Potential

EPA regulations at § 122.44(d)(1)(i) state, “Limitations must control all pollutants or pollutant parameters (either conventional, nonconventional, or toxic pollutants) which the Director determines are or may be discharged at a level that will *cause*, have the *reasonable potential to cause*, or *contribute* to an excursion above any [s]tate water quality standard, including [s]tate narrative criteria for water quality.” [emphasis added] Because of that regulation, EPA and many authorized NPDES states refer to the process that a permit writer uses to determine whether a WQBEL is required in an NPDES permit as a *reasonable potential analysis*. Wording the requirements of the regulation another way, a reasonable potential analysis is used to determine whether a discharge, alone or in combination with other sources of pollutants to a waterbody and under a set of conditions arrived at by making a series of reasonable assumptions, could lead to an excursion above an applicable water quality standard. The regulation also specifies that the reasonable potential determination must apply not only to numeric criteria, but also to narrative criteria (e.g., *no toxics in toxic amounts, presence of pollutants or pollutant parameters in amounts that would result in nuisance algal blooms*). A permit writer can conduct a reasonable potential analysis using effluent and receiving water data and modeling techniques, as described above, or using a non-quantitative approach. Both approaches are discussed below.

### 6.3.2 Conducting a Reasonable Potential Analysis Using Data

When determining the need for a WQBEL, a permit writer should use any available effluent and receiving water data as well as other information pertaining to the discharge and receiving water (e.g., type of industry, existing TBELs, compliance history, stream surveys), as the basis for a decision. The permit writer might already have data available from previous monitoring or he or she could decide to work with the permittee to generate data before permit issuance or as a condition of the new permit. EPA recommends that monitoring data be generated before effluent limitation development whenever possible. Monitoring should begin far enough in advance of permit development to allow sufficient time to conduct chemical analyses. Where data are generated as a condition of the permit (for example for a new permittee), it might be appropriate for the permit writer to include a reopener condition in the permit to allow the incorporation of a WQBEL if the monitoring data indicate that a WQBEL is required.

A reasonable potential analysis conducted with available data can be divided into four steps as shown in Exhibit 6-10 and discussed in detail below.

#### Exhibit 6-10 Steps of a reasonable potential analysis with available data

- Step 1. Determine the appropriate water quality model
- Step 2. Determine the expected receiving water concentration under critical conditions
- Step 3. Answer the question, “Is there reasonable potential?”
- Step 4. Document the reasonable potential determination in the fact sheet

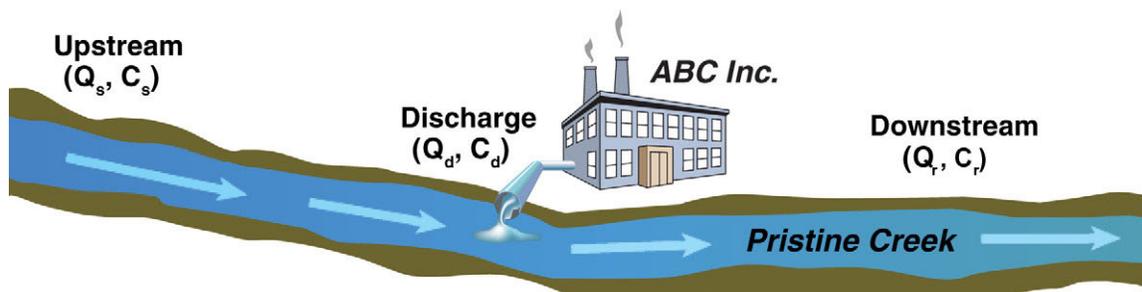
#### 6.3.2.1 Step 1: Determine the Appropriate Water Quality Model

Steady-state or dynamic water quality modeling techniques can be used in NPDES permitting. As discussed in section 6.2.3 above, the examples in this manual consider only steady-state modeling techniques, which consider the impact of a discharge on the receiving water modeled under a single set of critical conditions.

The specific steady-state model used will depend on the pollutant or parameter of concern and whether there is rapid and complete mixing or incomplete mixing of the effluent and the receiving water under critical conditions. For example, to model dissolved oxygen in a river, the permit writer might choose the Streeter-Phelps equation. For modeling heavy metals in an incomplete mix situation, the permit writer might choose the CORMIX model. For pollutants such as BOD, nutrients, or non-conservative parameters, the effects of biological activity and reaction chemistry should be modeled, in addition to the effects of dilution, to assess possible impacts on the receiving water. This manual focuses only on dilution of a pollutant discharged to the receiving water and does not address modeling biological activity or reaction chemistry in receiving waters. For additional information, permit writers should discuss modeling that accounts for biological activity or reaction chemistry with water quality modelers or other water quality specialists as needed and consult EPA's [Water Quality Models and Tools Website](http://www.epa.gov/waterscience/models/) <[www.epa.gov/waterscience/models/](http://www.epa.gov/waterscience/models/)>.

For many pollutants such as most toxic (priority) pollutants, conservative pollutants, and pollutants that can be treated as conservative pollutants when near-field effects are of concern, if there is rapid and complete mixing in a river or stream, the permit writer could use a simple mass-balance equation to model the effluent and receiving water. The simple mass-balance equation as applied to a hypothetical facility, ABC, Inc., discharging Pollutant Z to a free-flowing stream called Pristine Creek is presented in Exhibit 6-11 below.

**Exhibit 6-11 Simple mass-balance equation**



**Mass** = **Flow (Q)** X **Pollutant concentration (C)**  
 = in million gallons per day (mgd) or cubic feet per second (cfs) X in milligrams per liter (mg/L)

$$Q_s C_s + Q_d C_d = Q_r C_r$$

where

- $Q_s$  = stream flow in mgd or cfs above point of discharge
- $C_s$  = background in-stream pollutant concentration in mg/L
- $Q_d$  = effluent flow in mgd or cfs
- $C_d$  = effluent pollutant concentration in mg/L
- $Q_r$  = resultant in-stream flow, after discharge in mgd or cfs
- $C_r$  = resultant in-stream pollutant concentration in mg/L (after complete mixing occurs)

### 6.3.2.2 Step 2: Determine the Expected Receiving Water Concentration under Critical Conditions

When using a steady-state model, the permit writer, or water quality modeler, determines the impact of the effluent discharge on the receiving water under critical conditions. This step examines how this steady-state analysis is conducted in situations where there is incomplete mixing and then provides a detailed discussion of this analysis for situations where there is rapid and complete mixing.

#### **How are *critical conditions* defined?**

When using a steady-state water quality model, permit writers generally input values that reflect critical conditions. State permitting procedures should guide permit writers in this task. When characterizing the effluent and receiving water for water quality-based permitting, the permit writer should follow the permitting authority's policies and procedures for selecting the critical conditions to use in a steady-state model. The discussion in section 6.2.4 above provides a discussion of how those values might be selected.

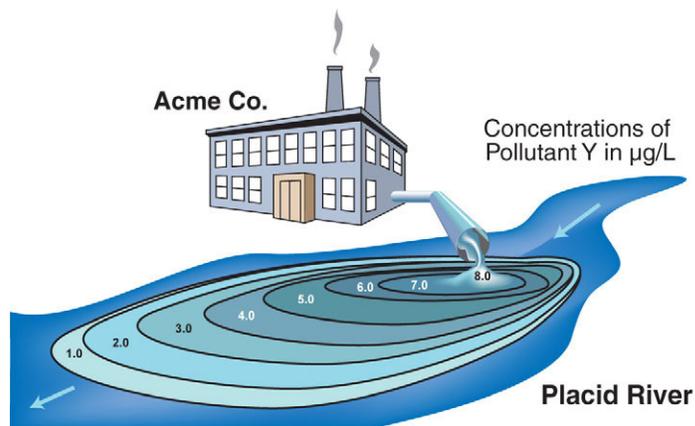
Permit writers generally would input into a steady-state model for a reasonable potential analysis the critical conditions identified in the effluent and receiving water characterization discussed in section 6.2.4 above. Recall that critical conditions include the following:

- Effluent critical conditions
  - Flow.
  - Pollutant concentration.
- Receiving water critical conditions
  - Flow (for rivers and streams).
  - Pollutant concentration.
  - Other receiving water characteristics such as tidal flux, temperature, pH, or hardness (depending on the waterbody and pollutant of concern)

As discussed in section 6.2.4.1 above, EPA and other permitting authorities have developed guidance for determining those critical conditions. Permit writers should rely on their permit authority's policies and procedures or past practices to determine values for all other critical conditions.

#### Expected Receiving Water Concentration in an Incomplete Mixing Situation

Exhibit 6-12 illustrates a situation where there is incomplete mixing of a discharge from a hypothetical facility, Acme Co., with the receiving water, the Placid River. The concentration of the pollutant of concern discharged by Acme Co. (Pollutant Y) is highest nearest the point of discharge and gradually decreases until the pollutant is completely mixed with the receiving water. To determine expected receiving water concentrations resulting from the Acme Co.'s discharge of Pollutant Y to the Placid River, the permit writer, or water quality modeler, would use the appropriate incomplete mixing model, calibrated to actual observations from field studies or dye studies, to simulate mixing under critical conditions. In Step 3 below, the concentrations of the pollutant of concern in the receiving water, as predicted by the water quality model, will be overlaid by a regulatory mixing zone established by the applicable water quality standard to determine whether WQBELs are needed.

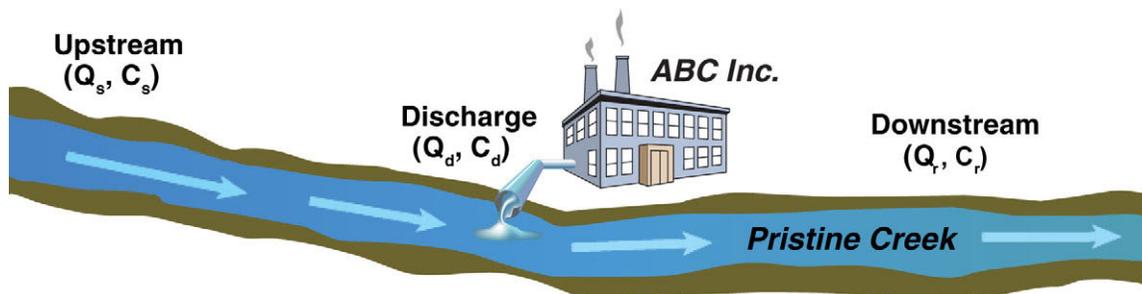
**Exhibit 6-12 Example of receiving water concentrations in an incomplete mixing situation determined using an incomplete mixing water quality model****Expected Receiving Water Concentration in Rapid and Complete Mixing Situation**

For many pollutants, if there is rapid and complete mixing in a river or stream, the permit writer could use the simple mass-balance equation presented in Exhibit 6-11 above to determine the expected receiving water concentration of the pollutant of concern under critical conditions. As noted previously, the simple mass-balance equation is a very basic steady-state model that can be used for most toxic pollutants, conservative pollutants, and other pollutants for which near-field effects are the primary concern. In Exhibit 6-13, that equation is applied to ABC Inc.'s discharge of Pollutant Z (a conservative pollutant) to Pristine Creek under conditions of rapid and complete mixing. The mass-balance equation is rearranged to show how it would be used in a reasonable potential analysis.

To use the simple mass-balance equation to predict receiving water impacts for a reasonable potential analysis, the permit writer needs to input one value for each variable and solve the equation for  $C_r$ , the downstream concentration of the pollutant. Because this model, like other steady-state models, uses a single value for each variable, the permit writer should be sure that the values selected reflect critical conditions for the discharge and the receiving water. In Exhibit 6-14, those critical conditions have been identified and the equation has been solved for  $C_r$ .

It is important for permit writers to remember that, in some situations, the selected steady-state model could be more complex than the simple mass-balance equation shown. For example, there could be other pollutant sources along the stream segment; the pollutant might not be conservative (e.g., BOD); or the parameter to be modeled might be affected by multiple pollutants (e.g., dissolved oxygen affected by BOD and nutrients). For illustrative purposes, this example focuses on a situation where using a simple mass-balance equation is sufficient (i.e., rapid and complete mixing of a conservative pollutant in a river or stream under steady-state conditions).

**Exhibit 6-13 Mass-balance equation for reasonable potential analysis for conservative pollutant under conditions of rapid and complete mixing**



The mass-balance equation can be used to determine whether the discharge from ABC Inc., would cause, have the reasonable potential to cause, or contribute to an excursion above the water quality standards applicable to Pristine Creek. The equation is used to predict the concentration of Pollutant Z, a conservative pollutant, in Pristine Creek under critical conditions. The predicted concentration can be compared to the applicable water quality criteria for Pollutant Z. Assume the discharge mixes rapidly and completely with Pristine Creek.

$$\text{Mass} = \begin{array}{l} \text{Flow (Q)} \\ \text{in million gallons per day} \\ \text{(mgd) or cubic feet per second} \\ \text{(cfs)} \end{array} \times \begin{array}{l} \text{Pollutant concentration (C)} \\ \text{in milligrams per liter (mg/L)} \end{array}$$

$$Q_s C_s + Q_d C_d = Q_r C_r$$

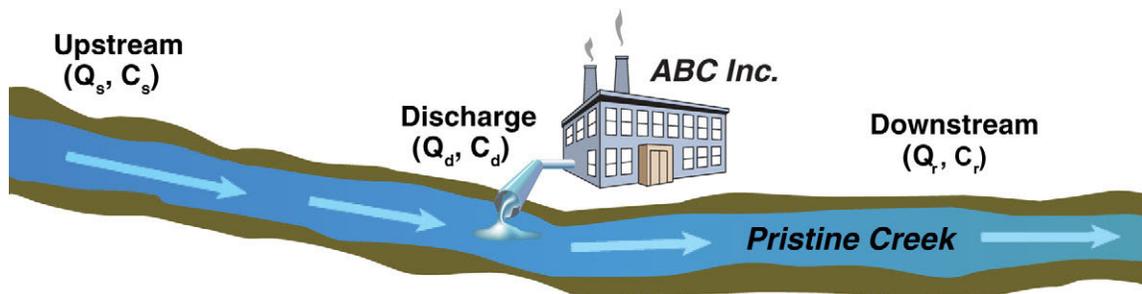
where

- $Q_s$  = critical stream flow in mgd or cfs above point of discharge
- $C_s$  = critical background in-stream pollutant concentration in mg/L
- $Q_d$  = critical effluent flow in mgd or cfs
- $C_d$  = critical effluent pollutant concentration in mg/L
- $Q_r$  = resultant in-stream flow, after discharge in mgd or cfs ( $Q_r = Q_s + Q_d$ )
- $C_r$  = resultant in-stream pollutant concentration in mg/L (after complete mixing occurs)

Rearrange the equation to determine the concentration of Pollutant Z in the waterbody downstream of a discharge under critical conditions:

$$C_r = \frac{(Q_d)(C_d) + (Q_s)(C_s)}{Q_r}$$

### Exhibit 6-14 Example of applying mass-balance equation to conduct reasonable potential analysis for conservative pollutant under conditions of rapid and complete mixing



$$\text{Mass-Balance Equation: } Q_s C_s + Q_d C_d = Q_r C_r$$

Dividing both sides of the mass-balance equation by  $Q_r$  gives the following:

$$C_r = \frac{(Q_d)(C_d) + (Q_s)(C_s)}{Q_r}$$

where  $C_r$  is the receiving water concentration downstream of the discharge

The following values are known for ABC Inc. and Pristine Creek:

$Q_s$ = critical upstream flow (water quality standards allow a dilution allowance of up to 100% of 1Q10 low flow for rapid and complete mixing)	= 1.20 cfs
$C_s$ = critical upstream concentration of Pollutant Z in Pristine Creek	= 0.75 mg/L
$Q_d$ = critical discharge flow	= 0.55 cfs
$C_d$ = statistically projected critical discharge concentration of Pollutant Z	= 2.20 mg/L
$Q_r$ = downstream flow	= $Q_d + Q_s = 0.55 + 1.20 = 1.75$ cfs

Acute aquatic life water quality criterion for Pollutant Z in Pristine Creek = 1.0 mg/L

Find the projected downstream concentration ( $C_r$ ) by inserting the given values into the equation as follows:

$$C_r = \frac{(0.55 \text{ cfs})(2.20 \text{ mg/L}) + (1.20 \text{ cfs})(0.75 \text{ mg/L})}{(1.75 \text{ cfs})}$$

$$= 1.2 \text{ mg/L of Pollutant Z}^*$$

\* calculated to 2 significant figures

#### 6.3.2.3 Step 3: Answer the Question, Is There Reasonable Potential?

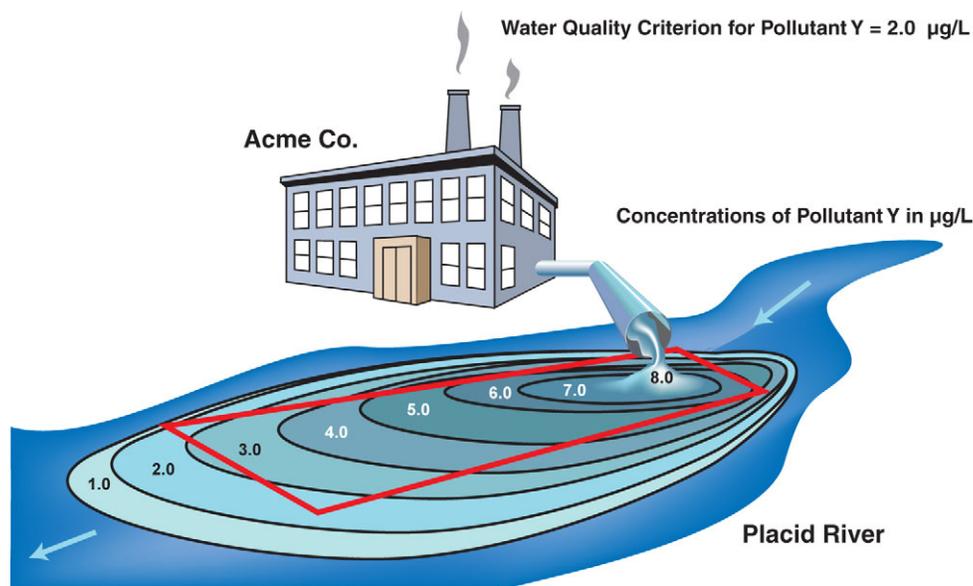
The next step in the reasonable potential analysis is to consider the results of water quality modeling to answer the question, *Is there reasonable potential?*

- For most pollutants, if the receiving water pollutant concentration projected by a steady-state model (e.g., a simple mass-balance equation or a more complex model) exceeds the applicable water quality criterion, there is *reasonable potential*, and the permit writer must calculate WQBELs. (Note that for dissolved oxygen, reasonable potential would occur if the water quality model indicates that the projected effluent concentration of the oxygen-demanding pollutants would result in depletion of dissolved oxygen below acceptable values in the receiving water).
- If the projected concentration is equal to or less than the applicable criterion, there is no reasonable potential and, thus far, there is no demonstrated need to calculate WQBELs.

### Reasonable Potential Determination in an Incomplete Mixing Situation

To determine whether there is reasonable potential in an incomplete mixing situation, the permit writer would compare the projected concentration of the pollutant of concern at the edge of the regulatory mixing zone or after accounting for the available dilution allowance, with the applicable water quality criterion. Exhibit 6-15 illustrates the reasonable potential determination for Acme Co. in a situation where the regulatory mixing zone is described by a geometric shape. In the example, the water quality criterion for Pollutant Y being considered is 2.0 micrograms per liter ( $\mu\text{g/L}$ ). The illustration shows that at many points along the edge of the regulatory mixing zone specified by the water quality standards, which is represented by the rectangle, the concentration of Pollutant Y exceeds 2.0  $\mu\text{g/L}$ . Therefore, there is reasonable potential, and the permit writer must calculate WQBELs for Pollutant Y for Acme Co.

#### Exhibit 6-15 Reasonable potential determination in an incomplete mixing situation



### Reasonable Potential Determination in a Rapid and Complete Mixing Situation

In the rapid and complete mixing example for ABC, Inc., shown in Exhibit 6-14 above, a projected downstream concentration ( $C_T$ ) of 1.2 mg/L of Pollutant Z was calculated. The permit writer would compare the calculated concentration to the acute aquatic life water quality criterion of 1.0 mg/L for Pollutant Z in Pristine Creek presented in Exhibit 6-14. Because 1.2 mg/L > 1.0 mg/L, the projected downstream concentration exceeds the water quality criterion; therefore, there is a reasonable potential for the water quality criterion to be exceeded, and the permit writer must calculate WQBELs for Pollutant Z.

A permit writer should repeat the reasonable potential analysis for all applicable criteria for the pollutant of concern and must remember that the critical conditions could differ depending on the criterion being evaluated. For example, the critical stream flow used when considering the acute aquatic life criterion might be the 1Q10 low flow, whereas the critical stream flow used when considering the chronic aquatic life criterion might be the 7Q10 low flow. If calculations demonstrate that the discharge of a pollutant of concern would cause, have the reasonable potential to cause, or contribute to an excursion of *any one* of the applicable criteria for that pollutant, the permit writer must develop WQBELs for that pollutant.

In addition, it is important for permit writers to remember that they must repeat the reasonable potential analysis for each pollutant of concern and calculate WQBELs where there is reasonable potential. For each pollutant for which there is no reasonable potential, the permit writer should consider whether there are any existing WQBELs in the previous permit and whether they should be retained. The permit writer would complete an anti-backsliding analysis (see Chapter 7 of this manual) to determine whether it is possible to remove any existing WQBELs from the reissued permit.

#### 6.3.2.4 Step 4: Document the Reasonable Potential Determination in the Fact Sheet

As a final step, permit writers need to document the details of the reasonable potential analysis in the NPDES permit fact sheet. The permit writer should clearly identify the information and procedures used to determine the need for WQBELs. The goal of that documentation is to provide the NPDES permit applicant and the public a transparent, reproducible, and defensible description of how each pollutant was evaluated, including the basis (i.e., reasonable potential analysis) for including or not including a WQBEL for any pollutant of concern.

### 6.3.3 Conducting a Reasonable Potential Analysis without Data

State implementation procedures might allow, or even require, a permit writer to determine reasonable potential through a qualitative assessment process without using available facility-specific effluent monitoring data or when such data are not available. For example, as noted in section 6.2.1.2 above, where there is a pollutant with a WLA from a TMDL, a permit writer must develop WQBELs or other permit requirements consistent with the assumptions of the TMDL. Even without a TMDL, a permitting authority could, at its own discretion, determine that WQBELs are needed for any pollutant associated with impairment of a waterbody. A permitting authority might also determine that WQBELs are required for specific pollutants for all facilities that exhibit certain operational or discharge characteristics (e.g., WQBELs for pathogens in all permits for POTWs discharging to contact recreational waters).

Types of information that the permit writer might find useful in a qualitative approach to determining reasonable potential include the following:

- Effluent variability information such as history of compliance problems and toxic impacts.
- Point and nonpoint source controls such as existing treatment technology, the type of industry, POTW treatment system, or BMPs in place.
- Species sensitivity data including in-stream data, adopted water quality criteria, or designated uses.
- Dilution information such as critical receiving water flows or mixing zones.

The permit writer should always provide justification for the decision to require WQBELs in the permit fact sheet or statement of basis and *must* do so where required by federal and state regulations. A thorough rationale is particularly important when the decision to include WQBELs is not based on an analysis of effluent data for the pollutant of concern.

After evaluating all available information characterizing the nature of the discharge without effluent monitoring data for the pollutant of concern, if the permit writer is not able to decide whether the discharge causes, has the reasonable potential to cause, or contributes to an excursion above a water

quality criterion, he or she may determine that effluent monitoring should be required to gather additional data. The permit writer might work with the permittee to obtain data before permit issuance, if sufficient time exists, or could require the monitoring as a condition of the newly issued or reissued permit. The permit writer might also include a clause in the permit that would allow the permitting authority to reopen the permit and impose an effluent limitation if the required monitoring establishes that there is reasonable potential that the discharge will cause or contribute to an excursion above a water quality criterion.

## 6.4 Calculate Parameter-specific QBELs

If a permit writer has determined that a pollutant or pollutant parameter is discharged at a level that will cause, have reasonable potential to cause, or contribute to an excursion above any state water quality standard, the permit writer must develop QBELs for that pollutant parameter. This manual presents the approach recommended by EPA's TSD for calculating QBELs for toxic (priority) pollutants. Many permitting authorities apply those or similar procedures to calculate QBELs for toxic pollutants and for a number of conventional or nonconventional pollutants with effluent concentrations that tend to follow a lognormal distribution. Permit writers should consult permitting authority policies and procedures to determine the methodology specific to their authorized NPDES permitting program, including the approach for pollutants with effluent concentrations that do not follow a lognormal distribution.

### 6.4.1 Calculating Parameter-specific QBELs from Aquatic Life Criteria

The TSD process for calculating QBELs from aquatic life criteria follows five steps as shown in Exhibit 6-16 and discussed in detail below.

#### Exhibit 6-16 Calculating parameter-specific QBELs from aquatic life criteria

- Step 1. Determine acute and chronic WLAs
- Step 2. Calculate long-term average (LTA) concentrations for each WLA
- Step 3. Select the lowest LTA as the performance basis for the permitted discharger
- Step 4. Calculate an average monthly limitation (AML) and a maximum daily limitation (MDL)
- Step 5. Document the calculation of QBELs in the fact sheet.

#### 6.4.1.1 Step 1: Determine Acute and Chronic WLAs

Before calculating a QBEL, the permit writer will first need to determine the appropriate WLAs for the point source discharge based on both the acute and chronic criteria. A WLA may be determined from a TMDL or calculated for an individual point source directly. Where an EPA-approved TMDL has been developed for a particular pollutant, the WLA for a specific point source discharger is the portion of that TMDL that is allocated to that point source, as discussed in section 6.2.1.2 above. Where no TMDL is available, a water quality model generally is used to calculate a WLA for the specific point source discharger. The WLA is the loading or concentration of pollutant that the specific point source may discharge while still allowing the water quality criterion to be attained downstream of that discharge. Of course, the WLA calculation should take into account any reserve capacity, safety factor, and contributions from other point and nonpoint sources as might be required by the applicable water quality standards regulations or implementation policies.

When a WLA is not given as part of a TMDL or where a separate WLA is needed to address the near-field effects of a discharge on water quality criteria, permit writers will, in many situations, use a steady-state water quality model to determine the appropriate WLA for a discharge. As discussed in section 6.3 above, steady-state models generally are run under a single set of critical conditions for protection of receiving water quality. If a permit writer uses a steady-state model with a specific set of critical conditions to assess reasonable potential, he or she generally may use the same model and critical conditions to calculate a WLA for the same discharge and pollutant of concern.

As with the reasonable potential assessment, the type of steady-state model used to determine a WLA depends on the type of mixing that occurs in the receiving water and the type of pollutant or parameter being modeled. As discussed in section 6.3.2 above, permit writers can use the mass-balance equation as a simple steady-state model for many pollutants, such as most toxic (priority) pollutants or any pollutant that can be treated as a conservative pollutant when considering near-field effects, if there is rapid and complete mixing in the receiving water. For pollutants or discharge situations that do not have those characteristics (e.g., non-conservative pollutants, concern about effects on a downstream waterbody), a water quality model other than the mass-balance equation would likely be more appropriate.

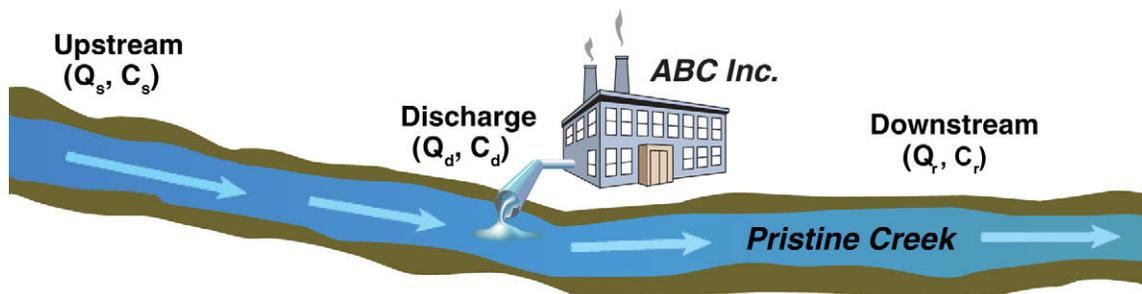
The mass-balance equation is presented again in Exhibit 6-17. In the exhibit, the equation is rearranged to show how it would be used to calculate a WLA for a conservative pollutant discharged to a river or stream under conditions of rapid and complete mixing.

#### 6.4.1.2 Step 2: Calculate LTA Concentrations for Each WLA

The requirements of a WLA generally must be interpreted in some way to be expressed as an effluent limitation. The goal of the permit writer is to derive effluent limitations that are enforceable, adequately account for effluent variability, consider available receiving water dilution, protect against acute and chronic impacts, account for compliance monitoring sampling frequency, and assure attainment of the WLA and water quality standards. In developing WQBELs, the permit writer develops limitations that require a facility to perform in such a way that the concentration of the pollutant of concern in the effluent discharged is nearly always below the WLA.

To accomplish that goal, EPA has developed a statistical permit limitation derivation procedure to translate WLAs into effluent limitations *for pollutants with effluent concentration measurements that tend to follow a lognormal distribution*. EPA believes that this procedure, discussed in Chapter 5 of the TSD, results in defensible, enforceable, and protective WQBELs for such pollutants. In addition, a number of states have adopted procedures based on, but not identical to, EPA's guidance that also provide defensible, enforceable, and protective WQBELs. Permit writers should always use the procedures adopted by their permitting authority. In addition, permit writers should recognize that alternative procedures would be used to calculate effluent limitations for pollutants with effluent concentrations that cannot generally be described using a lognormal distribution.

### Exhibit 6-17 Example of applying mass-balance equation to calculate WLAs for conservative pollutant under conditions of rapid and complete mixing



$$Q_s C_s + Q_d C_d = Q_r C_r$$

where

- $Q_s$  = background stream flow in mgd or cfs above point of discharge
- $C_s$  = background in-stream pollutant concentration in mg/L
- $Q_d$  = effluent flow in mgd or cfs
- $C_d$  = effluent pollutant concentration in mg/L = **WLA**
- $Q_r$  = resultant in-stream flow, after discharge in mgd or cfs
- $C_r$  = resultant in-stream pollutant concentration in mg/L (after complete mixing occurs)

Rearrange the equation to determine the WLA ( $C_d$ ) for ABC Inc., necessary to achieve the acute water quality criterion for Pollutant Z in Pristine Creek ( $C_r$ ) downstream of the discharge:

$$C_d = \frac{Q_r C_r - Q_s C_s}{Q_d}$$

The following values are known for ABC Inc., and Pristine Creek:

- $Q_s$  = critical upstream flow (water quality standards allow a dilution allowance of up to 100% of 1Q10 low flow for rapid and complete mixing) = 1.20 cfs
- $C_s$  = upstream concentration of Pollutant Z in Pristine Creek = 0.75 mg/L
- $Q_d$  = discharge flow = 0.55 cfs
- $Q_r$  = downstream flow =  $Q_d + Q_s = 0.55 + 1.20 = 1.75$  cfs
- $C_r$  = acute water quality criterion for Pollutant Z in Pristine Creek = 1.0 mg/L

Determine the WLA for ABC Inc., by inserting the given values into the equation as follows:

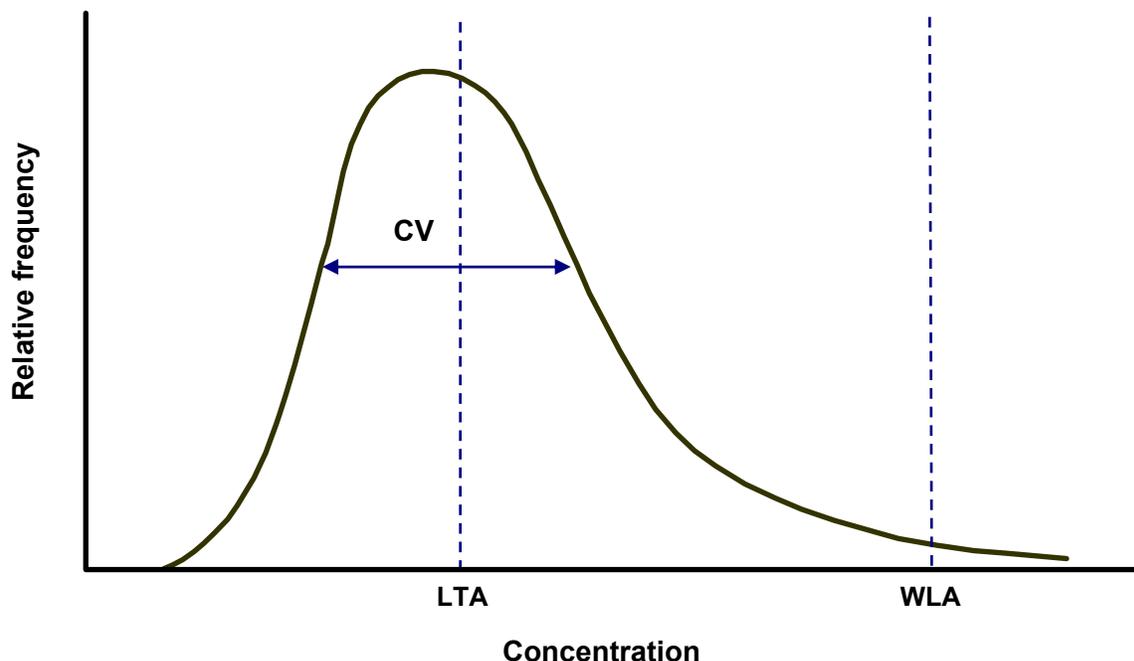
$$\begin{aligned} \text{WLA for ABC Inc.} = C_d &= \frac{(1.75 \text{ cfs})(1.0 \text{ mg/L}) - (1.20 \text{ cfs})(0.75 \text{ mg/L})}{(0.55 \text{ cfs})} \\ &= 1.5 \text{ mg/L of Pollutant Z}^* \end{aligned}$$

\* calculated to 2 significant figures

For those pollutants with effluent concentrations that do follow a lognormal distribution, the distribution can be described by determining a long-term average (or LTA) that ensures that the effluent pollutant concentration remains nearly always below the WLA and by the CV, a measure of the variability of data around the LTA. Exhibit 6-18 illustrates a lognormal distribution with the LTA, CV, and WLA highlighted.

When applying aquatic life criteria, a permit writer generally establishes a WLA based on the acute aquatic life criterion and a WLA based on the chronic aquatic life criterion. Thus, the permit writer determines two LTAs—one that would ensure that an effluent concentration is nearly always below the acute WLA and one that would ensure that an effluent concentration nearly always below the chronic WLA. Each LTA, acute and chronic, would represent a different performance expectation for the discharger.

### Exhibit 6-18 Example of lognormal distribution of effluent pollutant concentrations and calculation of LTA



#### 6.4.1.3 Step 3: Select the Lowest LTA as the Performance Basis for the Permitted Discharger

EPA recommends that WQBELs be based on a single performance expectation for a facility; therefore, once a permit writer has calculated LTA values for each WLA, he or she would select only one of those LTAs to define the required performance of the facility and serve as the basis for WQBELs. Because WQBELs must assure attainment of all applicable water quality criteria, the permit writer would select the lowest LTA as the basis for calculating effluent limitations. Selecting the lowest LTA would ensure that the facility's effluent pollutant concentration remains below all the calculated WLAs nearly all the time. Further, because WLAs are calculated using critical receiving water conditions, the limiting LTA would also ensure that water quality criteria are fully protected under nearly all conditions.

#### 6.4.1.4 Step 4: Calculate an Average Monthly Limitation (AML) and a Maximum Daily Limitation (MDL)

The NPDES regulations at § 122.45(d) require that all effluent limitations be expressed, unless impracticable, as both AMLs and MDLs for all discharges other than POTWs and as both AMLs and average weekly limitations (AWLs) for POTWs. The AML is the highest allowable value for the average of daily discharges over a calendar month. The MDL is the highest allowable daily discharge measured during a calendar day or 24-hour period representing a calendar day. The AWL is the highest allowable value for the average of daily discharges over a calendar week. For pollutants with limitations expressed in units of mass, the daily discharge is the total mass discharged over the day. For limitations expressed in other units, the daily discharge is the average measurement of the pollutant over the period of a day.

In the TSD, EPA recommends establishing an MDL, rather than an AWL, for discharges of toxic pollutants from POTWs. That approach is appropriate for at least two reasons. First, the basis for the AWL for POTWs is the secondary treatment requirements discussed in section 5.1.1.1 of this manual and is not related to the need for assuring attainment of water quality standards. Second, an AWL, which could be the average of up to seven daily discharges, could average out peak toxic concentrations and, therefore, the discharge's potential for causing acute toxic effects might be missed. An MDL would be more likely to identify potential acutely toxic impacts.

Chapter 5 of the TSD includes statistical tools for calculating MDLs and AMLs from the LTA value selected in Step 3 above. Again, note that those procedures apply to *pollutants with effluent concentration measurements that tend to follow a lognormal distribution*. EPA has not developed guidance on procedures for calculating effluent limitations for pollutants with effluent concentrations that generally cannot be described using a lognormal distribution. For such pollutants, permit writers should use other procedures as recommended by their permitting authority in its policies, procedures, or guidance.

Whether using the TSD procedures or other procedures for calculating QWBELs, the objective is to establish limitations calculated to require treatment plant performance levels that, after considering acceptable effluent variability, would have a very low statistical probability of exceeding the WLA and, therefore, would comply with the applicable water quality standards under most foreseeable conditions.

#### 6.4.1.5 Step 5: Document Calculation of QWBELs in the Fact Sheet

Permit writers should document in the NPDES permit fact sheet the process used to develop QWBELs. The permit writer should clearly identify the data and information used to determine the applicable water quality standards and how that information, or any applicable TMDL, was used to derive QWBELs and explain how the state's antidegradation policy was applied as part of the process. The information in the fact sheet should provide the NPDES permit applicant and the public a transparent, reproducible, and defensible description of how the permit writer properly derived QWBELs for the NPDES permit.

#### 6.4.2 Calculating Chemical-specific QWBELs based on Human Health Criteria for Toxic Pollutants

Developing QWBELs for toxic pollutants affecting human health is somewhat different from calculating QWBELs for other pollutants because (1) the exposure period of concern is generally longer (e.g., often a lifetime exposure) and (2) usually the average exposure, rather than the maximum exposure, is of concern. EPA's recommended approach for setting QWBELs for toxic pollutants for human health protection is to set the AML equal to the WLA calculated from the human health toxic pollutant criterion and calculate the MDL from the AML. Section 5.4.4 of the TSD describes statistical procedures used for such calculations for pollutants with effluent concentrations that follow a lognormal distribution. Once again, for pollutants with effluent concentrations that do not follow a lognormal distribution, permit writers should use other procedures as specified by their permitting authority.

If the permit writer calculates chemical-specific QWBELs from human health criteria, he or she should compare the limitations to any other calculated QWBELs (e.g., QWBELs based on aquatic life criteria) and TBELs and apply antidegradation and anti-backsliding requirements to determine the final limitations that meet all technology and water quality standards. As discussed above, that process should be documented in the fact sheet for the NPDES permit.

## 6.5 Calculate Reasonable Potential and WQBELs for WET

WET tests measure the degree of response of exposed aquatic test organisms to an effluent mixed in some proportion with control water (e.g., laboratory water or a non-toxic receiving water sample). WET testing is used as a second approach, in addition to the chemical-specific approach, to implementing water quality standards in NPDES permits. This section provides a brief introduction to WET testing and WET limitations.

### Test of Significant Toxicity (TST)

At the time of the writing of this guidance manual, EPA had recently published a new statistical approach that assesses the whole effluent toxicity (WET) measurement of wastewater effects on specific test organisms' ability to survive, grow, and reproduce. This new approach is called the Test of Significant Toxicity (TST) and is a statistical method that uses hypothesis testing techniques based on research and peer-reviewed publications. The hypothesis test under the TST approach examines whether an effluent, at the critical concentration (e.g., in-stream waste concentration [IWC]), and the control within a WET test differ by an unacceptable amount (the amount that would have a measured detrimental effect on the ability of aquatic organisms to thrive and survive). The TST implementation document and the TST technical document are available at the [NPDES WET Website](http://www.epa.gov/npdes/wet) <[www.epa.gov/npdes/wet](http://www.epa.gov/npdes/wet)>.

### 6.5.1 Types of WET Tests

In many WET tests, the effluent and control water are mixed in varying proportions to create a dilution series. Exhibit 6-19 is an example of a typical dilution series used in WET testing.

Exhibit 6-19 Example of typical dilution series



There are two types of WET tests: acute and chronic. An acute toxicity test usually is conducted over a short time, generally 96 hours or less, and the endpoint measured is mortality. The endpoint for an acute test is often expressed as an  $LC_{50}$  (i.e., the percent of effluent that is lethal to 50 percent of the exposed test organisms). A chronic toxicity test is usually conducted during a critical life phase of the organism and the endpoints measured are mortality and sub-lethal effects, such as changes in reproduction and growth. A chronic test can occur over a matter of hours or days, depending on the species tested and test endpoint. The endpoint of a chronic toxicity test often is expressed in one of the following ways:

- No observed effect concentration (NOEC), the highest concentration of effluent (i.e., highest percent effluent) at which no adverse effects are observed on the aquatic test organisms.
- Lowest observed effect concentration (LOEC), the lowest concentration of effluent that causes observable adverse effects in exposed test organisms.

- Inhibition concentration (IC), a point estimate of the effluent concentration that would cause a given percent reduction in a biological measurement of the test organisms.
- Effect concentration (EC), a point estimate of the effluent concentration that would cause an observable adverse effect in a given percentage of test organisms.

For additional information on WET monitoring and WET test methods, see section 8.2.4 of this manual.

### 6.5.2 Expressing WET Limitations or Test Results

There are two options for expressing WET limitations or test results. First, WET limitations or test results can be expressed directly in terms of the WET test endpoints discussed above (e.g., LC<sub>50</sub>, NOEC, and IC<sub>25</sub>). Alternatively, the limitations or test results can be expressed in terms of *toxic units* (TUs). A TU is the inverse of the sample fraction, calculated as 100 divided by the percent effluent. Exhibit 6-20 presents example TUs for expressing acute and chronic test results.

#### Exhibit 6-20 Example of toxic units

If an **acute test** result is a LC<sub>50</sub> of 60 percent, that result can be expressed as

$$\frac{100}{60} = 1.7 \text{ acute toxic units} = 1.7 \text{ TU}_a$$

If a **chronic test** result is an IC<sub>25</sub> of 40 percent effluent, that result can be expressed as

$$\frac{100}{40} = 2.5 \text{ chronic toxic units} = 2.5 \text{ TU}_c$$

It is important to distinguish acute TUs (TU<sub>a</sub>) from chronic TUs (TU<sub>c</sub>). The difference between TU<sub>a</sub> and TU<sub>c</sub> can be likened to the difference between miles and kilometers. Both miles and kilometers are used to measure distance, but a distance of 1.0 mile is not the same as a distance of 1.0 kilometer. Likewise, both TU<sub>a</sub> and TU<sub>c</sub> are expressions of the toxicity of an effluent, but 1.0 TU<sub>a</sub> is not the same as 1.0 TU<sub>c</sub>. It is possible, however, to determine the relationship between the acute toxicity of an effluent and the chronic toxicity of that same effluent, just as it is possible to determine the relationship between miles and kilometers (i.e., through a conversion factor). Unlike the conversion between miles and kilometers that remains constant, the conversion factor between acute and chronic toxic units varies from effluent to effluent.

For an effluent, the permit writer could develop a conversion factor that would allow conversion of TU<sub>a</sub> into equivalent TU<sub>c</sub> or vice versa. This conversion factor is known as an acute-to-chronic ratio (ACR) for that effluent. The ACR for an effluent may be calculated where there are at least 10 sets of paired acute and chronic WET test data available. The ACR is determined by calculating the mean of the individual ACRs for each pair of acute and chronic WET tests. Where there are not sufficient data to calculate an ACR for an effluent (i.e., less than 10 paired sets of acute and chronic WET test data), EPA recommends a default value of ACR = 10. Exhibit 6-21 presents examples showing how the ACR converts TU<sub>a</sub> into TU<sub>c</sub>, how to calculate an ACR from existing data, and how, once an ACR is calculated, a permit writer could estimate the chronic toxicity of an effluent sample from its measured acute toxicity or vice versa.

## Exhibit 6-21 Using the ACR

The ACR is expressed

$$ACR = \frac{\text{Acute Endpoint}}{\text{Chronic Endpoint}} = \frac{LC_{50}}{IC_{25}}$$

A TU is the inverse of the sample fraction. Therefore, by definition

$$TU_a = \frac{100}{LC_{50}} \quad TU_c = \frac{100}{IC_{25}}$$

Consequently, toxicity as percent sample, may be expressed

$$LC_{50} = \frac{100}{TU_a} \quad IC_{25} = \frac{100}{TU_c}$$

Substituting into the original equation gives

$$ACR = \frac{LC_{50}}{IC_{25}} = \frac{\frac{100}{TU_a}}{\frac{100}{TU_c}} = \frac{TU_c}{TU_a}$$
**Example 1**Given:  $LC_{50} = 28\%$ ,  $NOEC = 10\%$ 

$$ACR = \frac{LC_{50}}{IC_{25}} = \frac{28\%}{10\%} = 2.8$$

**Example 2**Given:  $TU_a = 3.6$ ,  $TU_c = 10.0$ 

$$ACR = \frac{TU_c}{TU_a} = \frac{10.0}{3.6} = 2.8$$

**Example 3**Given: Toxicity data for a facility's effluent for *C. dubia*, as presented in the table to the right.

The ACR in the third column is calculated using the following equation:

$$ACR = \frac{LC_{50}}{IC_{25}}$$

**Example 4**Given:  $TU_a = 1.8$ ,  $ACR = 3.5$ 

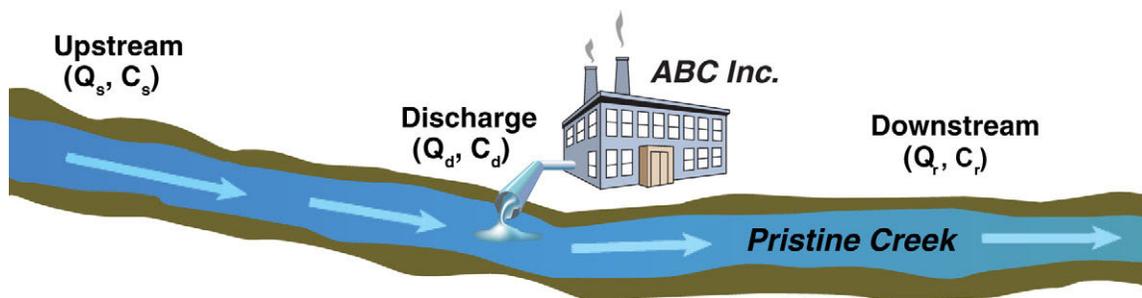
$$ACR = \frac{TU_c}{TU_a} \quad TU_c = ACR \times TU_a$$

$$\text{Estimated } TU_c = ACR \times TU_a = 3.5 \frac{TU_c}{TU_a} \times 1.8 TU_a = 6.3 TU_c$$

LC <sub>50</sub> (% effluent)	IC <sub>25</sub> (% effluent)	ACR
62	10	6.2
18	10	1.8
68	25	2.7
61	10	6.1
63	25	2.5
70	25	2.8
17	5	3.4
35	10	3.5
35	10	3.5
35	25	1.4
47	10	4.7
<b>Mean</b>		<b>3.5</b>

**6.5.3 Determining the Need for WET Limitations**

If a state has numeric criteria for WET, a permit writer could use the results of WET tests to project acute or chronic toxicity in the receiving water after accounting for the applicable dilution allowance or mixing zone made available in the water quality standards. The permit writer would compare the projected toxicity of the receiving water to the applicable water quality criterion for WET. If the projected toxicity exceeds the applicable numeric water quality criterion for WET, the discharge would cause, have the reasonable potential to cause, or contribute to an excursion above the applicable water quality standards, and the permit writer must develop a WQBEL for WET [see § 122.44(d)(1)(iv)]. In that way, numeric criteria for WET can be treated similarly to chemical-specific criteria. Exhibit 6-22 provides an example of how the mass-balance equation is used to conduct a reasonable potential analysis for WET.

**Exhibit 6-22 Example of mass-balance equation for a WET reasonable potential analysis**

The mass-balance equation can be used to determine whether the discharge from ABC Inc. would cause, have the reasonable potential to cause, or contribute to toxicity in Pristine Creek that exceeds the numeric water quality criteria for acute or chronic toxicity. Assume the discharge mixes rapidly and completely with Pristine Creek.

$$\text{Mass-Balance Equation: } Q_s C_s + Q_d C_d = Q_r C_r$$

Dividing both sides of the mass-balance equation by  $Q_r$  gives the following:

$$C_r = \frac{(Q_d)(C_d) + (Q_s)(C_s)}{Q_r}$$

The following values are known for ABC Inc. and Pristine Creek:

$Q_s$ = Critical upstream flow (1Q10 for acute protection)	= 23.6 cfs
(7Q10 for chronic protection)	= 70.9 cfs
$C_s$ = Upstream toxicity in Pristine Creek (acute)	= 0 TU <sub>a</sub>
(chronic)	= 0 TU <sub>c</sub>
$Q_d$ = Discharge flow	= 7.06 cfs
$C_d$ = Discharge toxicity (acute)	= 2.50 TU <sub>a</sub>
(chronic)	= 8.00 TU <sub>c</sub>
$Q_r$ = Downstream flow	= $Q_d + Q_s$
Acute Water Quality Criterion in Pristine Creek	= 0.3 TU <sub>a</sub>
Chronic Water Quality Criterion in Pristine Creek	= 1.0 TU <sub>c</sub>

Find the downstream concentration ( $C_r$ ) by inserting the given values into the equation as follows:

**For acute toxicity:**

$$C_r = \frac{(7.06 \text{ cfs})(2.5 \text{ TU}_a) + (23.6 \text{ cfs})(0 \text{ TU}_a)}{7.06 \text{ cfs} + 23.6 \text{ cfs}} = 0.58 \text{ TU}_a$$

The downstream concentration ( $C_r$ ) exceeds the water quality criterion for acute toxicity of 0.3 TU<sub>a</sub>.

**For chronic toxicity:**

$$C_r = \frac{(7.06 \text{ cfs})(8.00 \text{ TU}_c) + (70.9 \text{ cfs})(0 \text{ TU}_c)}{7.06 \text{ cfs} + 70.9 \text{ cfs}} = 0.72 \text{ TU}_c$$

The downstream concentration ( $C_r$ ) does not exceed the water quality criterion for chronic toxicity of 1.0 TU<sub>c</sub>.

In Exhibit 6-22 above, the downstream concentration under critical conditions for the acute water quality criterion ( $C_r = 0.58 \text{ TU}_a$ ) exceeds the water quality criterion for acute toxicity (0.3 TU<sub>a</sub>); therefore there is reasonable potential and WET limitations are required. WET limitations would be calculated in much the same way as limitations on specific chemicals. The limitations would be calculated to ensure that WET criteria are not exceeded after any available dilution or at the edge of the applicable mixing zone.

Where state water quality standards do not include numeric criteria for WET, a permit writer could evaluate the need for WQBELs for WET on the basis of narrative criteria; specifically, a narrative criterion stating that waterbodies must be free from *toxics in toxic amounts*. To make it easier for a permit writer to readily establish WET limitations in this situation, the permitting authority should have a policy for implementing the narrative criterion. Following the permitting authority's policy, if the permit writer determines that a discharge causes, has the reasonable potential to cause, or contributes to an in-stream excursion above a narrative criterion, the regulations at § 122.44(d)(1)(v) require that the permit include WQBELs for WET unless the permit writer demonstrates that parameter-specific limitations for the effluent are sufficient to attain and maintain applicable numeric and narrative water quality criteria. In other words, the permit must include WET limitations unless the permit writer is able to determine the specific pollutants that are the source of toxicity and include parameter-specific limitations for those pollutants that assure, and will continue to assure, attainment of water quality standards. If there are no criteria in the state water quality standards for the specific parameters causing the toxicity, the permit writer can establish WQBELs using one of three approaches outlined in § 122.44(d)(1)(vi):

- Use EPA's national recommended criteria.
- Calculate a numeric criterion that will attain and maintain the applicable narrative criterion.
- Control the pollutant using an indicator parameter for the pollutant of concern.

A permit also could include a requirement to conduct a toxicity identification evaluation and toxicity reduction evaluation (TIE/TRE) as a special condition in an NPDES permit. (Chapter 9 of this manual presents more information on special conditions.) A TIE/TRE is a site-specific study designed to systematically investigate and identify the causes of effluent toxicity problems, isolate the sources of that toxicity, identify and implement appropriate toxicity control options, and confirm the effectiveness of those control options and the reduction in toxicity. The permit writer might require a TIE/TRE when WET limitations are exceeded or, if there are no WET limitations in the permit, where WET testing demonstrates an unacceptable level of effluent toxicity. Because WET testing indicates the degree of toxicity of an effluent, but does not specifically identify the cause of that toxicity or ways to reduce toxicity, a TIE/TRE is necessary to achieve compliance with effluent limitations or other effluent toxicity requirements in NPDES permits. If a TIE/TRE is not required through the special conditions section of the permit, it could be required via a CWA section 308 letter, a CWA section 309 administrative order, or a consent decree.

## 6.6 Antidegradation Review

Early in the permit development process, a permit writer should check the state's antidegradation policy and implementation methods to determine what tier(s) of protection, if any, the state has assigned to the proposed receiving water for the parameter(s) of concern. The regulations concerning antidegradation and each of the tiers are described above in section 6.1.1.3. The tier of antidegradation protection is important for determining the required process for developing the water quality-based permit limits and conditions. In some cases, where a waterbody is classified as Tier 3 for antidegradation purposes, the permit writer might find that it is not possible to issue a permit for the proposed activity.

If the state has not specified the tier, the permit writer will need to evaluate, in accordance with the state's implementation procedures, whether the receiving waterbody is of high water quality for the parameters of concern, and thus will require Tier 2 protection. After identifying the tier(s) of protection for the

proposed receiving waterbody and parameter(s) of concern, the permit writer should consult the state's antidegradation implementation procedures relevant to the tier(s).

The following sections provide methods permit writers should consider for implementing, through the WQBEL development process, the three levels of protection typically found in a state's antidegradation policy. Implementation of the state's antidegradation policy could have a significant effect on the calculation of WQBELs.

### 6.6.1 Tier 1 Implementation

All waterbodies receive at least Tier 1 protection. Tier 1 protection means that the permit writer must include limits in the permit sufficient to maintain and protect water quality necessary to protect existing uses. In practice, for a Tier 1 receiving waterbody, the permit writer typically calculates the WQBELs on the basis of the applicable criteria because the state's designated uses and criteria to protect those uses must be sufficient to protect the existing uses. If a Tier 1 waterbody is impaired for a parameter that would be present in the proposed discharge, the permit writer should identify and consult any relevant TMDLs to determine what quantity of pollutant (if any) is appropriate.

### 6.6.2 Tier 2 Implementation

For new or increased discharges that could potentially lower water quality in high-quality waters, Tier 2 protection provides the state with a framework for making decisions regarding the degree to which it will protect and maintain the high water quality. A new or expanded discharge permit application typically triggers a Tier 2 antidegradation review. Depending on the outcome of the review, the permit could be written to maintain the existing high water quality or could be written to allow some degradation.

Each state's antidegradation policy or implementation procedures should describe the Tier 2 antidegradation review process. Though the process varies among states, EPA's antidegradation regulation at § 131.12 outlines the common elements of the process. To permit a new or increased discharge that would lower water quality, the state is required to make a finding on the basis of the following:

- The state must find that allowing lower water quality is necessary for important social or economic development in the area in which the waters are located.
  - The state would perform an alternatives analysis to evaluate whether the proposed discharge is actually *necessary* (i.e., whether there are less degrading feasible alternatives) and that might include consideration of a wide range of alternatives (e.g. non-discharging options, relocation of discharge, alternative processes, and innovative treatments).
  - The state should provide a justification of important social or economic development (or both) that would occur as a result of permitting the proposed discharge.
- The state's finding must be made after full satisfaction of its own intergovernmental coordination and public participation provisions.
- The state must assure that the highest statutory and regulatory requirements for all new and existing point sources will be achieved.
- The state must assure that all cost-effective and reasonable BMPs for nonpoint source control will be achieved.

- The state must assure that water quality will still protect existing uses.

If, after fulfilling the above conditions of the Tier 2 antidegradation review process, the state makes a determination to allow a new or increased discharge that would lower water quality, the permit writer may include such limitations in the NPDES permit for that discharge provided the limitations meet all other applicable technology and water quality standards.

### 6.6.3 Tier 3 Implementation

States identify their own ONRWs for Tier 3 protection, which requires that the water quality be maintained and protected. This is the most stringent level of protection. ONRWs often include waters in national or state parks, wildlife refuges, and waters of exceptional recreational or ecological significance. Waterbodies can be given Tier 3 protection regardless of their existing level of water quality. Some states implement Tier 3 by prohibiting any new or increased discharges to ONRWs or their tributaries that would result in lower water quality, with the exception of some limited activities such as those that would result in temporary changes in water quality ultimately resulting in restoration. Some states allow increased discharges as long as they are offset by equivalent or greater reductions elsewhere in the waterbody.

In addition to Tiers 1, 2, and 3, some states have a class of waters considered outstanding to the state and for which the state might have specific antidegradation requirements. Such waterbodies are sometimes referred to as *Tier 2 ½* waters because implementation of the antidegradation policy for them affords a greater degree of protection than Tier 2 but more flexibility than Tier 3.

Chapter 4 of EPA's WQS Handbook and the *Water Quality Standards Regulation Advance Notice of Proposed Rulemaking* (64 FR 36742, July 7, 1998) include additional information on implementing antidegradation policies. The permit writer should clearly explain the antidegradation analysis and how it affects calculation of WQBELs in the fact sheet or statement of basis for the permit.

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<sup>1</sup> U.S. Environmental Protection Agency. 1994. *Water Quality Standards Handbook: Second Edition* (WQS Handbook). EPA 823-B-94-005a. U.S. Environmental Protection Agency, Office of Water, Washington DC. <[www.epa.gov/waterscience/standards/handbook/](http://www.epa.gov/waterscience/standards/handbook/)>.

<sup>2</sup> U.S. Environmental Protection Agency. 2001. *Streamlined Water-Effect Ratio Procedure for Discharges of Copper*. EPA-822-R-01-005. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC. <[www.epa.gov/waterscience/criteria/copper/copper.pdf](http://www.epa.gov/waterscience/criteria/copper/copper.pdf)>.

<sup>3</sup> Davies, Tudor T. 1997. *Establishing Site Specific Aquatic Life Criteria Equal to Natural Background*. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC. <[www.epa.gov/waterscience/library/wqcriteria/naturalback.pdf](http://www.epa.gov/waterscience/library/wqcriteria/naturalback.pdf)>.

<sup>4</sup> U.S. Environmental Protection Agency. 1991. *Technical Support Document for Water Quality-Based Toxics Control* (TSD). EPA-505/2-90-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC. <[www.epa.gov/npdes/pubs/owm0264.pdf](http://www.epa.gov/npdes/pubs/owm0264.pdf)>.

<sup>5</sup> U.S. Environmental Protection Agency. 1990. *Biological Criteria: National Program Guidance for Surface Waters*. EPA-440/5-91-004. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC. <[www.epa.gov/bioindicators/html/biolcont.html](http://www.epa.gov/bioindicators/html/biolcont.html)>.