Appendix B

E. coli Bacteria Allocations and Daily Loads for the Tidal Basin and Washington Ship Channel

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Contents

Introduction

The purpose of this document is to revise the original 2004 *Final Total Maximum Daily Loads for Bacteria in Tidal Basin and Washington Ship Channel* (DDOH 2004). The revision incorporates a new water quality standard (WQS) for *Escherichia coli* (*E. coli*) that the District of Columbia (District) promulgated in October 2005 after the approval of the original total maximum daily loads (TMDLs). The allocations specified in the original TMDL are still in effect; this revision provides a translation of those loads to *E. coli*, the parameter on which the existing standard is based. The translation was performed using a translator equation developed from analysis of paired fecal coliform/*E. coli* sampling data collected from waters in the District.

In addition, daily loading expressions for the new *E. coli* allocations are also provided. This has been done to comply with the U.S. Environmental Protection Agency (EPA) obligations under the 2006 court case, *Friends of the Earth vs. the Environmental Protection Agency, 446 F.3d 140, 144* (D.C. Cir. 2006), which requires establishment of a daily loading expression in TMDLs in addition to any annual or seasonal loading expressions previously established in the TMDL.

Anacostia Riverkeepers, Friends of the Earth, and Potomac Riverkeepers filed a complaint (Case No.: 1:09-cv-00098-JDB) on January 15, 2009, because certain District TMDLs did not have a daily load expression established. EPA settled the complaint by agreeing to an established schedule that both the court and the plaintiffs to the case approved. The settlement agreement requires establishment of daily loads in the District. Bacteria TMDLs referenced in Paragraphs 24a, 24c, 24g, 24i, 24j, and 24l of the plaintiffs' complaint by December 2014. This TMDL revision satisfies that requirement for the 2004 *Final Total Maximum Daily Loads for Bacteria in Tidal Basin and Washington Ship Channel* (Paragraph 24l of the complaint).

Applicable Water Quality Standards

The Tidal Basin and Washington Ship Channel were on the District's 1998 303(d) lists because of excessive counts of fecal coliform bacteria that exceeded the District's WQS. The District WQS, Title 21 of the District of Columbia Municipal Regulations (DCMR) Chapter 11, 49 D.C. Reg. 3012 and D.C. Reg. 4854, specifies the categories of beneficial uses as

1. Class A. primary contact recreation
2. Class B. secondary contact recreation
3. Class C. protection and propagation of fish, shellfish, and wildlife
4. Class D. protection of human health related to consumption of fish and shellfish
5. Class E. navigation

WQS are derived from EPA recommendations on the basis of risk levels associated with swimming. Under the WQS that were in place at the time of the original TMDL, Class A and Class B waters were required to achieve or exceed the WQS for bacteria as measured by fecal coliform as the indicator organism. Fecal coliforms are microbes that live in the intestinal tracts of warm-blooded animals, whose presence indicates the potential for pathogens in the water.

When the original 2004 fecal coliform bacteria TMDL was developed for the Tidal Basin and Washington Ship Channel, the standard for Class A waters was a maximum 30-day geometric mean of 200 MPN, where *MPN* is a statistically derived estimate of the Most Probable Number of bacteria colonies in a 100 milliliter sample. This statistical estimate is often called a *count*,

although it is represented as a concentration. The geometric mean is based on a minimum of five samples within the 30-day period. The standard for Class B waters was a 30-day geometric mean of 1,000 MPN. However because both waterbodies were designated as Class A waters, which were subject to the more restrictive bacteria standard, the 200 MPN for Class A designation was used as the not-to-exceed criterion for both waterbodies in the original 2004 TMDL.

Effective January 1, 2008, the District bacteriological WQS changed from fecal coliform to *E. coli*. The current Class A water standards are a geometric mean of 126 MPN and 410 MPN for a single-sample value. The geometric mean is based on a minimum of five samples within the 30-day period and is used in both water quality trend assessments and permits. The single-sample value is valid for use only in assessing water quality trends. Class B and Class C waters do not have an *E. coli* standard. Currently, all waters subject to this TMDL, including the Tidal Basin and Washington Ship Channel, are designated as Class A waters (DCMR, WQS, 21-1101.2), see Table 1.

Table 1. Classification of the District's waters

Surface waters of the District	Use classes	
	Current use	Designated use
Potomac River	B, C, D, E	A, B, C, D, E
Potomac River tributaries (except as listed below)	B, C, D	A, B, C, D
Battery Kemble Creek	B, C, D	A, B, C, D
C & O Canal	B, C, D, E	A, B, C, D, E
Rock Creek	B, C, D, E	A, B, C, D, E
Rock Creek tributaries	B, C, D, E	A, B, C, D, E
Tidal Basin	B, C, D, E	A, B, C, D, E
Washington Ship Channel	B, C, D, E	A, B, C, D, E
Oxon Run	B, C, D	A, B, C, D
Anacostia River	B, C, D, E	A, B, C, D, E
Anacostia River tributaries (except as listed below)	B, C, D	A, B, C, D
Hickey Run	B, C, D	A, B, C, D
Watts Branch	B, C, D	A, B, C, D
Wetlands	C, D	C, D

Source: DCMR 1101.2

The waterbodies addressed by this revision are the same ones that received allocations under the original TMDL, the Tidal Basin and Washington Ship Channel.

Translation of Fecal Coliform Values to *E. Coli*

A *translator* is a mathematical equation that allows one parameter to be translated into another consistently and in a scientifically defensible manner. To support the TMDL revision, EPA and the District of Columbia Department of the Environment developed a District-specific translator

using the statistical relationship between paired fecal coliform and *E. coli* data collected in the District's waters (LimnoTech 2011 and 2012).[1] The data used to develop the DC translator was composed of paired fecal coliform and E. coli instream monitoring measurements for DC and adjacent waters collected by three agencies: DDOE, the Virginia Department of Environmental Quality (VDEQ), and the Maryland Department of the Environment (MDE). The dataset includes contains ambient instream water quality monitoring data as well as end-of-pipe data collected by DC Water at separate storm water system (SSWS) outfalls. CSO data was excluded from the dataset and was not used in the development of the translator. E.coli levels for CSO's were not calculated using the translator. (See Section CSO section below) The translator is representative of ambient and stormwater bacteria concentrations and was used to convert the original fecal coliform TMDL allocations into *E. coli* values. The District-specific translator equation is shown in Equation 1 below.

$$\text{Log2}(E.\ coli) = 0.9377[\text{Log2}(\text{fecal coliform})] - 0.4614 \qquad [1]$$

Use of the translator allowed for converting original fecal coliform annual load allocations to the current WQS for *E. coli*, while still relying on the original modeling and analysis.

Compliance with Revised WQS

Using the District-specific translator, a fecal coliform value of 200 MPN (the original District standard for bacteria) is associated with an *E. coli* value of approximately 104 MPN, which is below the 126 MPN *E. coli* criteria.

It is important to consider that under the original modeling analysis, reductions to sources of fecal bacteria were made until the waterbodies met the fecal coliform geometric mean standard of 200 MPN at all times. Therefore, under the original modeling analysis, fecal coliform loads translated to *E. coli* loads will result in loads that are more protective than WQS. The *E. coli* reductions in this TMDL meet approximately a geometric mean of 104 MPN, while the current bacteria standard is 126 MPN. This provides a 20 percent margin of safety to the TMDL.

Translation Methodology

This TMDL revision translates the original annual fecal coliform loads into equivalent annual *E. coli* loads. The December 2004 TMDL provides load allocations for the MPN of colonies of fecal coliform for various sources. The average annual loads were broken down by sources: separate storm sewers, direct runoff, and direct deposits (waterfowl). Modeling for the original TMDL found that no reductions were required from any source in order to meet criteria; however loads from the separate storm sewer and direct runoff were reduced by 10% and assigned to the Margin of Safety (MOS), while loads from waterfowl were not reduced (Table 2).

[1] Documentation related to development of the translator is in LimnoTech's 2011 Memorandum, *Final Memo Summarizing DC Bacteria Data and Recommending a DC Bacteria Translator (Task 2)* and Limno Tech's 2012 Memorandum, *Update on Development of DC Bacteria Translators*.

Table 2. Percent reduction to sources in original TMDL

Source	% Reduction
Separate Storm	10
Direct Runoff	10
Direct Deposits (Waterfowl)	0

The translation from fecal coliform to E. coli was made on the basis of concentrations. Available model files provide daily existing condition fecal coliform concentrations and flows. Equation 1 was applied to fecal coliform concentrations to develop the revised *E. coli* allocation for the separate storm sewers, direct runoff and direct deposits. The methodologies used to calculate the revised *E. coli* allocation for each source are more fully described below.

Separate Storm Sewers and Direct Runoff

1. From available model files, obtained the time series of the flow and fecal coliform loads for the existing condition. Calculated the fecal coliform concentrations using the load and flow (concentration = load / flow).
2. Applied Equation 1 to the TMDL fecal coliform concentrations to derive the TMDL *E. coli* concentrations.
3. Multiplied the daily *E. coli* concentrations by the flow volumes to derive the TMDL daily load time series.
4. Calculated the average annual *E. coli* TMDL load allocation from the *E. coli* daily load time series.

Direct Deposits (Waterfowl)

1. From available model files, obtained the time series of the flow and fecal coliform loads for the existing condition. Calculated the fecal coliform concentrations using the load and flow (concentration = load / flow).
2. Applied Equation 1 to the TMDL fecal coliform concentrations to derive the TMDL *E. coli* concentrations.
3. Multiplied the daily *E. coli* concentrations by the flow volumes to derive the TMDL daily load time series.
4. Calculated the average annual *E. coli* TMDL load allocation from the *E. coli* daily load time series.

Note that the modeling assumed loads from direct deposits were constant on a daily basis.

Allocations

The original December 2004 TMDL used a series of computer simulations to determine the level of annual load reductions needed to meet WQS. The WQS were considered to be met if no model segment had a fecal coliform maximum 30-day geometric mean exceeding the 200 MPN Class A standards. This revised TMDL considers standards to be met when all portions of the waterbody do not exceed the *E. coli* maximum 30-day geometric mean of 126 MPN Class A standard. Because the bacteria translation enables the calculation of the equivalent *E. coli* load,

under a given scenario that meets the fecal coliform standard, the equivalent *E. coli* standard will also be met with an additional margin of safety.

Table 3 presents the TMDL expressed in equivalent *E. coli* annual loads for each source. It also identifies to what portion of the allocation (LA or WLA) each source is assigned based on the approach used in the Decision Rationale (i.e., separate stormwater runoff comprises the WLA, while the direct runoff and direct deposits comprise the LA)[2] (USEPA 2004).

The following *E. coli* allocation is made for the sources for bacteria.

Table 3. Tidal Basin and Washington Ship Channel allocated annual loads (MPN/year) (*E. coli*, translator derived)

TMDL Components	Source	Tidal Basin	Washington Ship Channel
WLA	Separate Storm	5.53E+13	1.83E+14
LA	Direct Runoff	4.48E+13	7.67E+13
	Direct Deposits	4.11E+14	1.65E+14
MOS	Margin of Safety	1.11E+13	2.88E+13
TMDL	Total	5.23E+14	4.53E+14

[2] In the Decision Rationale, the TMDL for the Washington Ship Channel contains a typographical error, identifying the TMDL as 2.18E+16 instead of 2.28E+16. This revision used numbers from the TMDL report and not the Decision Rationale as the basis for all translations. The Decision Rationale was used only to guide division of the allowable loads into LA, WLA and MOS.

Daily Loads

In November 2006, EPA issued the memorandum *Establishing TMDL Daily Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA et. al., No. 05-5015 (April 25, 2006) and Implications for NPDES permits*, which recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increment in conjunction with other appropriate temporal expressions that might be necessary to implement the relevant WQS. In compliance with that recommendation, this section presents corresponding daily load expressions for the long-term load allocations for the Tidal Basin and Washington Ship Channel described in Table 3 above. These daily loads were developed in a manner consistent with the following assumptions in EPA's *Draft Options for Expressions of Daily Loads in TMDLs* (USEPA 2007):

1. Methods and information used to develop the daily load should be consistent with the approach used to develop the loading analysis.
2. The analysis should avoid added analytical burden without providing added benefit.
3. The daily load expression should incorporate terms that address acceptable variability in loading under the long-term loading allocation. Because many TMDLs are developed for precipitation-driven parameters, one number will often not represent an adequate daily load value. Rather, a range of values might need to be presented to account for allowable differences in loading due to seasonal or flow-related conditions (e.g., daily maximum and daily median).
4. The methodologies are applicable to a wide variety of TMDL situations; however, the specific application (e.g., data used, values selected) should be based on knowledge and consideration of site-specific characteristics and priorities.
5. The TMDL analysis on which the daily load expression is based fully meets the EPA requirements for approval, is appropriate for the specific pollutant and waterbody type, and results in attainment of water quality criteria in a manner that is consistent with the underlying analysis that was used to develop the original TMDLs.

To develop the daily load values in this TMDL revision, original model files were obtained for the Tidal Basin and Washington Ship Channel TMDL analysis.[3]

Calculation Approach for Tidal Basin and Ship Channel Nonpoint Sources

Daily load allocations were developed on the basis of the translated *E. coli* daily load time series for the simulation period (1988-1990). These were available from the methodology used to develop the revised *E. coli* allocations. From these time series, EPA identified the average and maximum daily load values for each source. The specific steps are summarized below:

1. Obtained the *E. coli* daily load time series for sources (separate storm sewer, direct runoff, and direct deposits (waterfowl)) to the Tidal Basin and Washington Ship Channel EFDC model.

2. Analyzed the time series for each source to identify the maximum *E. coli* daily load over the 3 year period of simulation.

[3] The original modeling analysis was performed using a 3-dimensional Environmental Fluid Dynamics Code (EFDC) model of the Washington Ship Channel and Tidal Basin (DDOH 2004).

3. Next, from the same time series, calculated the *E. coli* average daily load (for non-zero loading days) over the 3 year period of simulation for each source category. Average daily loads were calculated by summing all the simulated daily loads for each source and dividing the sum by the number of data points.

E. coli Daily Loads

Table 4 presents the *E. coli* daily loads for the Tidal Basin and Washington Ship Channel by source.

Table 4. Tidal Basin and Washington Ship Channel daily loads (*E. coli*)

Source	Daily load (MPN)	Tidal Basin	Washington Ship Channel
Separate Storm	Max daily	3.21E+12	1.06E+13
	Avg daily	5.10E+11	1.69E+12
Direct Runoff	Max daily	2.60E+12	4.45E+12
	Avg daily	4.13E+11	7.08E+11
Direct Deposits (Waterfowl)[a]	Max daily	1.13E+12	4.51E+11
	Avg daily	1.13E+12	4.51E+11

a. Direct deposits to the waterbodies were represented as a constant source; therefore, the average daily and maximum daily values are the same.

Assurance of Implementation—Daily Loads

The approach used to calculate daily loads in this TMDL identifies a representative maximum daily or average daily load for the annual TMDL for each source identified in the original report. The approach does not presume that the maximum daily load provided could be discharged every day and still meet the in-stream WQS. While expressions of daily loading values are useful in illustrating the variability in loading that can occur under a TMDL scenario, the annual load must also be met to comply with the TMDL.

Note that federal regulations at Title 40 of the *Code of Federal Regulations* section 122.44(d)(1)(vii)(B) require that, for a National Pollutant Discharge Elimination System (NPDES) permit for an individual point source, the effluent limitations must be consistent with the assumptions and requirements of any available wasteload allocation for the discharge prepared by the jurisdiction and approved by EPA. There is no express or implied statutory requirement that effluent limitations in NPDES permits necessarily be expressed in daily terms. The Clean Water Act definition of *effluent limitation* is quite broad (effluent limitation is "any restriction on quantities, rates, and concentrations of chemical, physical, biological, and other constituents which are discharged from point sources …"), see Clean Water Act section 502(11). Unlike the Clean Water Act's definition of TMDL, the Clean Water Act definition of *effluent limitation* does not contain a *daily* temporal restriction. NPDES permit regulations do not require that effluent limits in permits be expressed as maximum daily limits or even as numeric limitations in all circumstances, and such discretion exists regardless of the time increment chosen to express the TMDL. For further guidance, see Benjamin H. Grumbles' memo of

November 15, 2006, titled *Establishing TMDL Daily Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015 (April 25, 2006) and implications for NPDES Permits*.

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