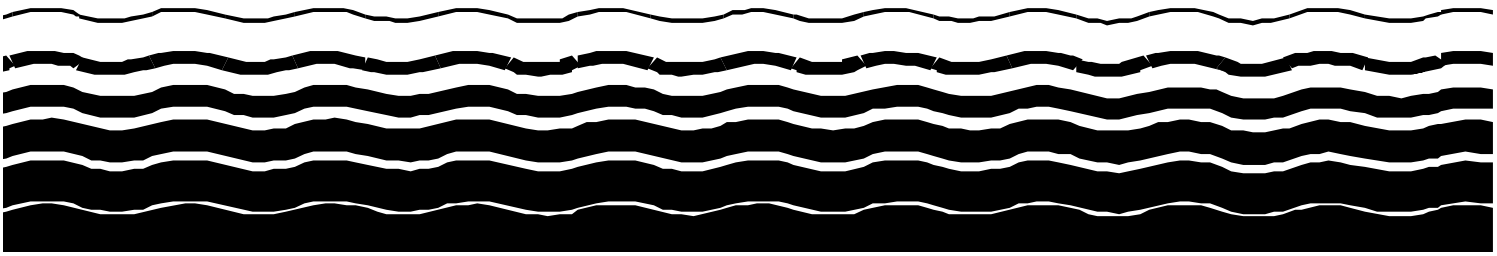
United States
Environmental Protection
Agency

Office of Water
(4607)

EPA 815-R-99-013
August 1999

Disinfection Profiling and Benchmarking Guidance Manual



DISCLAIMER

This manual describes the practice of disinfection profiling and benchmarking as required under the U.S. Environmental Protection Agency's (EPA) Interim Enhanced Surface Water Treatment Rule (IESWTR) promulgated December 16, 1998. Disinfection profiling and benchmarking are procedures to ensure that microbial inactivation is not significantly reduced due to implementation of the Stage 1 Disinfectant and Disinfection Byproduct Rule (DBPR) also promulgated on December 16, 1998.

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ACKNOWLEDGMENTS

The Environmental Protection Agency gratefully acknowledges the assistance of the members of the Microbial and Disinfection Byproducts Federal Advisory Committee and Technical Work Group for their comments and suggestions to improve this document. EPA also wishes to thank the representatives of drinking water utilities, researchers, and the American Water Works Association for their review and comment. In particular, the EPA would like to recognize the following individuals for their contributions:

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ACRONYMS

AOC	Assimilable organic carbon
ASDWA	Association of State Drinking Water Administrators
AWWA	American Water Works Association
AWWARF	AWWA Research Foundation
BAC	Biologically active carbon
BAF	Biologically active filtration
BAT	Best Available Technology
BDOC	Biodegradable organic carbon
BMP	Best Management Practice
C/C_o	Dimensionless concentration
CFR	Code of Federal Regulations
CFU	Coliform forming units
CSO	Combined Sewer Overflow
CT	Disinfectant residual concentration (C, in mg/L), multiplied by contact time (T, in min); a measure of disinfection effectiveness.
CWS	Community Water System
D/DBP	Disinfectants and disinfection byproducts
DBPR	Disinfectants and Disinfection Byproducts Rule
DBP	Disinfection byproduct
DBPFP	Disinfection byproduct formation potential
DOC	Dissolved organic carbon
DSE	Distribution system equivalent
EPA	United States Environmental Protection Agency
IESWTR	Interim Enhanced Surface Water Treatment Rule
GAC	Granular activated carbon
gpm	Gallons per minute
GWR	Ground Water Rule
GWSS	Ground Water Supply Survey
GWUDI	Ground water under the direct influence
HAA5	Five haloacetic acids
ICR	Information Collection Rule
IESWTR	Interim Enhanced Surface Water Treatment Rule
IOA	International Ozone Association
M-DBP	Microbial/disinfection byproducts
MCL	Maximum Contaminant Level

MCLG	Maximum Contaminant Level Goal
MDL	Method Detection Limit
mg/L	Milligrams per liter
mgd	Million Gallons per Day
MRDL	Maximum Residual Disinfectant Level (as mg/L)
MRDLG	Maximum Residual Disinfectant Level Goal
MRL	Minimum Reporting Level
NIPDWR	National Interim Primary Drinking Water Regulation
NOM	Natural Organic Matter
N_o	Influent concentration
NPS	Non-point source
N_t	Distribution system concentraion
NTU	Nepthelometric turbidity units
POE	Point-of-Entry Technologies
POU	Point-of-Use Technologies
ppb	Parts per billion
ppm	Parts per million
PWS	Public water system
Q	Peak hourly flow rate
RSC	Relative Source Contribution
SDWA	Safe Drinking Water Act
SM	Standard Methods
SSO	Sanitary Sewer Overflow
SWTR	Surface Water Treatment Rule
T_{10}	Contact time
TDT	Theoretical detention time
THM	Trihalomethane
THMFP	Trihalomethane formation potential
TOC	Total organic carbon
TNRCC	Texas Natural Resource Conservation Commission
TTHM	Total trihalomethane
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
V	Volume
WHPA	Wellhead protection area
WIDB	Water Industry Data Base

EXECUTIVE SUMMARY

The objective of this guidance manual is to help Public Water Systems (PWSs) in implementing the practice of disinfection profiling and benchmarking as required under the Interim Enhanced Surface Water Treatment Rule (IESWTR) promulgated December 16, 1998. The IESWTR applies to surface water or Ground Water Under Direct Influence (GWUDI) of surface water systems serving 10,000 people or more.

This guidance manual describes the applicability of the profiling and benchmarking provisions to PWSs and details the procedures for generating a disinfection profile and calculating the disinfection benchmark. Finally, this guidance manual provides guidance to PWSs on determining "significant changes" to disinfection practices, communicating with the State, and the use of the disinfection benchmark in modifying disinfection practices.

The IESWTR defines a disinfection profile as a compilation of daily *Giardia* and/or virus log inactivation over a period of a year or more. Disinfection benchmarking is a baseline or benchmark of historical microbial inactivation practices developed from disinfection profiling data.

Applicability

Systems are required to develop a disinfection profile for *Giardia* if their distribution system DBP running annual average for either TTHM or HAA5 concentrations in the distribution system is greater than or equal to 0.064 mg/L or 0.048 mg/L, respectively. Systems need one year of TTHM and HAA5 same time period data for disinfection profile determination.

Systems that are required to profile and intend to "significantly" modify their disinfection practice are required under the IESWTR to develop disinfection benchmarking for *Giardia*. Significant changes to disinfection practices are defined under IESWTR as:

- Moving the point of disinfection
- Changing the type of disinfectant
- Changing the disinfection process
- Making any other change designated as significant by the State.

Systems planing to modify their disinfection practices by adding or switching disinfectants to ozone or chloramines are required to develop a disinfection profile and benchmark for viruses. Moreover, EPA strongly recommends that systems switching to chlorine dioxide also develop a virus profile.

Creating a Disinfection Profile

Systems required to develop a disinfection profile must:

- Conduct daily monitoring for a minimum period of one year by no later than March 2001.
- And may also use 1 or 2 years of acceptable grandfathered data, in addition to the 1-year of new operational data.
- Or may use grandfathered data to develop a 3-year disinfection profile. Systems must coordinate with the State to confirm acceptability of grandfathered data no later than March 2001, but must conduct the required monitoring until the State approves the system=s request to use grandfathered data.

Use of CT Values for Disinfection Profiling

The Surface Water Treatment Rule (SWTR) requires physical removal and/or inactivation of 3-logs (99.9 percent) of *Giardia* and 4-logs (99.99 percent) of viruses. For disinfection profiling and benchmarking, the CT (see p. v for definition) approach will be used to compute the log inactivation of *Giardia* or viruses achieved during water treatment.

To use the SWTR CT tables, disinfectant type, temperature, and pH (for chlorine only) data are needed. Using this operating information, the CT value corresponding to inactivation of 3-logs of *Giardia* ($CT_{3\text{-log, }Giardia}$) and/or 4-logs of viruses ($CT_{4\text{-log, virus}}$) can be read from the SWTR CT tables. Once the CT required to achieve 3-log inactivation of *Giardia* and/or 4-log inactivation of viruses is determined, the actual plant CT needs to be calculated. By determining contact time (T_{10}) for each treatment unit within a disinfection segment (based on baffling factors or tracer studies) T_{10} is multiplied by residual disinfectant concentration for the disinfection segment.

The plant log inactivation for *Giardia* and/or viruses is the sum of log inactivation for each segment. From the daily estimated plant log inactivation data, a disinfection profile can be created.

Determining the Benchmark

From the daily plant log inactivation records, systems need to compute the average log inactivation for each calendar month. The lowest monthly average log inactivation values for each 12-month period are then averaged to determine the benchmark. If one year of data is available, the lowest monthly average log inactivation is the disinfection benchmark.

Systems considering modifications to the disinfection practices can use the benchmark to assess modification impacts. This assessment is done by calculating the "modification benchmark" and comparing it to the current benchmark.

If the modification to disinfection practice results in a lower inactivation, an alternative disinfection benchmark may improve a system's ability to meet the DBPR MCLs without significantly compromising existing microbial protection.

Systems, under State guidance, may choose to develop an alternative benchmark that is lower than the existing benchmark. For example, a system may choose to develop an alternative benchmark when the system cannot simultaneously meet the disinfection benchmark and the Stage 1 DBPR MCLs. The system may also choose this course of action because of very high levels of microbial inactivation and/or high quality source water that has low pathogen occurrence levels.

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1. Introduction

This manual is one in a series of guidance manuals published by EPA to assist both States and Public Water Systems (PWSs) in complying with the Interim Enhanced Surface Water Treatment Rule (IESWTR) and Stage 1 Disinfectant and Disinfection Byproduct Rule (DBPR) drinking water regulations. Other EPA guidance manuals include:

- Alternative Disinfectants and Oxidants Guidance Manual (1999)
- Microbial and Disinfection Byproduct Simultaneous Compliance Guidance Manual (1999)
- Uncovered Finished Water Reservoirs Guidance Manual (1999)
- Unfiltered Systems Guidance Manual (1999)
- Guidance Manual for Compliance with the Interim Enhanced Surface Water Treatment Rule: Turbidity Provisions (1999)
- Guidance Manual for Conducting Sanitary Surveys of Public Water Systems; Surface Water and Ground Water Under the Direct Influence (GWUDI) of Surface Water (1999)
- Guidance Manual for Enhanced Coagulation and Enhanced Precipitative Softening (1999).

This guidance manual describes the practice of disinfection profiling and benchmarking as required under the U.S. Environmental Protection Agency's (EPA) IESWTR promulgated December 16, 1998. This guidance manual will assist PWSs and States with the implementation of the disinfection profiling and benchmarking provisions of the IESWTR. As described in the IESWTR, these provisions are intended to ensure that microbial inactivation is not unduly compromised as public water systems strive to meet the Stage 1 DBPR.

This guidance manual is organized into several chapters and appendices which are intended to accomplish the following:

- Defines disinfection profiling and benchmarking, State involvement, and provides a list of primary resources of information used to develop this guidance (Chapter 1).
- Describes the applicability of the profiling and benchmarking provisions to public water systems (Chapter 2).
- Provides a description of the procedures for generating a disinfection profile and provides an example profile (Chapter 3).
- Provides a description of the procedures for calculating the disinfection benchmark and provides an example of a benchmark calculation (Chapter 4).
- Discusses the use of the benchmark in modifying disinfection practices, communicating with the State, and assessing "significant changes" to

disinfection practices (Chapter 5).

- Discusses how a system may use an alternative benchmark in consultation with the State to remain in compliance with the Stage 1 DBPR MCLs while still not compromising microbial protection (Chapter 6).
- Provides an overview of the development of profiling and benchmarking regulations (Appendix A).
- Explains the significance of the log inactivation concept (Appendix B).
- Provides the CT values for inactivations achieved by various disinfectants (Appendix C).
- Presents discussions on the determination of contact time (Appendix D).
- Provides an example of the Regression Method in determining $CT_{3\text{-log},\textit{Giardia}}$ (Appendix E).

1.1 Disinfection Profiling and Benchmarking

The IESWTR requires water systems to develop a disinfection profile if they exceed certain disinfection byproduct (DBP) levels in their distribution system. Water systems will have to develop a profile if their average total trihalomethane (TTHM) or five haloacetic acids (HAA5) concentrations in the distribution system exceed specified concentrations. Thus ***applicable PWSs must develop a disinfection profile*** if either of the following conditions exist:

- The TTHM annual average, based on quarterly samples, is $\geq$ 0.064 mg/L; or
- The HAA5 annual average, based on quarterly samples, is $\geq$ 0.048 mg/L.

The Microbial and Disinfection Byproduct (M-DBP) Advisory Committee recommended a value of 80 percent of the maximum contaminant levels (MCLs) because available data indicated that DBP levels varied from year to year due to many factors (i.e., changes in source water quality, changes in water demand, etc.). The Advisory Committee targeted these systems as likely candidates to modify their disinfection practices to comply with the Stage 1 DBPR. Systems have until March 2000 to complete DBP monitoring if data are not already available. Precursor removal strategies could be used in lieu of or in conjunction with changes to existing disinfection practices for Stage 1 DBPR compliance.

Only systems required to develop a profile and proposing to make significant changes to disinfection practices are required to develop a benchmark and submit it and other pertinent information to the State as part of the consultation process. ***Note that profiling and benchmarking based on virus inactivation is required only for systems proposing to add or switch to ozone or chloramines. Virus profiling and benchmarking is strongly recommended for systems proposing to add or switch to chlorine dioxide.***

1.2 Purpose of Disinfection Profiling and Benchmarking

Under the IESWTR, disinfection profiling and benchmarking are used to determine the existing levels of disinfection. As water systems comply with the Stage 1 DBPR, they may make significant modifications to their existing disinfection practices. It is essential that water systems understand the impact on microbial protection while making significant changes in their disinfection practices. Disinfection profiling and benchmarking are procedures by which systems and States, working together, can ensure that there will be no significant reduction in microbial protection as the result of modifying disinfection practices to meet DBP MCLs under the Stage 1 DBPR (USEPA, 1997a).

1.2.1 Disinfection Profiling: Definition and Purpose

The IESWTR defines a disinfection profile as a compilation of daily *Giardia* and/or virus log inactivations over a period of a year or more (USEPA, 1997a). Inactivation of pathogens is typically reported in orders of magnitude inactivation of organisms on a logarithmic scale. As an illustration, a 2-log inactivation corresponds to a 99 percent inactivation and a 3-log inactivation corresponds to a 99.9 percent inactivation (see Appendix B for further discussion). As required under the IESWTR, a disinfection profile must be developed for a period between one to three years, depending on the availability and quality of existing data (see Section 2.3).

The daily log inactivation values are calculated based on daily measurements of operational data (i.e., disinfectant residual concentration, contact time, temperature, and pH). A plot of daily log inactivation values versus time provides a visual representation of the log inactivation that the treatment plant achieved over time. From this plot, changes in log inactivation due to temperature, flow, disinfectant residual concentrations, or other changes can be seen.

The procedures and calculations for disinfection profiling are discussed in detail in Chapter 3 of this manual.

1.2.2 Disinfection Benchmarking: Definition and Purpose

Disinfection benchmarking is a baseline or benchmark of historical microbial inactivation practices developed from disinfection profiling data. The benchmark is determined from interpretation and analysis of the disinfection profile. This benchmark value identifies the lowest log inactivation that a system has achieved over a period of time. As used under the IESWTR, the benchmark sets the target disinfection level for alternative disinfection schemes. A minimum of 3-log *Giardia lamblia* and 4-log virus removal and/or inactivation performance must be achieved at all times to comply with the existing Surface Water Treatment Rule (SWTR) promulgated in 1989. Inactivation levels below the benchmark may be implemented after State consultation. States should evaluate inactivation levels below the benchmark by taking source water, watershed, and treatment factors into consideration.

The objective of the disinfection benchmark is to facilitate interactions between the States and PWSs for the purpose of assessing the impact on microbial risk of proposed significant changes to existing disinfection practices. The disinfection benchmark provides a criterion for the designs of alternative disinfection strategies. A system that is required to prepare a disinfection profile will not be allowed to make a significant change to disinfection practices without first consulting with the State.

1.3 State Review

Under the IESWTR, States will perform the review of disinfection profiles and benchmarks for water systems. The State will review disinfection profiles as part of periodic sanitary surveys. If a system is required to develop a disinfection profile and subsequently decides to make a significant change in disinfection practice, the system must consult with the State before implementing such a change. Significant changes are defined under IESWTR as (USEPA, 1998a):

1. Moving the point of disinfection
2. Changing the type of disinfectant
3. Changing the disinfection process
4. Making any other change designated as significant by the State.

Supporting materials for obtaining approval from the State must include a description of the proposed change, the disinfection profile, and an analysis of how the proposed change will affect existing levels of microbial protection.

1.4 Primary Information Sources

This document was developed using several primary reference documents previously developed by EPA. Material from the following publications were used substantially throughout this document:

- AWWA. 1991. *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*. Washington, D.C. (Also published by USEPA, 1991)
- USEPA. 1997a. "National Primary Drinking Water Regulations; Interim Enhanced Surface Water Treatment Rule; Notice of Data Availability; Proposed Rule." 62 *FR* 59485. November 3.
- USEPA. 1998a. "National Primary Drinking Water Regulations; Interim Enhanced Surface Water Treatment Rule; Final Rule." 63 *FR* 69477. December 16.

Because each of the above documents was previously published by the EPA and provides substantial reference material throughout this document, specific citations are not provided when a publication is paraphrased in this document.

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2. APPLICABILITY OF DISINFECTION PROFILING AND BENCHMARKING

Disinfection profiling and disinfection benchmarking are two separate provisions under the IESWTR and are triggered by separate criteria, although the benchmarking process requires profiling. This chapter illustrates the applicability of the disinfection profiling and benchmarking provisions under the IESWTR to public water systems and how a water system can make this determination.

2.1 Systems Subject to the IESWTR

The IESWTR applies only to water systems using surface water or ground water under the direct influence (GWUDI) of surface water, that serve 10,000 or more people. Systems that serve fewer than 10,000 people are not regulated under the IESWTR and, therefore, the disinfection profile and benchmark provisions do not apply to these systems at this time, although the Long-Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR), expected to be promulgated in November 2000, will likely require profiling and benchmarking for these systems. If a system's source water is not defined as surface water or GWUDI as defined under the IESWTR, the profile and benchmark provisions are not applicable.

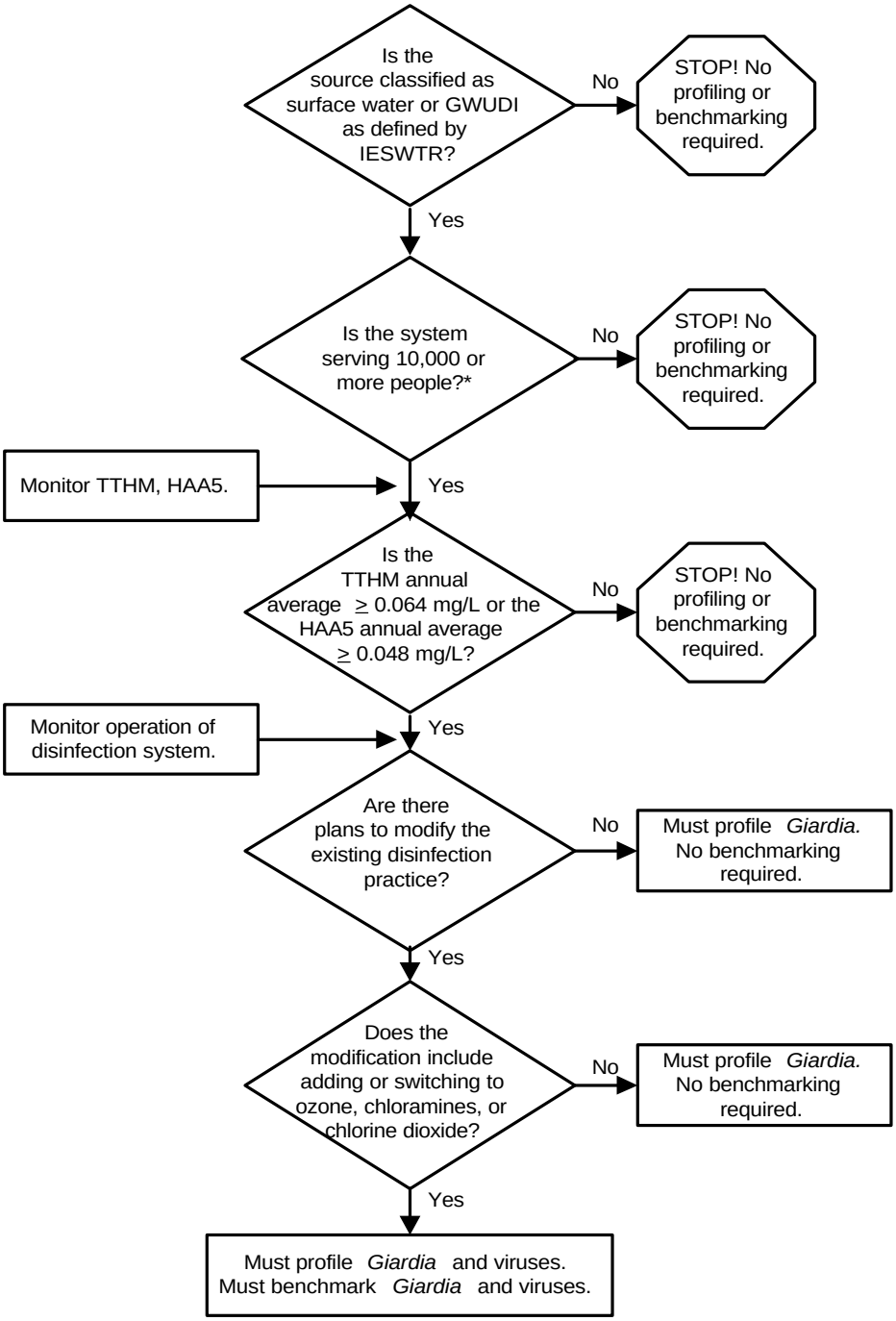
2.2 Profiling and Benchmarking Applicability

The IESWTR specifies that disinfection profiles and benchmarks may be based upon the inactivation of *Giardia* and, in some cases, viruses. Disinfection profile and/or benchmark development must, at a minimum, be based upon the inactivation of *Giardia*. However, under certain circumstances, as explained in Section 2.3 (and highlighted in Figure 2-1), some systems will be required to develop an additional profile and benchmark based on virus inactivation. The process for determining the applicability of disinfection profiling and benchmarking to public water systems is described in the following sections and illustrated in a corresponding decision tree (Figure 2-1).

2.3 Systems Required to Profile *Giardia*

Systems are required to develop a disinfection profile for *Giardia* if their distribution system DBP concentrations exceed certain criteria. Specifically, if the running annual average for either TTHM or HAA5 concentrations in the distribution system are greater than or equal to 0.064 mg/L or 0.048 mg/L, respectively, water systems must develop a profile for *Giardia*. The 12-month profile must be generated by March 2001.

Systems with existing DBP concentrations approaching or exceeding these MCLs are more likely to modify disinfection practices; therefore, these systems are required to develop a disinfection profile. Systems with very low DBP concentrations are not likely



* Systems serving fewer than 10,000 people will have to comply at a later date.

Figure 2-1. Profile and Benchmark Decision Tree

to modify their disinfection practices to control DBPs under the Stage 1 DBPR and are, therefore, not required to develop a profile. However, these systems may modify disinfection practices for other reasons and may find profile data useful for design purposes.

2.3.1 *Giardia* Profile

As depicted in Figure 2-1, systems meeting the size and source water applicability requirements must develop a disinfection profile for *Giardia* if either of the following conditions exist:

- The TTHM annual average concentration in the distribution system, for the most recent one-year period, is greater than or equal to 0.064 mg/L; or
- The HAA5 annual average concentration in the distribution system, for the most recent one-year period, is greater than or equal to 0.048 mg/L.

The TTHM and HAA5 data used to determine whether disinfection profiling is required must meet the specifications described in Section 2.3.2. As shown in Figure 2-1, systems that do not meet either of these criteria would not have to conduct a disinfection profile or benchmark.

The Advisory Committee selected the TTHM and HAA5 criteria listed above for determining the applicability of disinfection profiling for *Giardia* based upon the prediction that water systems not achieving DBP concentrations at least 20 percent below MCLs would likely change disinfection practices to control DBPs (i.e., apply a 20 percent margin of safety) to ensure continuing compliance.

2.3.2 TTHM and HAA5 Data Requirements

As described above, TTHM and HAA5 data are used to make the profiling determination for *Giardia*. The IESWTR specifies the TTHM and HAA5 data that are to be used for the disinfection profile determination. In all cases, the following criteria apply:

- One year of TTHM and HAA5 data is used to make a profiling determination.
- The TTHM and HAA5 data must be from the same time period.

Since the Information Collection Rule (ICR) requires the collection of TTHM and HAA5 data consistent with the profiling applicability determination, the discussion of data requirements for ICR and non-ICR systems is presented separately.

ICR Systems

Systems participating in the ICR have the required quarterly TTHM and HAA5 data and are assigned to use these data to determine applicability of benchmarking unless the State determines otherwise. Therefore, the requirements listed above apply to ICR systems' TTHM and HAA5 data. ICR TTHM and HAA5 values are computed as the annual average of quarterly averages of the Distribution System Equivalent (DSE) sample, two average residence time samples and one maximum residence time sample.

Non-ICR Systems

All water systems affected by the IESWTR are currently conducting quarterly monitoring of TTHMs under the current TTHM regulation. However, only some non-ICR systems have conducted the necessary HAA5 quarterly monitoring. For those water systems with existing HAA5 data, the State will decide the applicability of using that non-ICR data in the profiling determination based on the following criteria:

- **Applicable HAA5 Data**: These systems have HAA5 data that meet the provisions of 40 *Code of Federal Regulations* (*CFR*) §141.72 (a)(2)(ii) (Disinfection profiling and benchmarking), which stipulates that systems using "grandfathered" data must use TTHM data collected at the same time under the provisions of §141.12 (Maximum contaminant levels for total trihalomethanes) and §141.30 (Total trihalomethanes sampling, analytical and other requirements). The state must be confident that the sample collection, handling, and analyses were adequate to provide accurate results. If a system has made a modification to its treatment train since the HAA5 samples were collected, and this modification would likely have an impact on HAA5 formation, the state must carefully consider whether the data are still applicable to the modified system.
- **No HAA5 Data or Data Not Applicable**: These systems either do not have HAA5 data or have data that are judged by the State to not be adequate for the disinfection profile applicability determination (i.e., data may not be applicable if sample location, handling, and analytical method requirements currently applied to TTHM monitoring as outlined in 40 *CFR* §141.12 and §141.30 are not met). Systems without adequate HAA5 data must perform HAA5 quarterly monitoring that meets the requirements specified in 40 *CFR* §141.12 and §141.30. The monitoring must be for four quarters; must completed no later than March 2000; and must be collected during the same time period as TTHM data.

State Approval of a More Representative Data Set

The State has the authority to approve a more representative data set to determine profiling applicability if the system makes such a request or if the State determines that a more representative data set exists. This may occur under a variety of situations, including, but not limited to:

- A change in treatment or disinfection practice(s)
- A change in source water or source water blending.

2.4 Systems Required to Benchmark *Giardia*

Systems required to profile that intend to significantly modify their disinfection practice are required under the IESWTR to develop disinfection benchmarking for *Giardia*. A more detailed description of what constitutes a significant modification is presented in Chapter 5.

2.5 Systems Required to Profile and Benchmark Viruses

Under the IESWTR, some systems are required to create a disinfection profile and benchmark for viruses in addition to *Giardia*. A system must create a disinfection profile and benchmark for viruses if all of the following are true:

1. The system is a surface water system or GWUDI serving 10,000 people or more.
2. The TTHM annual average $\geq$ 0.064 mg/L or HAA5 annual average $\geq$ 0.048 mg/L.
3. The system plans to modify their disinfection practices by adding or switching disinfectants to ozone or chloramines. EPA strongly recommends that systems switching to chlorine dioxide also develop a virus profile.

For systems adding or switching disinfectants to ozone, chloramines, or chlorine dioxide, meeting a benchmark based on *Giardia* does not ensure that the inactivation of viruses will be maintained. Chlorine is much more effective at inactivating viruses than it is at inactivating *Giardia.* Alternative disinfectants such as ozone, chloramines, and chlorine dioxide are relatively less effective at inactivating viruses as they are inactivating *Giardia*. For this reason, systems switching to alternative disinfectants must profile and benchmark viruses inactivation.

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