Water and Wastewater Regulatory Compliance Corner
Stage 2 Disinfectants and Disinfection Byproducts Rule
Published October 12, 2021

Background

Drinking Water Regulation in America

The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources—rivers, lakes, reservoirs, springs, and ground water wells.

SDWA authorizes the United States Environmental Protection Agency (EPA) to set national health-based standards for drinking water to protect against both naturally occurring and synthetic contaminants that may be found in drinking water. EPA, Tribal Nations, states, and water systems then work together to make sure that these standards are met.

Introduction to Regulation

To protect customers, US EPA has issued specific regulations and rules that water utility systems must follow to make sure they are providing safe drinking water. US EPA issued the Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR) in 1998 that requires water systems to monitor the water they provide to customers for any potential harmful by-products of the disinfection process. For a complete understanding of this rule also read the Regulatory Corner entitled "Stage 1 Disinfection Byproducts Rule."

In 2006, the EPA released the Stage 2 Disinfection Byproducts Rule (Stage 2 DBPR). The Stage 2 DBPR adds on to the Stage 1 DBPR by taking a risk-based approach to disinfection byproducts (DBP) monitoring and reduction by targeting public water systems (PWSs) with the greatest risk. Stage 2 DBPR strengthens public health protection by tightening compliance monitoring requirements for total Trihalomethanes (TTHM) and Haloacetic acids (HAA5).

Terms to Know

Acute health effect: Effect that develops immediately or within a short time frame (i.e., a single glass of water).

Conventional filtration: Conventional treatment removes particulate matter from water by forcing the water to pass through porous media. The filtration system consists of filters with varying sizes of pores, and is often made up of sand, gravel, and charcoal.

Chronic health effect: Longer periods of exposure such as a single glass of water each day for decades are believed to be linked to a cancer risk for consumers. Thus, regulations surrounding DBPs are aimed at reducing the repeated exposure over time and is thus evaluated on an average basis over time.

Community Water System: A public water system that supplies water to the same population year-round.

Disinfection Byproduct (DBP): DBPs form when water containing organic substances is disinfected. In most cases, the organic substances are naturally occurring, such as humic and fulvic acids resulting from decaying vegetation. A group of chlorinated organic compounds called THMs was one of the first products of the reaction of chlorine

with humic substances to be recognized. The principal THMs of concern are chloroform, bromodichloromethane, chlorodibromomethane, and bromoform.

Disinfection Byproduct (DBP) Precursor: Precursors for DBPs are carbon molecules that are in the source water. These are present to form DBPs. Often, spring rainfall will drive runoff (humic and fulvic acids) into the source water which increases the number of DBPs formed. Total Organic Carbon (TOC) is a method used to measure the number of DBPs coming into the water treatment plant and can be used to assist operators in adjusting their systems to reduce the formation of DBPs. Some systems are upgraded with pretreatment chemical addition that does not use chlorine substituting in chemicals such as ozone or chlorine dioxide to avert the formation of DBPs.

Dual sample set: A set of two samples collected at the same time and same location, with one sample analyzed for total trihalomethanes (TTHM) and the other analyzed for five haloacetic acids (HAA5).

Haloacetic acids (HAA5): The sum of five specific haloacetic acids, which are mono-, di-, and trichloroacetic acids plus mono- and dibromoacetic acids.

Humic Acid: Humic acids are fully decomposed remains of organic life; refers to a complex mixture of many different acids. They exist naturally as part of nature's life cycle in soils, oceans, and streams.

Locational Running Annual Average (LRAA): A value calculated by separately averaging the four quarterly samples at each monitoring location. If there are four locations, there will be four LRAA values.

Maximum Contaminant Level (MCL): The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

Maximum Contaminant Level Goal (MCLG): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

Maximum Residual Disinfectant Level (MRDL): The highest level of a disinfectant allowed in drinking water. Addition of a disinfectant is necessary for control of microbial contaminants. For instance, cholera is an acute diarrheal infection caused by ingestion of food or water contaminated with the bacterium Vibrio cholerae. Researchers have estimated that each year there are 1.3 to 4.0 million cases of cholera, and 21,000 to 43,000 deaths worldwide. Disinfection of water systems is critical to protect Tribal Nation public health.

Maximum Residual Disinfectant Level Goal (MRDLG): The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

Natural Organic Matter (NOM): Natural organic matter (NOM) in source water is a complex mixture of many carbon-based compounds that result from the breakdown/decay of plant and animal tissue (humic and fulvic acids).

Non-Transient, Non-Community Water System (NTNCWS): A public water system that regularly supplies water to at least 25 of the same people at least six months per year. Some examples are schools, factories, office buildings and hospitals which have their own water systems.

Peak Historical Month: The month with the highest TTHM or the highest HAA5 levels or the warmest water temperature. It is meant to represent the "worst case" scenario for DBP formation.

Residual Disinfectant: The amount of disinfectant in the distribution system, after water has left the treatment facility.

Running Annual Average (RAA): The running annual average is the average of the LRAA values collected in a sampling system. If there are 4 monitoring locations, the RAA will be the average of the 4 LRAA values. DBP compliance values are based solely on the RAA, not a single quarterly result at any-one monitoring location.

Subpart H systems: Public water systems using surface water or ground water under the direct influence of surface water (via mixing) as a source.

Transient Non-Community Water System (TNCWS): A public water system that provides water in a place such as a gas station or campground where people do not remain for extended periods of time.

Total Trihalomethanes (TTHMs): Disinfection by-product compounds formed by the reaction of organic material (humic and fulvic acids) in water with chlorine or other disinfectants. Total Trihalomethanes (TTHMs) consist of the following compounds: chloroform, dichlorobromomethane, bromodichloromethane, and bromoform. THMs are regulated as a group, with a MCL established for total TTHMs.

Total Organic Carbon (TOC): Number of organic compounds contained in a sample of water. This is directly influenced by the NOM present in source water.

Overview

What Is the Difference between Stage 1 and Stage 2 DBP Rules?

As in Stage 1, the Stage 2 DBPR focuses on monitoring for and reducing concentrations of TTHMs and HAA5s.

The Stage 1 DBPR running annual average (RAA) calculation allowed some locations within a distribution system to have higher DBP annual averages than others as long as the system-wide average was below the maximum contaminant level (MCL) thus potentially exposing citizens in those areas to numbers above the MCL which could cause a chronic effect.

The Stage 2 DBPR tightened requirements for DBPs, not by modifying numerical value of MCL but by:

- Changing the way compliance values are calculated
- Changing the compliance monitoring locations to sites representative of the greatest TTHM and HAA5 formation.

The Stage 2 DBPR bases compliance on a locational running annual average (LRAA) calculation, where the annual average at each sampling location in the distribution system will be used to determine compliance with the MCLs of 0.080 mg/L (80 µg/L) and 0.060 mg/L (60 µg/L) for TTHM and HAA5, respectively.

THE 80/60 RULE
The 80 µg/L and 60 µg/L LRAA levels are sometimes referred to as "the 80/60 rule."

What Does Stage 2 DBPR Require?

The risk-targeting components of the Stage 2 DBPR focus the greatest amount of change where the greatest amount of risk may exist. Therefore, the provisions of Stage 2 DBPR focus first on identifying the higher risk locations in the distribution system through analyzing the system for highest concentration of DBPs, which helps water systems deliver compliant water to all customers.

The rule then addresses reducing exposure and lowering DBP peaks in distribution systems by using a new method to determine MCL compliance (locational running annual average [LRAA]), defining operational evaluation levels, and regulating consecutive systems. Regulating consecutive systems is a component of the rule that has brought some Tribal Nations that receive their water as a bulk purchase from a nearby community into this regulation. The goal is to protect Tribal Nation citizens from long-term exposure to TTHMs and HAA5s which form over time and are often seen at the ends of the distribution system where many consecutive systems are located. The number of compliance monitoring sites is based on the population served and the source water type. EPA believes that population-based monitoring provides better risk-targeting and is easier to implement.

Developing a Monitoring Plan

Tribal Nation water systems must develop and implement a monitoring plan to be kept on file for EPA and public review. The monitoring plan must contain:

- Monitoring locations;
- Monitoring dates;
- Compliance calculation procedures; and
- Monitoring plans for any other systems in the combined distribution system.

The water system may revise the monitoring plan to reflect changes in treatment, distribution system operations and layout (including new service areas), or other factors that may affect DBP formation after consultation with the EPA where the Tribal Nation would describe the need for change in the sampling locations and why the change is appropriate.

If the system changes monitoring locations, it must replace existing compliance monitoring locations with the lowest LRAA with new locations that reflect the current distribution system locations with expected high TTHM or HAA5 levels. The EPA may also require modifications in the Tribal Nation monitoring plan from time to time.

Selecting Monitoring Locations and the Initial Distribution System Evaluation

To select applicable monitoring locations, systems must complete an **Initial Distribution System Evaluation (IDSE)**.

WHAT IS AN IDSE?

An IDSE is a one-time study conducted by water systems to identify distribution system locations with high concentration of TTHMs and HAA5s. Water systems will use the results from the IDSE, along with their Stage 1 DBPR compliance monitoring data, to select compliance monitoring locations for the Stage 2 DBPR.

CWS serving fewer than 10,000 people are subject to the IDSE requirements of the Stage 2 DBPR if they use chlorine or chloramine as a primary or residual disinfectant but are not required to monitor if ONLY ultraviolet light (UV) is used (no hypochlorite is used in the distribution system). IDSE requirements do not apply to NTNCWSs serving fewer than 10,000 people. Transient non-community water systems (TNCWSs) are not subject to any part of the Stage 2 DBPR.

HOW IS AN IDSE COMPLETED?

There are four options available to systems to meet IDSE requirements. The option available to each water system will depend on technical resources, existing monitoring results, size, and preference.

- **Very Small System (VSS) Waiver:** Systems serving fewer than 500 people that have TTHM and HAA5 data automatically receive the VSS waiver unless they are notified by EPA or their state that they must conduct an IDSE. Systems receiving VSS waiver have no further IDSE requirements and should keep the waiver in their files in perpetuity.
- **40/30 Certification:** Systems can fulfill the IDSE requirements by certifying that all individual TTHM and HAA5 monitoring results for compliance with the Stage 1 DBPR are less than or equal to 40 µg/L for TTHM and 30 µg/L for HAA5 during a prescribed 2-year period. In addition, the system must not have had any Stage 1 DBPR monitoring violations for TTHM and HAA5 during the same period. The system must submit the required 40/30 certifications and, unless told otherwise by EPA or their state, they have no further requirements under the IDSE. The Tribal Nation should keep the 40/30 submittal in their files in perpetuity.
- **Standard Monitoring:** Any system can choose to conduct standard monitoring, even if they receive a VSS waiver or qualify for the 40/30 certification. Standard monitoring entails 1 year of distribution system monitoring at multiple locations (in addition to Stage 1 DBPR monitoring). The required sampling frequency and minimum number of sample locations depend on population served and source water type (see Table 1). Systems conducting standard monitoring must prepare a standard monitoring plan and an IDSE report.
- **System Specific Study (SSS):** Systems can meet IDSE requirements using existing monitoring results or a hydraulic model if their data or model meet certain minimum criteria. Systems conducting an SSS must prepare as SSS plan and IDSE report. These are generally provided by a Professional Engineer; typically the team that holds the water model for the system.

EPA has developed two guidance manuals to help water systems comply with the IDSE requirement.

- The IDSE Guide for Systems Serving < 10,000 People is targeted to smaller systems and focuses on information they are most likely to use. It covers VSS waivers, 40/30 certifications for systems with low DBP levels, and standard monitoring.

- The Initial Distribution System Evaluation (IDSE) Guidance Manual is comprehensive and contains technical guidance for all system sizes and types and all IDSE options. If you already have extensive DBP monitoring results and/or a hydraulic model of your distribution system, you should read the IDSE Guidance Manual to determine if you qualify for the SSS option to meet IDSE requirements or consult with your Professional Engineer for assistance in meeting the requirements.

Tips for Selecting High TTHM Sites	
Good TTHM Sites	**Avoid**
• Downstream of tanks and booster chlorination • Hydraulic and geographic dead ends (prior to last customer) • Sites with difficulty maintaining residual disinfectant levels • Areas with low water use • Areas of high historic levels	• Dead ends with no users • Sites after the last hydrant or blowoff • Sites upstream of booster chlorination • The last house on a dead end

Tips for Selecting High HAA5 Sites	
Good HAA5 Sites	**Avoid**
• Downstream of booster chlorination • Sites with low but detectable residual disinfectant levels • Areas of high historic levels • Areas with high residence time	• Areas with known biofilm growth • Areas with difficulty maintaining a residual • The last house on a dead end

Routine Monitoring

Stage 2 DBPR bases monitoring schedules on the population served by that water system. Routine monitoring requires the system to monitor no fewer than the number of locations identified in the table below.

All systems must monitor during the month of highest DBP concentrations.

Required Sampling Frequency of the Distribution System Based on Population and Source Water Type			
Source Water Type	**Population size category**	**Routine Monitoring Frequency**	**Distribution system monitoring location total per monitoring period**
Surface Water or Groundwater directly influenced by surface water (see definition for Subpart H above)	<500	Per year	2
	500 - 3,300	Per quarter	2
	3,301 - 9,999	Per quarter	2
	10,000 - 49,999	Per quarter	4
	50,0000 - 249,999	Per quarter	8
Ground Water	<500	Per year	2
	500 - 9,999	Pear year	2
	10,000 - 99,999	Per quarter	4

Reduced Monitoring

Systems may qualify for reduced monitoring, which is a monitoring schedule that is less frequent than the routine monitoring schedule described above if they qualify as follows:

- Systems can **qualify** for reduced monitoring if (based on at least one year of monitoring at routine compliance monitoring locations) if the LRAA at each location is:
  - ≤40 µg/L for TTHM
  - ≤30 µg/L for HAA5
- Systems may **remain** on reduced monitoring if,
  - For systems with annual or less frequent reduced monitoring,
    - › each TTHM sample is ≤60 µg/L and
    - › each HAA5 sample is ≤45 µg/L.
  - For systems with quarterly reduced monitoring:
    - › the TTHM LRAA is ≤40 µg/L
    - › THE HAA5 LRAA is ≤30 µg/L
- Systems must **return** to routine monitoring if:
  - The LRAA at any location exceeds either:
    - › 40 µg/L for TTHM or
    - › 30 µg/L for HAA5 or
    - › if the source water annual average TOC level, before any treatment, exceeds 4.0 mg/L or 4000 µg/L (consult Water and Wastewater Regulatory Compliance Corner Stage 1 DBPR Regulatory Corner section titled "Enhance Coagulation Compliance for Control of DBP Precursors" for more information on TOCs)
  - The annual (or less frequent) sample at any location exceeds either
    - › 60 µg/L for TTHM or
    - › 45 µg/L for HAA5, or
    - › if the source water annual average TOC level, before any treatment, exceeds 4.0 mg/L or 4000 µg/L

Reduced TTHM and HAA5 Monitoring Requirements by Source Water and Population			
Source Water Type	**Population Size Category**	**Reduced Monitoring Frequency**	**Distribution system monitoring location per monitoring period**
Surface Water or Groundwater directly influenced by surface water (see definition for Subpart H above)	<500		Monitoring may not be reduced
	500 – 3,000	Per year	1 TTHM and 1 HAA5 sample: • one at the location and during the quarter with the highest TTHM single measurement, • one at the location and during the quarter with the highest HAA5 single measurement. • One dual sample set per year if the highest TTHM and HAA5 measurements occurred at the same location and quarter. Dual Sample set is a set of two samples collected at the same time and same location, with one sample analyzed for TTHM and the other analyzed for HAA5.
Surface Water or Groundwater directly influenced by surface water (see definition for Subpart H above)	3,301 – 9,999	Per year	2 dual sample sets (see definition above): • one at the location and during the quarter with the highest TTHM single measurement, • one at the location and during the quarter with the highest HAA5 single measurement.
	10,000 – 49,999	Per quarter	2 dual sample sets a t the locations with the highest TTHM and highest HAA5 LRAAs.
	50,000 – 249,999	Per quarter	4 dual sample sets - at the locations with the two highest TTHM and two highest HAA5 LRAAs.

Reduced TTHM and HAA5 Monitoring Requirements by Source Water and Population			
Source Water Type	**Population Size Category**	**Reduced Monitoring Frequency**	**Distribution system monitoring location per monitoring period**
Ground Water	<500	Every third year	1 TTHM and 1 HAA5 sample: • one at the location and during the quarter with the highest TTHM single measurement • one at the location and during the quarter with the highest HAA5 single measurement • 1 dual sample set per year if the highest TTHM and HAA5 measurements occurred at the same location and quarter.
	500 – 9,999	Per year	1 TTHM and 1 HAA5 sample: • one at the location and during the quarter with the highest TTHM single measurement • one at the location and during the quarter with the highest HAA5 single measurement • 1 dual sample set per year if the highest TTHM and HAA5 measurements occurred at the same location and quarter.
	10,000 – 99,999	Per year	2 dual sample sets: • one at the location and during the quarter with the highest TTHM single measurement • one at the location and during the quarter with the highest HAA5 single measurement.

Increased Monitoring

If the water system monitors at a particular location annually or less frequently than annually the system must increase monitoring to dual sample sets once per quarter (taken every 90 days) at all locations if:

- Any single TTHM sample is > 80 µg/L or
- Any single HAA5 sample is > 60 µg/L

A system under increased monitoring may return to routine monitoring if at least four consecutive quarters and the LRAA for every monitoring location is ≤60 µg/L for TTHM and ≤45 µg/L for HAA5.

Increased monitoring is not based on an LRAA but on individual sample results. If any sample at any location is above either of the MCLs (80 µg/L for TTHM and 60 µg/L for HAA5), then increased monitoring applies system-wide, not just at one location.

Systems that currently monitor quarterly cannot increase monitoring frequency, as quarterly is the most frequent monitoring cycle required.

LRAA MCLs for TTHM and HAA5

The compliance value in Stage 2 DBPR is called the locational running annual average (LRAA) and is calculated by separately averaging the four quarterly samples at each monitoring location. Calculating the LRAA will reduce exposures to high DBP concentrations by ensuring that each monitoring site is in compliance with the MCLs as an annual average, while providing all customers drinking water that more consistently meets the MCLs. For an LRAA, an annual average must be computed at each monitoring location.

Example of HAA5 Sampling Data and How to Calculate the LRAA and Determine Compliance Status

Year	Quarter	Sampling Location				
		A	B	C	D	
1	3	34	56	79	79	These values are the actual levels sampled at each location for DBPs (listed in µg/L)
1	4	46	93	19	62	
2	1	11	14	89	17	
2	2	16	81	71	77	
LRAA		26.75	61	64.5	58.75	These numbers are the averages of samples at each sampling location

Under Stage 2 DBPR, LRAA values are used for TTHM and HAA5 compliance. Since this data is for HAA5, there are two sample locations in violation of the Stage 2 DBPR. Which two are they?

If you determined that sample location B and D were non-compliant you would be correct. What would be your next step as the operator of record?

If you answered increase monitoring to quarterly until the LRAA is < 60 ug/L you are correct! If consistent compliance cannot be achieved, consider working with a Professional Engineer with knowledge of water operations.

Operational Evaluation Levels

As a part of Stage 2 DBPR compliance monitoring, water systems are required to monitor Operational Evaluation Levels (OELs). The OEL must be calculated every quarter by using the three most recent quarters, with double the current quarter, of results at one sample location.

CALCULATING AN OEL

If we are in Quarter 4, then our OEL formula would look like:

$$\frac{(Q2+Q3+Q4+Q4)}{4} = \text{OEL}$$

For example, to calculate the OEL for sample location A in the above table:

$$\frac{(46+11+16+16)}{4} = 22.5\ (\mu g/L)$$

The water system has an exceedance if:

- The OEL for TTHM is more than 0.080 mg/L (80 µg/L)
- The OEL for HAA5 is more than 0.060 mg/L (60 µg/L)

If an OEL is exceeded, the water system must conduct an Operational Evaluation

Operational Evaluation

This evaluation assesses source water, treatment, and distribution system processes, and helps identify actions to decrease any high DBP levels and avoid MCL violations. The Operational Evaluation must be completed when the system has an exceedance of the Operational Evaluation Level. The operational evaluation includes an examination of system treatment and distribution operational practices, including:

- Storage tank operations
- Excess storage capacity
- Distribution system flushing
- Changes in sources or source water quality
- Treatment changes
- Any problems that may contribute to TTHM and HAA5 formation

Systems must also identify what steps could be considered to minimize future operational evaluation level exceedances. These operational evaluation levels will act as an early warning for a possible MCL violation in the following quarter. Information gathered from the operational evaluation must be compiled into a report and sent to EPA for review within 90 days after being notified of the high TTHM or HAA5 sample result that causes the OEL to exceed the MCL.

The EPA provides a guidance manual that assists PWS in meeting requirements for operational evaluations. These reports are typically generated by a Professional Engineer, and Standard Operating Procedures (SOP) should be developed to assist the operator in maintaining consistent compliance with DBP regulations. Operators should be trained on the SOPs and the water operator of record should field verify that procedures are being followed. SCADA systems can also be integrated to assist in achieving compliance by installing automated flushing systems, etc.

System Reporting and Recordkeeping Requirements for Stage 2 DBPR

Stage 2 DBPR, consistent with Stage 1 DBPR, requires public water systems (including consecutive systems) to report monitoring data to EPA within ten days after the end of the compliance period if sampling frequency is greater than quarterly. If a system monitors quarterly, the data must be submitted 10 days after the end of the quarter. As with other chemical analysis data, the system must keep the results for 10 years.

Systems must report compliance with Stage 2 TTHM and HAA5 MCLs (0.080 mg/L TTHM and 0.060 mg/L HAA5, as LRAAs) per the schedule in Table 1 unless the Tribal Nation has opted in and been approved for reduced monitoring. Reporting for DBP monitoring will remain generally consistent with Stage 1 DBPR reporting requirements. Refer to "Reporting and Recordkeeping" on Page 8 of the USET Water and Wastewater Regulatory Compliance Corner Stage 1 DBPR Regulatory Corner.