Missouri Department of Natural Resources

Water Protection Program
Water Pollution Control Branch

3 *Part III: Effluent Limitation Procedures:* Water Quality-Based Effluent Limits

3.4 Water Quality-Based Effluent Limits

One of the central tenets of Sections 301 and 302 of the federal Clean Water Act addressing technology-based (TBELs) and water quality-based effluent limits (WQBELs), respectively, is the comparison between applicable TBELs and WQBELs to determine which is the most protective of water quality. When developing effluent limitations, a water quality review must consider limits based on both the TBELs to control the pollutants and WQBELs that are protective of the water quality standards of the receiving water. Portions of the effluent regulations [e.g. 10 CSR 20-7.015(8)(B)3.C.] require water quality-based effluent limits for BOD, TSS, and pH, if these POCs may endanger or degrade water quality of the receiving water body. Similar requirements are in other sections of 10 CSR 20-7.015 as well. For toxic chemicals, U.S. EPA's regulations at 40 CFR 122.44 (d)(1)(i) require effluent limitations for all pollutants that are or may be discharged at a level that will cause, or have the reasonable potential to cause or contribute, an in-stream excursion above a narrative or numeric water quality standard (see Part 4, Procedures for Reasonable Potential to Exceed (RTPE) and Specific WQBELs).

3.4.1 General Water Quality Standards Application to Permitting Process

In Part 2, *Introduction to Water Quality Standards*, we covered considerations needed to determine limits that are protective of water quality standards for a POC. As reviewers or permit writers, our task involves the translation of the water quality standards into permit limits and ultimately into the permitting process. In the *Introduction to Water Quality Standards*, we discussed the water body classifications and designated beneficial uses derived from the Water Quality Standards (10 CSR 20-7.031, Tables G and H), water quality criteria (numeric criteria and narrative criteria), requirements of the antidegradation policy, critical receiving water low flow for WQBEL calculations, mixing zones, and Whole Effluent Toxicity Testing.

This section of Part 3 will cover the basic modeling, statistical concepts and tools that EPA developed to use when calculating WQBELs. In Part 4 of this guidance, this section will be combined with the water quality standards requirements that are found in Part 2 to develop specific water quality-based effluent limitations. For more details on water quality-based permitting, refer to the EPA's *Technical Support Document for Water Quality-Based Toxics Control* (TSD). EPA-505/2-90-001.

An additional water quality standards process is the assessment of water bodies to determine whether they are attaining the established standards. These assessments are published in a 305 (b) report and 303 (d) listings of impaired waterbodies by our Water

Quality Monitoring and Assessment Section in the Water Pollution Control Branch. Section 303(d) of the Clean Water Act establishes a process for states to identify waters within its boundaries where implementing technology-based controls are inadequate to achieve water quality standards. After identifying potential water quality problems, the State sets priorities for which water bodies to target first for further evaluation. The State may then reevaluate the established water quality standards for specific waters and, if necessary, refine the standards; or the State may then set controls on point and nonpoint sources in a Total Maximum Daily Load (TMDL) document. A TMDL is an analysis of the entire water body and the amount of the pollutant from point, nonpoint, and natural background sources, including a margin of safety, that may be discharged to a water body and still ensure that the water body attains water quality standards. When assessing point source discharges to determine whether controls based on water quality standards are necessary (Figure 2), we may conduct an analysis of the self-monitoring and reporting of the effluent discharge to determine whether the discharge causes, has the "reasonable potential" to cause, or contributes to an excursion of any water quality criteria in the receiving water (For more information on this procedure, see Part 4, Specific WQBELs Processes and RPTE). Where water quality standards-based effluent limits are necessary, we allocate responsibility for controls through wasteload allocations (WLAs) and then effluent limits in NPDES permits consistent with those WLA.

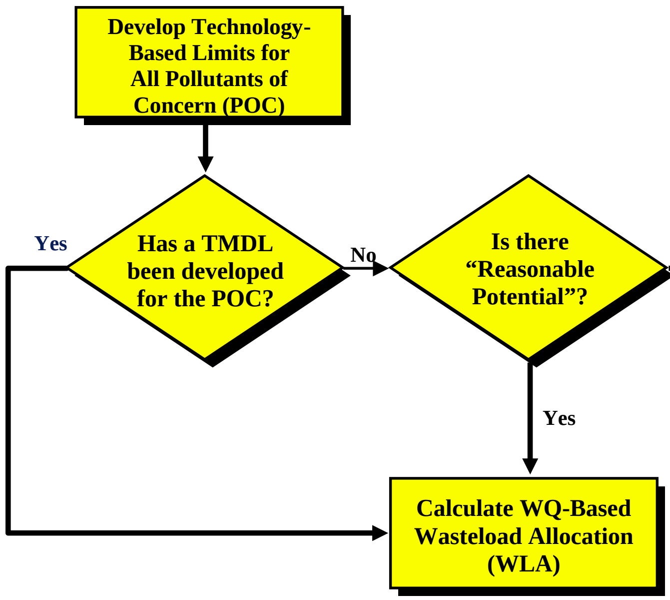

Figure 2. Simplified Water Quality Standards Application to Permitting Process for an Existing Facility.

3.4.1.1. Wasteload Allocation

Before calculating the WQBEL, the reviewer must first determine the point source's wasteload allocation. As described above, the WLA is a fraction of the TMDL for a water body that is assigned to the point source. When technology-based controls are not adequate to protect water quality, then a water quality-based control must be developed. Based on TMDL, point source WLA and nonpoint source load allocations predict load levels that attain and maintain applicable narrative and numerical water quality standards. Some TMDLs are simple, considering a single point source WLA and background concentrations of the pollutant from other sources. These TMDLs rely on mass balance and simplified water quality models that assume steady state or constant conditions for variables such as background concentrations, stream flow, and design flow. The more complex models or dynamic modeling involve multiple point and nonpoint source pollutant load and simulate cumulative chemical fate and transport of pollutants.

3.4.1.2. Water Quality Models

Water quality models provide a predictive link between in-stream water quality concentration and loading from point and non-point sources. Water Quality Standards serve as regulatory targets during the modeling and WLA process. A water quality model is a link, often quantitative, between independent (influential) and dependent (predicted) variables. In the context of the WLA environment, dependent variables are generally pollutants that directly influence a water quality criterion. The relationship between independent and dependent variables describes model structure or form.

A water quality model should be selected based on its adequacy for the intended use, for the specific water body, and for the critical conditions occurring at that water body. An obvious choice for narrowing the selection of an appropriate model is based on the water body type (river, estuary, or lake) and the type of analysis (BOD/DO, conservative pollutants, toxics, etc.).

Simple Dilution Model--A simple dilution model is the simplest of the water quality modeling techniques. These models are mass balance equations that consider pollutant loadings and dilution but do not incorporate elements of transport or environmental reactions.

Steady-State Model--In steady-state models, pollutant loadings, transport processes, and reactions are generally held constant with respect to time. Mass is neither stored nor lost, rather sinks are in balance with sources (accumulation = zero). Some steady-state models are calculator type models that can be determined on a hand-held calculator, while other models are computer based. Steady-state frameworks are the most commonly used water quality model because they are easy to implement and interpret (For more information see EPA *Compendium of Tools for Watershed Assessment and TMDL Development* (1997)). An example of this type of model is the **Streeter-Phelps** equations and modifications thereof. For more information see *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water.* EPA/600/6-85/002a. A more complex version of a steady-state computer model is QUAL2E/QUAL2K Water Quality Model.

A steady-state model requires single constant inputs for effluent flow, effluent concentration, background receiving water concentrations, receiving water flow in form of hydrologically-based low flow conditions (currently used in Missouri, see Section 2.6.1 Low Flow Conditions), and metrological conditions such as temperature. EPA has encouraged Missouri to use the two-value aquatic life criteria process in developing WLAs, i.e., calculating both acute and chronic WLAs. The calculation of these two WLA values enables the reviewer to calculate the more limiting of the long-term average (LTA, see Section 3.4.3.2 below). The WLA is also calculated for the worst case assumptions of flow, effluent, and environmental conditions. For example, ammonia steady-state model would include the maximum effluent discharge, highest upstream concentration, highest pH, and highest temperature. The results from steady-state models are often interpreted as long-term or daily average values.

Dynamic Models--Continuous simulation models are similar to steady-state models in that they consider all pollutant loadings, transport processes, and reactions; however, these processes are allowed to vary continuously with respect to time. Examples of these processes are the temporal variations in hydraulics and waste loadings. Continuous models allow for the continuous prediction of time series variation in water quality. These models are complex (transport, load, and reaction are time-variable) and require more data to properly calibrate and verify. Continuous models are useful in evaluating time variable water quality responses. Results from continuous simulation models allow interpretation of average, maximum, or minimum values depending on the nature of the input parameters.

Stochastic prediction involves the random selection of input variables based on a range of values that is specified by the user. Model outputs are computed repeatedly and are presented as probability distributions of predicted water quality parameters. Elements of stochastic modeling can be included in any water quality model using Monte Carlo methods.

QUAL2E/QUAL2K is considered a quasi-dynamic model because upstream flow and waste loading are held constant while the model allows the meteorology and water quality conditions downstream of the upstream boundaries to vary. Models such as WASP5, HSPF, and CE-QUAL-RIV1 are truly dynamic since they simulate continuous temporal variations in stream hydraulics and waste loading.

3.4.1.3. Statistics and Distribution to Derive WQBEL

According to the EPA’s TSD [EPA-505/2-90-001], the daily effluent concentrations are generally lognormal distributed. The vast majority of the data that have been analyzed by EPA indicate the effluent data are lognormal distributed. Ambient water quality data are also considered lognormal distributed.

When lognormal data are log transformed, the properties of the normal distribution apply to the transformed data. Thus, effluent data may be described using standard descriptive statistics such as the mean concentration, the long-term average (LTA), and the coefficient of variation (CV) of the pollutant. The CV is a standard statistical measure of the relative variations of a distribution or set of data, defined as the ratio of the standard deviation to the mean. The LTA value for the pollutant parameter is a composite mean of the effluent data for a treatment facility. Both the LTA and the CV are used to develop permit limits. The water quality-based permit limits process operates by determining the waste load allocation (WLA), determined from water quality standards, which defines the appropriate discharge level that meets the requirements of the water quality standards. The WLA in turn determines the requisite target LTA for the treatment facility in order to meet that WLA. Permit limits may then be derived from this targeted LTA and CV.

Estimates of the CV can be used when the actual CV cannot be calculated or if the available data sets for calculating the CV are small. The first approach is to use a conservative estimate of the CV that assumes relatively high variability (e.g., CV = 0.6) in the final permit limit. The second approach is to collect additional data to obtain a more definitive value for the CV. In either case, the reviewer may use the LTA equations found in Table 5-1 within the EPA TSD [EPA-505/2-90-001] or use the Table 5-1 values to discern the WLA multiplier.

3.4.1.4. Percentiles for WQBELs

The use of a WLA from steady-state model alone to set permit limits would produce regular violations of water quality standards. To simulate the natural variation of effluent quality, the EPA developed equations that can be use in conjunction with the LTA and CV values that are based upon two probability distributions: 95% percentile probability and the 99% percentile probability. This process ensures that water quality-based permit limits are set at the upper bounds of acceptable performance. The purpose of a permit limit is to specify an upper bound of acceptable effluent quality.

The selection of a probability basis to be used in the two-value steady-state WLA model or equations is a decision made by the permitting authority (see Part 4, Section 4.1, General WQBELS for description of the WQBEL equations and processes). In Missouri for the calculation of the LTAs from both acute and chronic WLAs, we use the 0.01 probability (99th percentile level). The equation for WLA multiplier uses the CV value only and a z-value of 2.326. For aquatic life uses, the reviewer may use the equations found in Table 5-1 within the EPA TSD [EPA-505/2-90-001] or use the Table 5-1 values to discern the multiplier. For calculation of permit limits from the most stringent of the two LTAs, we use 0.01 probability basis (99th percentile level) for the maximum daily limit (MDL) and 0.05 probability basis (95th percentile level) for the average monthly limits (see Section 3.4.1.5 and 3.4.1.6).

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The overall combination of the CV, number of monitoring samples, and the assumed probability basis for calculating the LTA from the WLA, and the use of the most stringent LTA, has different effects on the derived limits depending upon the selection made for each. For more information on the effects of CV, monitoring sample size, etc, refer to the TSD [EPA-505/2-90-001], page 107.

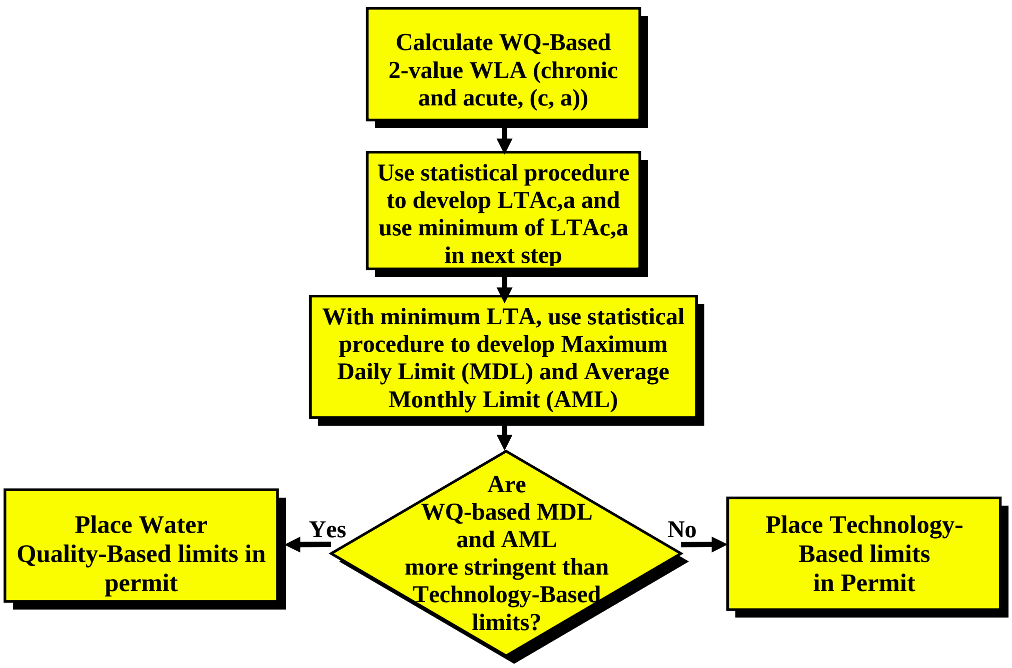

Figure 3. The Two-value Steady-State WLA Procedure for Aquatic Life Protection.

3.4.1.5. Maximum Daily Limit (MDL)

The maximum daily limit (MDL) is the highest allowable discharge value measured during a calendar day or 24-hour period representing a calendar day. A MDL is determined through a comparison of technology and water quality-based effluent limitations (Figure 3). Once the limiting or most stringent LTA (chronic and acute) is determined as described above using the two-value steady state WLA model or other type of steady state model such as QUAL2E/2K, the next step is to determine the multiplier to apply to the most stringent LTA. For calculation of permit limits, we use 0.01 probability basis (99th percentile level) for the MDL. The equation for the maximum daily limit LTA multiplier uses the CV value only and a z-value of 2.326. For aquatic life uses, the reviewer may use the equations found in Table 5-2 within the EPA TSD or use the Table 5-2 values to discern the multiplier. For the protection of human health, calculation of MDL is based upon the effluent variability CV and the number of samples per month using a multiplier provided in Table 5-3 of the EPA TSD [EPA-505/2-90-001]. By default, CV of 0.6 is recommended by EPA for discharges without effluent monitoring data. For 5-day biochemical oxygen demand (BOD_5) limit WQBEL determination, see the *DO Modeling Administrative Guidance* for more information.

3.4.1.6. Average Monthly Limit (AML)

The average monthly limit (AML) is the highest allowable value for the average of daily discharges obtained over a calendar month. An AML is determined through a comparison of technology and water quality-based effluent limitations (Figure 2). Once the limiting or most stringent LTA (chronic and acute) is determined as described above using the two-value steady state WLA model or other type of steady state model such as QUAL2E/2K, the next step is to determine the multiplier to apply to the most stringent LTA. For calculation of permit limits, we use 0.05 probability basis (95th percentile level) for the average monthly limits. The equation for the AML LTA multipliers use a combination of the CV value, z value and the 'n' number of samples collected month. For aquatic life uses, the reviewer may use the equations found in Table 5-2 within the EPA TSD [EPA-505/2-90-001] or use the Table 5-2 values to discern the multiplier. The 'n' value must reflect the averaging period for the pollutant's criteria continuous concentration (CCC). For example, a conservative pollutant's CCC for aquatic life was developed based upon a 4-day average exposure duration, thus the number of sample per month must be n = 4. Similarly, for ammonia, the averaging period for the CCC is 30 days, thus the number of sample per month must be n = 30 (see Total Ammonia Nitrogen Criteria Implementation Guidance). For the protection of human health, calculation of AML is set equal to the WLA (see EPA TSD [EPA-505/2-90-001], page 105). For 5-day biochemical oxygen demand (BOD_5) limit WQBEL determination, see the *DO Modeling Administrative Guidance* for more information.

3.4.2. Antibacksliding Considerations

Federal Clean Water Act Section 402(o) and 303(d) (4) and 40 CFR 122.44(l) prohibit the renewal, reissuance, or modification of an existing permit that contains effluent limitations, permit conditions or standards that are less stringent than those established in the previous permit. Some exemptions exist where backsliding on limitations or permit conditions would be allowed. For those attaining standards with the discharge, exceptions are allowed as long as limit is consistent with EPA effluent guidelines and state water quality standards and more importantly attaining standards. Also, for those waters not attaining standards, exceptions are allowed as long as existing limit is based on a TMDL or WLA, and the limit will assure attainment of WQS, and be consistent with technology-based requirements. Finally, case-by-case exceptions to the antibacksliding consideration are allowed when there are:
1- substantial alternations or additions to permitted facility,
2- new information that was not available at the time of the permit issuance,
3- technical mistakes or misinterpretations of the law in permit issuance,
4- events beyond the permittee's control and no reasonable alternative,
5- modifications to the permit under one of several CWA sections, or

6- circumstances where the permittee has been unable to meet the permit limitations after properly operating and maintaining required treatment facilities.

See the Water Pollution Control Branch's Permit Manual or EPA *Permit Writer's Manual* for more information.

3.4.3. Best Professional Judgment

The permit writer develops Best Professional Judgment (BPJ) permit limits when EPA effluent limit guidelines (ELGs) do not exist or secondary treatment limits do not apply to a discharge. These permit limits are technology based that are derived on a case-by-case basis for non-municipal facilities. BPJ is defined as the highest quality technical opinion developed by the permit writer after taking into account all reasonable information, terms, and conditions of the NPDES permit. Rationale for a BPJ permit limit must be carefully drafted to withstand the scrutiny of not only the permittee but the general public and ultimately administrative law judge.

Once the need for the BPJ limit has been determined, the next step is to ensure that the pollutant that is not regulated under an effluent guideline was considered by EPA while developing the ELGs for a specific industry as not a candidate for an ELG. In developing BPJ limits, the reviewer must consider the same factors that EPA uses to develop ELGs. These factors are discussed in Section 3.3 of this guidance. There are numerous references to rely upon for which to draft BPJ limits. These can be found in EPA's *NPDES Permit Writer's Manual*, Exhibit 5-5.

3.4.4. Single vs. Multiple Discharges

The development of effluent limits for a reach of stream with multiple discharges in close proximity increases the complexity of the WLA equations. Typically, those pollutants that are in common with the two or more dischargers must be considered when developing the WLA. The EPA's TSD [EPA-505/2-90-001] provides guidance on developing a WLA and permit limit for a discharger that encounters multiple discharges for the same pollutant. Dynamic modeling or more complicated steady-state modeling may be needed to adequately address a multiple discharge scenario.

Also, consideration must be given to the assimilative capacity of this pollutant for discharges in the same segment of waterbody. The water quality criteria and degradation are both considerations for a multiple discharge scenario of the water body segment. Multiple discharges cannot exceed the threshold values established in the AIP, May 2008. The AIP provides guidance on determining the assimilative capacity of a Tier 2 pollutant in situations where multiple discharges in the same water body segment exist.

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3.4.5. Developing Limits in Accordance with Antidegradation Procedure

In situations where technology-based effluent limit (i.e., ELG, secondary treatment limit, equivalent-to-secondary treatment limit) may be applicable, the reviewer should include when applicable justification for assigning limits that are based on water quality standard such as the antidegradation procedure. The authority to assign limits based on an antidegradation requirement can be found in Section III, page 35, of the AIP that says, "The department develops draft permit effluent limits based on effluent guidelines, the applicable Water Quality Standards (WQS), EWQ and antidegradation requirements." Section II.B.2.b) of the AIP also states: "The base cost of pollution control is the cost of the controls required to protect existing uses and to achieve the highest statutory and regulatory requirements, i.e., the more stringent of water quality-based effluent limits for existing use protection or technology-based effluent limits." WQBEL for antidegradation purposes must be one that protects the assimilative capacity, i.e., the minimally-degrading effluent limit (see Section 4.3.4, Special Antidegradation Considerations).

The reviewer may find further justification for the development of effluent limits in accordance with antidegradation policy in federal regulations. Federal regulations provide for permit adjustments to equivalent-to-secondary treatment standards in 40 CFR 133. This regulation discusses the application of effluent limits that are more stringent than equivalent-to-secondary treatment for BOD and TSS that are based on past performance for existing facilities or design capacity of treatment for new facilities.

Parts 2 and 4 of this guidance discuss the antidegradation requirements related to effluent limit development for waste water discharge permitting.

Below is a list and brief description of revisions made to Part III General Procedures: Water Quality Based Effluent Limits:

Version	Date Completed	Description
Version 1.0	August 18, 2009	Original version written by Todd Blanc.