Standard Operating Procedure
Pathogen Indicator TMDL SOP

Commonwealth of Kentucky
Energy and Environment Cabinet
Department for Environmental Protection
Division of Water
Water Quality Branch
TMDL Section

Effective Date: January 1, 2009
Revision Date: May 4, 2011
Revision No. 1.0
Document Control No. DOWSOP03002

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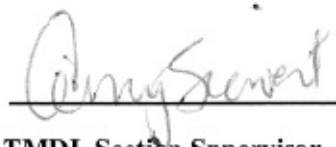
Signature Page

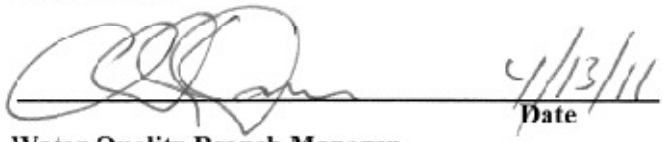
Date

Project Manager
Eric Liebenauer



Date

TMDL Section Supervisor
Amy Siewert



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Document Revision History

Date of Revision	Section(s) Revised	Revision Explanation
May 4, 2011	All pages in Section 4.F, Procedure, have been moved to the Standard Work Document (whichever version is the most current revision). Also, a list of acronyms was added after the Table of Contents, as well as the Transportation-WLA, University-WLA and Military-WLA in Section 4.D.1. Other TMDL terms (e.g., "load") were more specifically defined. Last, the distinction between "pathogen indicator" and "pathogen" was clarified in Section 4.A, while allowing both terms to be used for the sake of brevity.	This revision created a separate Standard Work Document to explain the procedures needed to complete a pathogen TMDL: The Standard Work document can be changed without the need for Division-level signatures when changes in the TMDL environment (i.e., shifting legal, administrative, technical or other requirements) dictate an adjustment in pathogen TMDL procedures. The presence of the list of acronyms is self-explanatory, as is the added definition of TMDL-related terms. The MS4 program has expanded to include universities, military bases and the Kentucky Transportation Cabinet, in addition to City- and County-MS4s. TMDLs will list a MS4-WLA when these sources are present. The difference between a pathogen and a pathogen indicator was not addressed in the first revision of this document.

Suggested Citation: Kentucky Division of Water (KDOW). 2011. Pathogen Indicator TMDL SOP Revision 1.0. Kentucky Department for Environmental Protection, Division of Water, Frankfort, Kentucky.

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LIST OF ACRONYMS

Basins	Better Assessment Science Integrating Point and Non Point Sources: http://www.epa.gov/athens/wwqtsc/html/basins.html
CFR	Code of Federal Regulations
CWA	Clean Water Act
E.	*Escherichia* (as *E. coli*)
EPA	Environmental Protection Agency
FDC	Flow Duration Curve
HYSEP	Hydrograph Separation
KAR	Kentucky Administrative Regulations
KDOW	Kentucky Division of Water
KPC	Kentucky Personnel Cabinet
KPDES	Kentucky Pollution Discharge Elimination System
LA	Load Allocation
LDC	Load Duration Curve
LSPC	Loading Simulation Program in C++
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
PCR	Primary Contact Recreation
QAPP	Quality Assurance Project Plan
QUAL2K	QUAL2K is not an acronym: http://www.epa.gov/athens/wwqtsc/html/qual2k.html
SCR	Secondary Contact Recreation
SOP	Standard Operating Procedure
STP	Sewage Treatment Plant
SWS	Sanitary Wastewater System
TMDL	Total Maximum Daily Load
URL	Uniform Resource Locator
USGS	United States Geological Survey
WASP	Water Quality Analysis Simulation Program

WLA	Waste Load Allocation
WQC	Water Quality Criteria
WQS	Water Quality Standard

4.0 PROCEDURES

4.A PURPOSE. Section 303(d)(1)(C) of the Clean Water Act (CWA) and its associated policy and program requirements for water quality planning, management, and implementation (40 CFR Part 130) require the establishment of a Total Maximum Daily Load (TMDL) for the achievement of state Water Quality Standards (WQS) when a waterbody is water quality-limited (i.e., impaired for one or more designated uses). A TMDL identifies the pollutant/waterbody-specific assimilative capacity which will allow the waterbody to meet its designated uses (the designated uses are Primary Contact Recreation (PCR), Secondary Contact Recreation (SCR), Drinking Water Supply, Fish Consumption, Warm Water Aquatic Habitat/Cold Water Aquatic Habitat, and Outstanding State Resource Waterway), which includes an appropriate margin of safety (MOS). The designated uses for each waterbody, along with the associated numerical or narrative Water Quality Criteria (WQC) to protect those uses, are found in 401 KAR 10:031. However, the purpose of this document is to provide Standard Operating Procedures (SOPs) for pathogen impairments, which are defined as listings for fecal coliform or *E. coli*, which are indicators for the presence of pathogenic organisms (such as *Giardia lamblia* protozoa, the hepatitis A virus, *Cryptosporidium* protozoa, the *Vibrio cholerae* bacteria, polioviruses, the harmful subtypes of *E. coli* such as *E. coli* 0157:H7, etc.), and may be referred to as either "pathogen indicators" or, for brevity, simply as "pathogens." One advantage of using pathogen indicators as opposed to testing for individual pathogenic organisms is that using indicators is much less resource intensive, avoiding the problems encountered when culturing many types of waterborne pathogens. Also, indicators allow the use of standardized tests that produce defensible, comparable data (EPA, 2001).

Pathogens impair for the PCR use, the SCR use, or both. Pathogens do not impair for any of the other designated uses, so only methods used to set pathogen TMDLs for PCR and SCR will be described in this SOP.

According to the *General EPA/State Outline for Development of TMDLs* (EPA, 1991), the TMDL, the Wasteload Allocation (WLA, if Kentucky Pollutant Discharge Elimination System (KPDES)-permitted sources are present which discharge the pollutant of concern to the impaired segment) and a Load Allocation (LA, if non-KPDES-permitted sources are present which discharge the pollutant of concern to the impaired segment) must be determined using "…water quality analytical models or other analytical tools." *Modeling* and *data analysis* are tools that assess various loading allocation scenarios which aid the TMDL development process. *Modeling* is defined as a predictive simulation of real-world conditions (e.g., predictive, empirical and/or mechanistic tools such as QUAL2K, Basins, WASP, LSPC, etc.), whereas *data analysis* is defined as a mathematical representation or interpretation of existing data with no predictive value (i.e., any conclusions apply only to the time when the data were collected, but the conclusions can be used to calculate the TMDL).

If water quality modeling is used, the approach must meet the requirements stated in Kentucky's *Quality Assurance Project Plan, Data Analysis for TMDL Development,*

Version 1.0 (KDOW, 2009). If data analysis is used, the procedures in both the QAPP and this SOP must be followed.

4.B APPLICABILITY / SCOPE. This SOP applies to all TMDL documents written by the Kentucky Division of Water (KDOW) for pathogens that do not use predictive modeling (i.e., analytical pathogen TMDLs).

4.C SUMMARY OF PROCEDURE. Analytical pathogen TMDLs will employ a *Load Duration Curve* (LDC) approach to setting the TMDL Target if sufficient data exist and are available to support this approach (see Section 4.F.1.4 of the Kentucky Pathogen SOP Standard Work Document). If not, the *Mean Annual Flow* (MAF) method will be used to set the TMDL Target (see Section 4.F.3 of the Kentucky Pathogen SOP Standard Work Document). Also, the TMDL Section Supervisor may approve the use of the MAF even if sufficient data exist to support the LDC approach. If conditions arise that are not covered by this SOP, the final decision will rest with the TMDL Section Supervisor.

4.D DEFINITIONS

4.D.1 TMDL. According to EPA (2007), a TMDL calculation is performed as follows:

$$TMDL = WLA + LA + MOS$$
(Equation 1)

The WLA has three components:

$$WLA = SWS\text{-}WLA + MS4\text{-}WLA + Future\ Growth\text{-}WLA$$
(Equation 2)

Definitions:
TMDL: the WQC, expressed as a load. The WQC is defined as an instantaneous concentration of 240 colonies/100 ml for *E. coli* or 400 colonies/100 ml for fecal coliform.
MOS: the Margin of Safety, which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties in the relationship between effluent limits and water quality.
TMDL Target: the TMDL minus the MOS.
WLA: the Wasteload Allocation, which is the allowable loading of pollutants into the stream from KPDES-permitted sources, such as SWSs and MS4s.
SWS-WLA: the WLA for KPDES-permitted sources, which have discharge limits for pathogen indicators (including wastewater treatment plants, package plants and home units).
Future Growth-WLA: the allowable loading for future KPDES-permitted sources, including new SWSs, expansion of existing SWSs, new storm water sources, and growth of existing storm water sources (such as MS4s). Also includes the allocation for the KPDES-permitted sources that existed but were not known at the time the TMDL was written.

Remainder: the TMDL minus the MOS and minus the SWS-WLA (also equal to Future Growth-WLA plus the MS4-WLA and the LA).
MS4-WLA: the WLA for KPDES-permitted municipal separate storm water sewer systems (including cities, counties, roads and right-of-ways owned by the Kentucky Transportation Cabinet (KYTC), universities and military bases).
LA: the Load Allocation, which is the allowable loading of pollutants into the stream from sources not permitted by KPDES and from natural background.
Seasonality: yearly factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.
Critical Condition: the time period when the pollutant conditions are expected to be at their worst.
MAF: the Mean Annual Flow as defined by USGS.
Adjusted MAF: the MAF plus SWS-WLA design flows.
Critical Flow: the flow used to calculate the TMDL as a load (is equivalent to the Adjusted MAF for MAF TMDLs)
Existing Conditions: the load that exists in the watershed at the time of TMDL development (i.e., sampling) and is causing the impairment.
Percent Reduction: the loading reduction needed to bring the existing condition in line with the TMDL target.
Load: concentration * flow * conversion factor
Concentration: colonies per 100 milliliters (colonies/100ml)
Flow (i.e. stream discharge): cubic feet per second (cfs)
Conversion Factor: the value that converts the product of concentration and flow to load (in units of colonies per day); it is derived from the calculation of the following components: $(28.31685 L/f^3 * 86400 seconds/day * 1000ml/L)/(100ml)$ and is equal to 24,465,758.4.

4.D.2 Flow Duration Curve. A FDC is a graphical plot showing a cumulative frequency distribution of the percent of time flows are exceeded vs. flow, as described in *An Approach for Using Load Duration Curves in the Development of TMDLs* (EPA, 2007). See Figure 4.D.1 for an example FDC.

4.D.3 Load Duration Curve. A LDC is a graphical plot showing a cumulative frequency distribution of the percent of time flows are exceeded vs. load. The curve is plotted at a load that corresponds to the loading at the TMDL. See *An Approach for Using Load Duration Curves in the Development of TMDLs* (EPA, 2007) for further details. Figure 4.D.2 shows an example LDC.

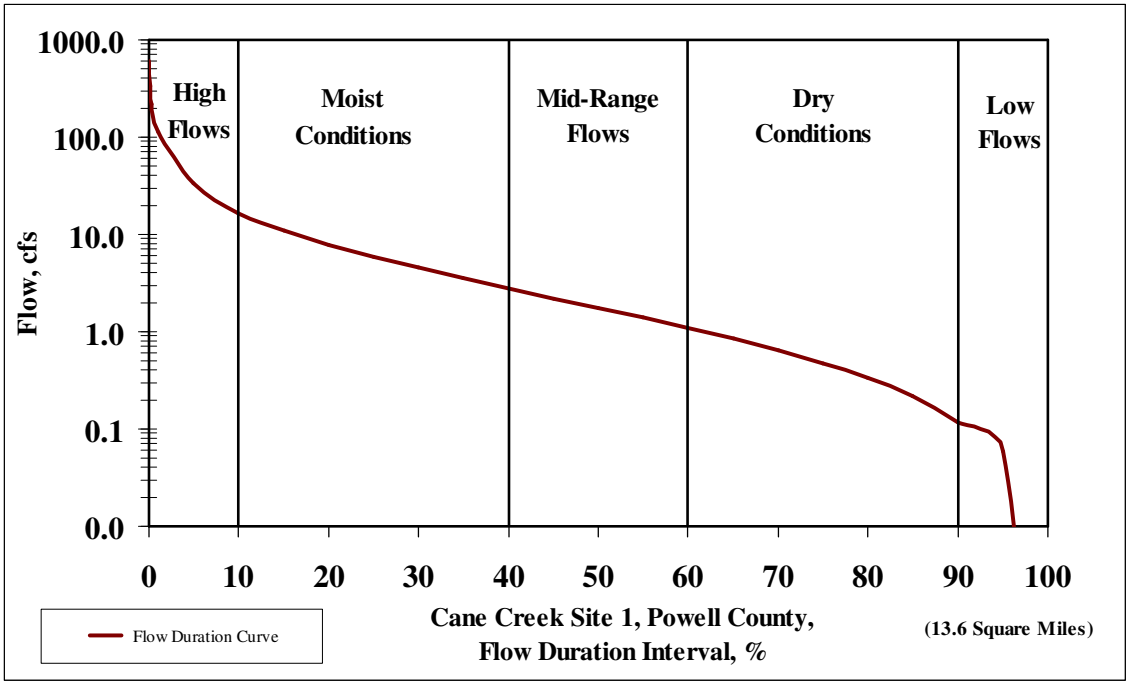

Figure 4.D.1 Flow Duration Curve

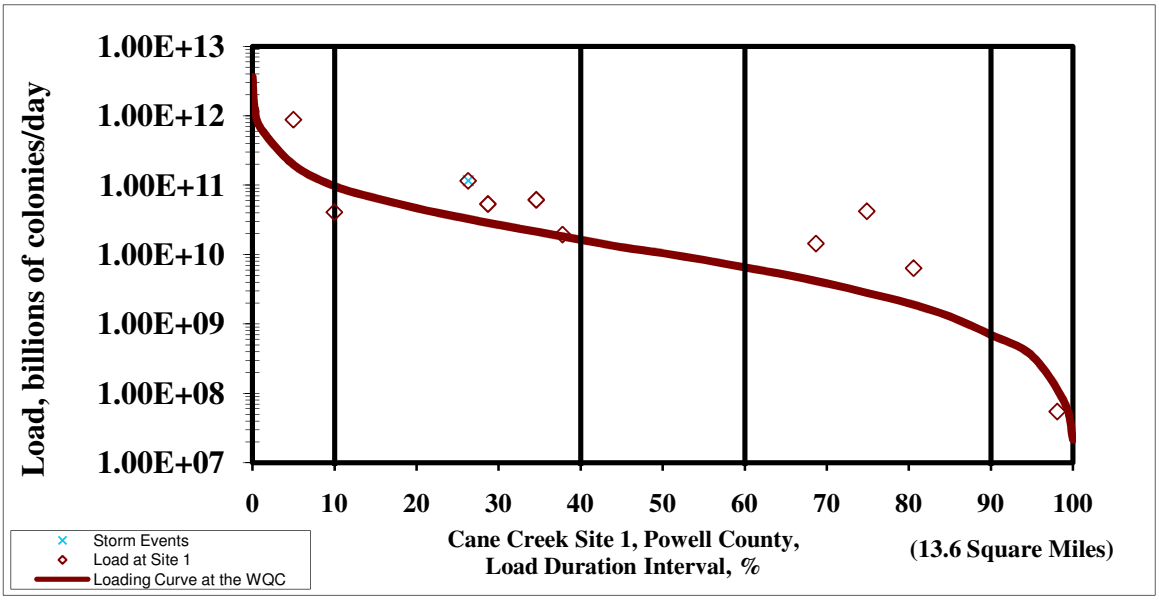

Figure 4.D.2 Load Duration Curve

4.D.4 MAF. According to *Estimating Mean Annual Streamflow of Rural Streams in Kentucky* (USGS, 2002), the MAF (Q_a) is defined as the mean of the series of annual mean streamflow values at a given site or station. It is calculated using the following equation:

$$Q_a = \left(\sum_{i=1}^{N_a} Q_{ai} \right) / N_a ,$$

(Equation 3)

Where Q_{ai} is the annual mean streamflow for the i^{th} year, and N_a is the number of annual mean streamflows at the site or station for its period of record.

4.E PERSONNEL QUALIFICATIONS / RESPONSIBILITIES. No specialized training is required for KDOW TMDL writers. New TMDL Section staff members are trained by the TMDL Section Supervisor or designee as needed. All DOW staff members must meet the minimum educational and/or experiential requirements for their position title, as determined by the Kentucky Personnel Cabinet (KPC). KPC maintains employment records documenting minimum educational and/or experiential requirements, and the KDOW Resource Planning and Program Support Branch maintains training records. While no specific training courses are required, in the case of current staff, all TMDL Section members have received Load Duration Curve training.

4.F PROCEDURE

The procedure for calculating pathogen TMDL allocations are found in *Pathogen Indicator TMDL SOP Standard Work Document (Current Revision).* The Standard Work Document was created separately from this SOP so that it can be changed without the need for Division-level signatures when changes in the TMDL environment (i.e., shifting legal, administrative, technical or other requirements) dictate an adjustment in pathogen TMDL procedures. The most current revision of the Standard Work Document is incorporated by reference into this SOP. Outdated revisions are not addressed by this SOP; only the most current revision is incorporated.

The Standard Work Document currently includes the following:

- Section 4.F.1, Initial Tasks;
- Section 4.F.2, Load Duration Curve Method (Excel™ Spreadsheet);
- Section 4.F.3, Load Duration Curve Method (WATERS/Topmodel);
- Section 4.F.4, Mean Annual Flow Method, and;
- Section 4.F.5, Inferring Pathogen Sources.

4.G CRITERIA.

Pathogen TMDLs must meet the following criteria:

1. They must conform to this SOP and its incorporated Standard Work Document;
2. They must set the TMDL at the WQC as set forth in 401 KAR 10:031;
3. They must meet the requirements in the latest version of KDOW's *Quality Assurance Project Plan, Data Analysis for TMDL Development* (KDOW, 2009), and;
4. They must be approved by the TMDL Section Supervisor. The TMDL Section Supervisor checks the "Approved" box and initials the Coordination Sheet for the Proposed Draft when approving the TMDL. The same procedure is followed for the Proposed Draft and the Final TMDL before it is sent to EPA for final approval.

4.H RECORDS MANAGEMENT. As stated in DOW's *Quality Assurance Project Plan, Data Analysis for TMDL Development* (KDOW, 2009), the Final TMDL and the TMDL QAPP Checklist are maintained in the Administrative Record indefinitely.

5.0 QUALITY CONTROL AND QUALITY ASSURANCE SECTION. The TMDL Section Supervisor completes the Modeling and Data Evaluation TMDL QAPP Checklist for each pathogen TMDL submittal as required by the *Quality Assurance Project Plan, Data Analysis for TMDL Development* (KDOW, 2009).

6.0 REFERENCES

33 U.S.C. § 1251, Section 303(d). Clean Water Act. 1972.

40 CFR Part 130. Water Quality Planning and Management Regulations. 1985.

Kentucky Division of Water. 2009. Quality Assurance Project Plan, Data Analysis for TMDL Development, Version 1.0 (Draft). Frankfort, KY 40601.

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U.S. Environmental Protection Agency. August, 2007. An Approach for Using Load Duration Curves in the Development of TMDLs (EPA 841-B-07-006). Office of Wetlands, Oceans and Watersheds. 1200 Pennsylvania Ave NW, Washington, DC 20460.

United States Geological Survey. 2002. Estimating Mean Annual Streamflow of Rural Streams in Kentucky, Water-Resources Investigations Report 02-4206. Denver, CO 80225-0286.