

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT  
BUREAU OF WATER

# WATER QUALITY STANDARDS WHITE PAPER

---

DURATION AND FREQUENCY FOR ASSESSING  
NUMERIC CRITERIA



JANUARY 10, 2011

# DURATION AND FREQUENCY FOR ASSESSING NUMERIC CRITERIA

---

## ISSUE

---

**Should Kansas define applicable duration and frequency values for its criteria to assess surface water quality?**

It is the mission of the Kansas Department of Health and Environment (KDHE) to protect the health and environment of all Kansans by promoting responsible choices. One facet of this mission is the setting of water quality standards based on the best science available.

---

## CURRENT CRITERIA

---

Currently, the Kansas Water Quality Standards (KSWQS) define water quality criteria by the magnitude of the acceptable concentration. There are no explicit statements outlining the acceptable duration or frequency of digressions over those criteria. For certain pollutants (ammonia, bacteria), the duration or frequency is implied within other provisions of the KSWQS. The process of assessing ambient water quality against the applicable water quality criteria interprets acceptable occurrence of digressions through the 303(d) listing methodology preceding the development of the biennial list of impaired waters.

---

## BACKGROUND

---

Water quality criteria have three components: magnitude, duration and frequency. Magnitude refers to the concentration of a pollutant and is represented by the numeric criterion. Samples with concentrations higher than the criterion are referred to as “digressions”. Duration is the period of time over which concentrations can be averaged and aquatic life can be exposed to elevated levels of pollutants without harm. Water quality criteria were not intended to be instantaneous values never to be exceeded. EPA currently recommends a 4-day averaging period for most chronic criteria (long term impacts on growth or reproduction) and a 1-hour period for most acute criteria (short term lethal

impacts). Concentrations exceeding criteria values beyond the designated duration are referred to as “excursions”. Frequency is the number of times an excursion can occur over time without impairing the aquatic community or other use. Typically, EPA has set the acceptable frequency at once every three years, based on studies of ecological recovery after a pollution event. An occurrence happening more often than the designated frequency is termed an “exceedance” and is the basis for listing that water as impaired by not meeting water quality standards.

Different durations and frequency are possible for other designated uses, such as public water supply. For human health concerns, a lifetime (70-year) exposure may be designated or criteria are evaluated on annual averages. In the KSWQS, bacteria impairment for streams can be declared only if a geometric mean<sup>1</sup> of five samples taken within a 30-day period exceeds the criterion. Ammonia toxicity is determined using a 30-day average low flow. Background concentrations of naturally elevated salts may supplant existing criteria and are calculated as averages of concentrations occurring at low flow. The only mention of frequency and averaging period (duration) is in the provision for alternate low flows, with the admonition that using those flows to set effluent limits cannot cause excursions to occur more than once every three years.

For aquatic life, the standards regarding toxic substances states: “Conditions of acute toxicity shall not occur in classified surface waters outside of zones of initial dilution, nor shall conditions of chronic toxicity occur in classified surface waters outside of mixing zones.” Without defining those conditions of toxicity (acceptable duration and frequency), one interpretation of the water quality standard could be there are to be no digressions in the waters of the state; one sample value over the applicable criterion is cause for listing the water as impaired.

The problem with duration and frequency arises in the assessment of using monitoring data to ascertain which waters are not meeting water quality standards. KDHE monitors a suite of pollutants typically by sampling once every 2-3 months. These bi-monthly or quarterly sample values are not strictly representative of the applicable duration for the associated criteria. Financial constraints limit the likelihood of aligning the amount and frequency of sampling to conform with the default duration and frequencies supported by EPA. KDHE prepares a methodology for interpreting its sample data in the context of water quality criteria. Originally, many of the data were assessed through the “10% rule”; if no more than 10% of the sample values were greater than applicable criterion, then the water was deemed to fully support the designated use protected by that criterion.

Statistically, the 10% rule tends to overstate the number of impaired waters by declaring a water as impaired when in reality it is not. To counteract this error, many states, including Kansas, used a binomial<sup>2</sup> statistical test of the samples to make listing determinations. The binomial approach will typically not list compliant waters, but it can leave truly impaired waters off the list, particularly when the number of samples is small. Kansas adds safeguards in its approach to minimize the possibility of missing impaired waters.

---

<sup>1</sup> A geometric mean is the nth root of the product of n numbers. A geometric mean is used to determine the central tendency of group of numbers that can vary widely. Thus, the geometric mean tends to dampen the effect of very high or low values which would bias an arithmetic mean.

<sup>2</sup> A test of statistical significance based on probability.

In its 2004 and 2006 guidance on developing the listing methodology, EPA states that while methods such as the 10% rule or binomial analysis may be fine for conventional pollutants (pH, total suspended solids, biochemical oxygen demand, etc), they are not to be used in assessing toxic pollutants (metals, mercury, polychlorinated biphenyls [PCBs], other organics, some pesticides, etc). In those cases, the default frequency of more than one occurrence in three years dictates impairment and listing decisions. EPA also intimated that methodologies for listing decisions that define acceptable duration or frequencies of digressions among sampled data may constitute a change in water quality standards, outside the statutory triennial review process.

Kansas used the binomial approach for a number of pollutants, including chronic concentrations of metals and pesticides. In cases where salt concentrations were represented by an alternative background concentration, median values were evaluated against those background concentrations. Additionally, in 2008 and 2010, Kansas made stream listings for phosphorus or total suspended solids as determined through comparing median values to specific thresholds. Acute criteria and dissolved oxygen were assessed by the once-in-three year frequency. Streams were deemed impaired by *E coli* bacteria if the geometric mean from intensive sampling was greater than the criterion once. In all cases, the duration and frequency aspects of the criterion was implied by the methodology analysis, but had no direct tie to specific language within the water quality standards.

---

**KANSAS ASSESSMENT EXAMPLES FROM 2010 303(D) LIST**

---

Pollutant	Assessment for Listing	Kansas R @ Wamego	Wildcat Creek	Grasshopper Creek
Assessment Years		2000 – 2009	1993, 97, 2001, 2003, 2007	1992, 96 – 98, 2000, 04, & 08
Atrazine	Binomial: 10% > 3 ppb	0/30 samples (6 excds needed to list)	0/13 samples (3 excds needed)	<b>15/83 samples (12 excds needed)</b>
Acute Copper	> 1 exceedance per 3 yrs	1 excds in 10 years	1 excd in 5 years	<b>7 excds in 7 years</b>
Chronic Copper	Binomial: 10% > chronic criterion	1/59 samples (9 excds needed to list)	1/28 samples (5 excds needed)	<b>19/97 samples (14 excds needed)</b>
Dissolved Oxygen	> 1 exceedance per 3 yrs	0 excds in 10 years	<b>3 excds in 5 years</b>	0 excds in 7 years
E coli Bacteria	One Geometric Mean > primary rec criterion (262 CFUs/100 ml [427 for Grasshopper Crk])	11 Geomeans in 2004-06 & 08; ranging from 28 - 215	<b>4 Geomeans in 2008; 3 over 262</b>	<b>3 Geomeans in 2010; 2 over 427</b>
Total P	Median TP > 201 ppb	<b>Median TP = 288 ppb</b>	Median TP = 189 ppb	<b>Median TP = 210 ppb</b>
Total Susp Solids	Median TSS > 50 ppm	<b>Median TSS = 54 ppm</b>	Median TSS = 30 ppm	Median TSS = 36 ppm
<b>Statistics in Bold Red indicate evidence of impairment (justification for listing or TMDL)</b>				

---

## OTHER STATES' APPROACH

---

The water quality standards and listing methodologies from a number of states were examined to ascertain how they dealt with duration and frequency of their sampling data in the listing process. The following table summarizes their approaches.

State	Duration	Frequency	Listing Approach	WQS Remarks
<b>Minnesota</b>	Toxics: 1-d max; 4-d avg; Human Health: 30-d avg	1 in 3-yr	>1/3-yr or > 10% samples	
<b>Utah</b>	Toxics: 1-hr max; 4-d avg; Conventional: 30-d avg	1 in 3-yr	> 1/3-yr or > 10% samples	
<b>Pennsylvania</b>	1-hr max; 4-d avg; 30-d avg		Binomial and > 10% samples	<i>Criteria to be achieved 99% of time</i>
<b>Ohio</b>	Annual average; biological monitoring	Nitrate > 1/5-yr	Biomonitoring; annual avg	
<b>North Carolina</b>			> 10% samples	
<b>Oklahoma</b>	2-yr rolling average; 7-d avg		> 2 with >2 orders of magnitude difference; rolling averages; 10% samples	
<b>Colorado</b>	1-d or 3-d avgs	1 in 3 yrs	50 <sup>th</sup> or 85 <sup>th</sup> percentile > criteria;	
<b>North Dakota</b>	1-hr and 4-d avg	1 in 3 yrs	> 10% samples; not exceeded in 3-yr period	
<b>Tennessee</b>			> 10% samples	<i>In general, deviations from normal water conditions are undesirable, but the magnitude and duration of the deviations shall be considered in interpreting the criteria.</i>
<b>Florida</b>	1-hr, 4-d avg	1 in 3 yrs	Binomial	<i>Planning list, then verified list (303(d))</i>
<b>New Jersey</b>	4 days for AL; Longterm average for HH	1 in 5 yrs; 1 in 3 yrs for toxics	> 1 in 3 or 5 yrs	

---

## OPTIONS

---

There are a number of options for Kansas to use in applying duration and frequency to its water quality criteria in assessing surface waters for impairment status.

1. Continue as is, use methodology to define listing frequencies and duration with no direct tie-back to the KSWQS
2. Define duration and frequency for each pollutant in the KSWQS
3. Place assessment procedures in the KSWQS, e.g., Utah's WQS state: *"For water quality assessment purposes, up to 10 percent of the representative samples may exceed the minimum or maximum criteria for DO, pH, E.coli, TDS and temperature, including situations where such criteria have been adopted on a site-specific basis."*
4. Delegate the definition of the applicable durations and frequencies to the listing assessment methodology by the KSWQS; e.g., *"Digressions from the numeric criteria in tables 1a, 1b, 1c, 1d, 1e, 1g, 1h, 1i and 1j of the "Kansas surface water quality standards: tables of numeric criteria," as adopted by reference in subsection (d) of this regulation, will be assessed for the purposes of Section 303(d) of the Federal clean water act, with consideration of acceptable duration and frequency of such digressions such that the designated uses of Kansas water remains fully supported, through analyses documented in the assessment methodology supporting the listing decisions for water quality impaired surface waters."*
5. Refer interpretation of duration and frequency of water quality criteria for impaired water [303(d)] listing purposes to the *Kansas Implementation Procedures: Surface Water Quality Standards*, adopted by reference in the KSWQS.

**Impact Considerations:** Continuation of the status quo invites potential challenges to KDHE's methodology for assessing and listing impaired waters. Challenges could result in prolonged and expensive legal proceedings. Adopting a modification to the Kansas Surface Water Quality Standards (WQS) that incorporates Kansas' methodology for interpreting duration and frequency – either directly in regulation or as a part of the WQS Implementation Procedures – should provide KDHE a strong defense from any such challenges. Securing a provision for allowance of the occasional digression from water quality standards also directs water quality restoration efforts toward waters that are truly impaired, thereby increasing the effectiveness of those efforts.

---

## REFERENCES

---

1. KDHE, *METHODOLOGY FOR THE EVALUATION AND DEVELOPMENT OF THE 2010 SECTION 303(D) LIST OF IMPAIRED WATER BODIES FOR KANSAS*; February 17, 2010; [http://www.kdheks.gov/tmdl/download/2010\\_303\\_d\\_Methodology\\_Draft.pdf](http://www.kdheks.gov/tmdl/download/2010_303_d_Methodology_Draft.pdf)
2. EPA 2006 Guidance on Integrated Reports, [http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2006IRG\\_index.cfm](http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2006IRG_index.cfm)
3. EPA Guidance for 2004 Assessment, Listing and Reporting Requirements, [http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/tmdl0103\\_index.cfm](http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/tmdl0103_index.cfm)
4. Utah 2008 Integrated Report – Water Quality Assessment, [http://www.waterquality.utah.gov/documents/2008\\_IR\\_Part1\\_71409\\_fin.pdf](http://www.waterquality.utah.gov/documents/2008_IR_Part1_71409_fin.pdf)
5. Oklahoma 2008 Integrated Report – Surface Water Assessment; [http://www.deq.state.ok.us/WQDnew/305b\\_303d/2008\\_integrated\\_report\\_entire\\_document.pdf](http://www.deq.state.ok.us/WQDnew/305b_303d/2008_integrated_report_entire_document.pdf)
6. Colorado 2010 Section 303(d) Listing Methodology, [http://www.cdphe.state.co.us/op/wqcc/SpecialTopics/303\(d\)/303dLM2010.pdf](http://www.cdphe.state.co.us/op/wqcc/SpecialTopics/303(d)/303dLM2010.pdf)
7. Tennessee 2008 Section 303(d) List, <http://tn.gov/environment/wpc/publications/pdf/2008pf303dlist.pdf>
8. North Carolina 2010 Use Assessment Methodology, [http://portal.ncdenr.org/c/document\\_library/get\\_file?uuid=51ce1253-59e8-4d6b-a496-ac8e15441532&groupId=38364](http://portal.ncdenr.org/c/document_library/get_file?uuid=51ce1253-59e8-4d6b-a496-ac8e15441532&groupId=38364)
9. Ohio 2010 Integrated Report, <http://www.epa.state.oh.us/dsw/tmdl/2010IntReport/2010OhioIntegratedReport.aspx>
10. Pennsylvania Stream Chemistry Statistical Assessments, <http://files.dep.state.pa.us/Water/Drinking%20Water%20and%20Facility%20Regulation/WaterQualityPortalFiles/Methodology/ChemistryEvaluations.pdf>
11. Minnesota Guidance Manual for Assessing the Quality of Minnesota Surface Waters <http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/assessment-and-listing/tmdl-water-quality-assessment.html>
12. Florida Identification of Impaired Surface Waters; <https://www.flrules.org/gateway/chapterhome.asp?chapter=62-303>
13. North Dakota 2008 Integrated Report; [http://www.ndhealth.gov/WQ/SW/Z7\\_Publications/IntegratedReports/2008%20North%20Dakota%20Integrated%20Report-Final%20Approved%2020080929.pdf](http://www.ndhealth.gov/WQ/SW/Z7_Publications/IntegratedReports/2008%20North%20Dakota%20Integrated%20Report-Final%20Approved%2020080929.pdf)
14. New Jersey 2008 Integrated Report, [http://www.nj.gov/dep/wms/bwqsa/2008\\_final\\_IR\\_complete.pdf](http://www.nj.gov/dep/wms/bwqsa/2008_final_IR_complete.pdf)