Appendix D: Definitions and Calculations for DMRs

Definitions

The following are definitions of some terms used for reporting on the Discharge Monitoring Report (DMR).

Annual Average Flow

The arithmetic average of all daily flow determinations taken within the preceding 12 consecutive calendar months. The annual average flow determination shall consist of daily flow volume determinations made by a totalizing meter, charted on a chart recorder and limited to major domestic wastewater discharge facilities with a 1 million gallons per day or greater permitted flow.

Daily Average Flow

The arithmetic average of all determinations of the daily discharge within a period of one calendar month. The daily average flow determination shall consist of determinations made on at least four separate days. If instantaneous measurements are used to determine the daily discharge, the determination shall be the arithmetic average of all instantaneous measurements taken during that month. Daily average flow determination for intermittent discharges shall consist of a minimum of three flow determinations on days of discharge.

Daily Maximum Flow

The highest total flow for any 24-hour period in a calendar month.

Instantaneous Flow

The measured flow during the minimum time required to interpret the flow measuring device.

2-hour Peak Flow

Applies to domestic wastewater treatment plants: The maximum flow sustained for a two-hour period during the period of daily discharge. Multiple measurements of instantaneous maximum flow within a two hour period may be compared to the permitted 2-hour peak flow.

Maximum 2-hour Peak Flow

Applies to domestic wastewater treatment plants: The highest 2-hour peak flow for any 24-hour period in a calendar month.

Daily Average Concentration

The arithmetic average of all effluent samples, composite or grab as required by the permit, within a period of one calendar month, consisting of at least four separate representative measurements. When four samples are not available in a calendar month, the arithmetic average of the four most recent measurements or the arithmetic average (weighted by flow) of all values taken during the month shall be used as the daily average concentration.

7-day Average Concentration

The arithmetic average of all effluent samples, composite or grab as required by the permit, within a period of one calendar week, Sunday through Saturday.

Daily Maximum Concentration

The maximum concentration measured on a single day, by composite sample unless otherwise specified in the permit, within a period of one calendar month.

Fecal Coliform Bacteria Concentration

The number of colonies of fecal coliform bacteria per 100 milliliters of effluent. The fecal coliform bacteria daily average is a geometric mean of the values for the effluent samples collected in a calendar month. The geometric mean shall be determined by calculating the n^{th} root of the product of all measurements made in a particular period of time.

For example in a month's time, where n equals the number of measurements made; or, computed as the antilogarithm of the arithmetic average of the logarithms of each measurement made. For any measurement of fecal coliform bacteria equaling zero, a substituted value of one shall be made for input into either computation method.

Composite Sample

For domestic wastewater, a sample made up of a minimum of three effluent portions collected in a continuous 24-hour period or during the period of daily discharge if less than 24 hours, and combined in volumes proportional to flow, and collected no closer than two hours apart. For industrial wastewater, a composite sample is a sample made up of a minimum of three effluent portions collected in a continuous 24-hour period or during the period of daily discharge if less than 24 hours, and combined in volumes proportional to flow, and collected no closer than one hour apart.

Grab Sample

An individual sample collected in less than 15 minutes at peak flows.

Example Calculations & Reporting for Concentration, Loading, Flow, Cl2 Residual & pH

The example calculations and reporting instructions described in this section are illustrated using data in Table D.1 - Example Daily Operations Log for March.

Table D.1 - *Example Daily Operations Log for March*

Day of Week	Date	Flow (MGD)	BOD (mg/L)	TSS (mg/L)	pH (s.u.)	CL_2 (mg/L)	BOD_5 (lbs/dy)	TSS (lbs/dy)
Sunday	3/1	0.17						
Monday	3/2	0.20				2.00		
Tuesday	3/3	0.19	22.00	30.00	7.50	1.40	34.86	47.54
Wednesday	3/4	0.17				1.30		
Thursday	3/5	0.14				1.00		
Friday	3/6	0.15				1.00		
Saturday	3/7	0.13						
Sunday	3/8	0.17						
Monday	3/9	0.23				1.40		
Tuesday	3/10	0.20	29.00	23.00	7.00	2.10	48.37	38.36
Wednesday	3/11	0.34				1.10		
Thursday	3/12	0.30				1.00		
Friday	3/13	0.20				1.20		
Saturday	3/14	0.14						
Sunday	3/15	0.15						
Monday	3/16	0.20				0.00		
Tuesday	3/17	0.18	18.00	16.00	7.20	1.30	27.02	24.02
Wednesday	3/18	0.17				1.10		
Thursday	3/19	0.21				1.40		
Friday	3/20	0.22				1.40		
Saturday	3/21	0.13						
Sunday	3/22	0.14						
Monday	3/23	0.21				1.00		
Tuesday	3/24	0.19	10.00		6.00	1.30	15.85	
Wednesday	3/25	0.18				1.70		
Thursday	3/26	0.20				1.30		
Friday	3/27	0.17				2.10		
Saturday	3/28	0.15						
Sunday	3/29	0.13						
Monday	3/30	0.19				2.20		
Tuesday	3/31	0.14				1.40		
Total	31	5.69	79.00	69.00	–	–	126.10	109.92
Average	–	0.183	19.75	23.12	N/A	N/A	31.53	36.64
Maximum	–	0.34	29.00	30.00	7.50	2.20	48.37	47.54
Minimum	–	0.13	10.00	16.00	6.00	0.00	15.85	24.02

Reporting of Concentration

The example Daily Operations Log shows that four individual BOD5 grab samples were obtained during the month as follows:

March 3 - 22.00 mg/L
March 10 - 29.00 mg/L
March 17 - 18.00 mg/L
March 24 - 10.00 mg/L

The daily average concentration is calculated by adding the four values obtained and dividing by the number of samples taken during the month. The calculated BOD5 daily average is 19.75 mg/L. (See Figure D.1.)

$$\frac{(22.00 + 29.00 + 18.00 + 10.00)}{4} = 19.75 \text{ mg/L Daily Average } BOD_5$$

Figure D.1

The highest BOD5 concentration was obtained on March 10. This value is reported as the maximum BOD5 individual grab for the reporting period.

Reporting of Loadings

Some parameters in the permit are limited in terms of pounds per day (lbs/day). Although all of these parameters are measured initially in milligrams per liter (mg/L), conversion to lbs/day can be achieved by using the following formula. **Always be sure to use the flow measurement determined on the day when sampling was done**. (See Figure D.2.)

Flow on day of sampling (MGD) x concentration (mg/L) x 8.34 (lbs/gal) = Loading (lbs/day)

Figure D.2

Table D.2

March 3	-	(.19 MGD) (22.00 mg/L) (8.34 lbs/gal)	=	34.86 lbs/day
March 10	-	(.20 MGD) (29.00 mg/L) (8.34 lbs/gal)	=	48.37 lbs/day
March 17	-	(.18 MGD) (18.00 mg/L) (8.34 lbs/gal)	=	27.02 lbs/day
March 24	-	(.19 MGD) (10.00 mg/L) (8.34 lbs/gal)	=	15.85 lbs/day

Using the four BOD5 concentrations and the flow measurements obtained on the days of sampling, the individual daily loadings are calculated as in Table D.2.
The daily average loading (lbs/day) is calculated by adding the individual daily loading values together and dividing by the number of samples taken during the month. The calculated BOD5 daily average loading is 31.53 lbs/day. (See Figure D.3).

$$\frac{(34.86 + 48.37 + 27.02 + 15.85)}{4} = 31.53 \text{ lbs/day Daily Average } BOD_5$$

Figure D.3

Flow-weighted Averages

When four samples are not available in a calendar month, the daily average concentration should be calculated using the four most recent measurements or the arithmetic average (weighted by flow) of all values taken during the month. The example Daily Operations Log shows that TSS grab samples were taken only three times during the month. The values obtained and the flows on the days of sampling are as shown in Table D.3.

Table D.3

	TSS (mg/L)	Flow on day of sampling (MGD)
March 3	30.00	.19
March 10	23.00	.20
March 17	16.00	.18
	Total flow on sample days	.57

To calculate the flow-weighted concentration for each sample, the equation in Figure A4.4 must be used. The flow-weighted average concentration is then determined by adding the flow-weighted concentrations for the individual samples together. (See Figure D.5 and Table D.4.)

$$\text{Concentration (mg/L)} \times \frac{\text{Flow on day of sampling (MGD)}}{\text{Total flow on days of sampling (MGD)}} = \text{Flow-weighted Concentration}$$

Figure D.4

Sum of Flow-weighted Concentrations = Flow-weighted Daily Average Concentration

Figure A4.5

Table D.4

March 3	30.00 mg/L x .19/.57	=	10.00
March 10	23.00 mg/L x .20/.57	=	8.07
March 17	16.00 mg/L x .18/.57	=	5.05
Flow-weighted Daily Average TSS Concentration		=	23.12 mg/L

To calculate the daily average flow-weighted loading, the equation illustrated in Figure A4.6 must be used.

$$\text{Daily average flow-weighted concentration} \times \text{Average of flows on sampling days} \times 8.34 \text{ lbs/gal} = \text{Flow-weighted Daily Average Loading (lbs/day)}$$

$$23.12 \text{ mg/L} \times \frac{.19 + .20 + .18}{3} \times 8.34 = 36.64 \text{ lbs/day Flow-weighted Daily Average TSS Loading}$$

Figure D.6

pH

A review of the example Daily Operations Log indicates four pH values were obtained during the reporting period ranging from a minimum value of 6.80 s.u. on March 24 to a maximum value of 7.50 s.u. on March 3. The highest pH value obtained on March 3 is reported as the maximum pH for the reporting period. The lowest pH value obtained on March 24 is reported as the minimum pH for the reporting period. (*Note that pH is not subject to averaging.*)

Cl2 Residual

A review of the example Daily Operations Log shows Cl2 residual values ranging from a minimum value of 0.00 mg/L on March 16 to a maximum value of 2.20 mg/L on March 30 were obtained during the reporting period. The highest Cl2 value obtained on March 30 is reported as the maximum Cl2 residual for the reporting period. The lowest Cl2 value obtained on March 16 is reported as the minimum CL2 residual for the reporting period. (*Note that chlorine residual is not subject to averaging.*)

Flow

Daily Average Flow and Daily Maximum Flow

The average daily flow is calculated by adding the individual daily flow measurements together and dividing by the number of days on which flow measurements were taken during the month. The average daily flow calculated from the example Daily Operations Log is 0.183 MGD. The daily maximum flow is the highest daily flow value obtained during the reporting period. On the example Daily Operations Log, the daily maximum flow value is 0.34 MGD , which occurred on March 11.

Annual Average Flow

The annual average flow is the arithmetic average of all daily flow determinations taken during the previous 12-month period. It is calculated by adding the individual daily flow measurements together and dividing by the number of measurements taken during the previous 365 days. For example, if the total flow recorded during a 12-month period is 600 MG and during that period of time flow measurements were obtained once per day, the annual average would be calculated as in Figure D.7.

600 MG/365 Days = 1.64 MGD Annual Average Flow

Figure D.7

For new facilities, the first annual average should be calculated based on the number of measurements taken during the first full month of operation. The second annual average should be calculated based on the number of measurements taken during the first and second months of operation. The third annual average should be calculated based on the number of measurements taken during the first, second and third months of operation, etc. After twelve months of operation, all annual average flows should be calculated using the sum of the individual flow measurements divided by the number of measurements taken during the previous 365 days.

For example, during the first full month of operation, if the total flow recorded is 45 MG and 30 flow measurements were taken (one each day), the annual average flow would be calculated by dividing the total flow by the number of measurements taken during the month: **45 MG/30 Measurements = 1.5 MGD Annual Average Flow.** During the next 30 days, if the total flow recorded is 75 MG and 31 measurements were taken (one each day), the annual average flow would be calculated by dividing the total flow for the first 61 days by the number of measurements taken during that period: **45 MG + 75 MG/61 Measurements = 1.967 MGD Annual Average Flow.** During the third month of operation, if the total flow recorded is 65 MG and 31 measurements were taken (one each day), the annual average would be calculated by dividing the total flows for the first 92 days by the number of measurements taken during that period: **45 MG + 75 MG + 65 MG / 92 Measurements = 2.01 MGD Annual Average Flow.**

2-hour Peak Flow

The 2-hour peak flow is the maximum flow sustained for a two-hour period during the period of daily discharge. The maximum 2-hour peak flow which is reported on the Discharge Monitoring Report should be the highest 2-hour peak flow for any 24-hour period in a calendar month. ater Permits and Resource Management Division.

Calculating Fecal Coliform Geometric Mean

Fecal coliform bacteria concentration is the number of colonies of fecal coliform bacteria per 100 milliliters effluent. Fecal coliform bacteria daily average is the geometric mean of the fecal coliform samples collected in a calendar month. The following instructions show two ways to calculate the geometric mean.

nth Root

The geometric mean can be calculated as the *n*th root of the product of *n* data points. In this case, *n* is the number of fecal coliform bacteria sample results.

$$\textbf{Geometric Mean} = \sqrt[n]{X_1 X_2 X_3 X_4 X_5 \ldots X_n}$$

For example, if five fecal coliform bacteria samples are taken and the samples results are 99, 126, 90, 420, and 2200 colonies/mL, the calculated geometric mean is 253.

$$(99)(126)(90)(420)(22) = 1.037 \times 10^{12}$$
$$\sqrt[5]{1.037 \times 1012} = 253$$

Antilog

The geometric mean can also be calculated by taking the antilog of the arithmetic average of the logarithms of the sample results. The following instructions describe how this can be done using the data provided in the chart as an example. (See Table D.5.)

1. Calculate the logarithm for each sample result. For example: The second sample result in the chart is 120. Enter 120 into the calculator and press the log function. The result is 2.079. This is the log of 120. *
2. Calculate the arithmetic average of the logarithms. To do this, add all of the logarithm values together and divide the sum by the number of logarithm values. In the example in the chart, the sum of the logs is 13.703. Since there are 7 log values, divide 13.703 by seven to determine the average of the logs. The result is 1.9576. **

Table D.4

Colonies per 100 mL (sample results)	Log of Colonies per 100 mL
10	1
120	2.079*
601	2.779
48	1.681
130	2.114
11	1.041
1020	3.009
Arithmetic Average	13.703 ÷ 7 = 1.9576 **
Geometric Mean	Antilog of 1.9576 = 91 ***

3. Take the antilog of the arithmetic average of the logarithms. This will be the geometric mean. Using the example in the chart, enter 1.9576 into the calculator and press the antilog function. The result is 91. This is the geometric mean for the sample results. ***

Using the MAL Provision to Determine Reportable Results

For some parameters (toxic organic and inorganic constituents), the permit will contain a provision in the Other Requirements section stating that compliance/ noncompliance determinations will be based on the minimum analytical level (MAL) for the parameter, and effluent concentrations measured as less than the MAL are deemed to be compliant with the permit limits. This permit provision further states that when an analysis of an effluent sample for the parameter results in a measurement of less than the MAL that parameter shall be reported as "<(MAL value)" and this shall be interpreted as a value of zero (0) for compliance purposes. This means, in these instances, to record the concentration for the sample as < (MAL value) for the purposes of determining daily maximum concentration and use a zero for that measurement when calculating the daily average concentration and the daily average loading. The following examples show how to determine reportable values based on the MAL permit provision, using Mercury as an illustration.

MAL for Mercury = 0.0002 mg/L (0.2 µg/l)

Example 1: Some measured values above the MAL and some below the MAL (see Table D.5)

Values to be Reported on the DMR:
Daily Maximum Concentration: 0.00034 mg/L
Daily Average Concentration: 0.00015 mg/L
Daily Average Loading: 0.00144 lbs/day

Example 2: All measured values below the MAL (see Table D.6)

Values to be Reported on the DMR
Daily Maximum Concentration: <0.0002 mg/L
Daily Average Concentration: 0 mg/L
Daily Average Loading: 0 lbs/day

Table D.5

Sample	Lab Result for Mercury (mg/L)	Concentration (mg/L) to be used for calculating average & loading	Flow on day of sample collection (MGD)	Loading (lbs/day)
Sample 1	0.00014 (<0.0002)	0.0	1.022	0.0
Sample 2	0.00028	0.00028	1.039	0.00242
Sample 3	0.00034	0.00034	1.186	0.00336
Sample 4	0.00012 (<0.0002)	0.0	0.974	0.0
Average	—	0.00015	—	0.00144

Table D.6

Sample	Lab Result for Mercury (mg/L)	Concentration (mg/L) to be used for calculating average & loading	Flow on day of sample collection (MGD)	Loading (lbs/day)
Sample 1	0.00014 (<0.0002)	0.0	1.183	0.0
Sample 2	0.00011 (<0.0002)	0.0	0.966	0.0
Sample 3	0.00018 (<0.0002)	0.0	1.205	0.0
Sample 4	0.00015 (<0.0002)	0.0	1.078	0.0
Average	---	0.0	—	0.0

Note: When an analysis of an effluent sample for a parameter covered by the MAL permit provision indicates no detectable levels and the test method detection level is not as sensitive as the specified MAL, then the level of detection achieved must be used for that sample result in determining reportable maximum and average values. A zero (0) may not be used.

No Detection for Non-MAL Parameters

When an analysis of an effluent sample indicates no detectable levels for a parameter not covered by the MAL permit provision, the level of detection achieved must be used for that sample result in determining reportable maximum and average values. A zero (0) may not be used.

Calculating Sewage Sludge Dry Metric Tons

On the SLDP DMR for sewage sludge production and use, the permittee must report the amount of sewage sludge produced and the amount of sewage sludge disposed or beneficially reused in dry metric tons. The following calculations show how to convert gallons or cubic yards of sewage sludge into dry metric tons.

Converting Gallons to Dry Metric Tons

To convert gallons of sewage sludge to dry metric tons, the equations in Figure D.7 can be used.

Where:

X = Gallons of sewage sludge

% = Percent of solids in the sewage sludge

The other values in the equation are conversion factors.

For example, if the permittee disposes of 22,500 gallons of sewage sludge that has a solids content of 5%, the amount disposed is 4.26 dry metric tons. (See Figure D.8)

Converting Cubic Yards to Dry Metric Tons

To convert cubic yards of sewage sludge to dry metric tons, the equations in Figure D.9 can be used.

Where:

X = Cubic yards of sewage sludge

Y = Unit weight of sewage sludge in pounds per cu ft

% = Percent of solids in the sewage sludge

$$\frac{(100)(27)(75)(0.25)}{(2.2046)(1000)} = 22.96 \text{ dry metric tons}$$

Figure D.10

The other values in the equation are conversion factors.

For example, if the permittee disposes of 100 cubic yards of sewage sludge with a solids content of 25% and a unit weight of 75 pounds per cubic foot, the amount disposed is 22.96 dry metric tons. (See Figure D.10)

$$\frac{(22500)(8.34)(0.05)}{(2.2046)(1000)} = 4.26 \text{ dry metric tons}$$

Figure D.8

$$\frac{X \text{ gal}}{1} \times \frac{8.34 \text{ lbs}}{1 \text{ gal}} \times \frac{1 \text{ KG}}{2.2046 \text{ lbs}} \times \frac{1 \text{ MT}}{1000 \text{ KG}} \times \frac{\% \text{ Dry MT}}{1 \text{ MT}} = \text{Dry Metric Tons}$$

Short Conversion $\frac{(X)(8.34)(\%)}{(2.2046)(1000)}$

Where:
X = Gallons of sewage sludge

Figure D.7

$$\frac{X \text{ yd}^3}{1} \times \frac{27 \text{ ft}^3}{1 \text{ yd}^3} \times \frac{Y \text{ lbs}}{1 \text{ ft}^3} \times \frac{1 \text{ KG}}{2.2046 \text{ lbs}} \times \frac{1 \text{ MT}}{1000 \text{ KG}} \times \frac{\% \text{ Dry MT}}{1 \text{ MT}} = \text{Dry Metric Tons}$$

Short Conversion: $\frac{(X)(27)(Y)(\%)}{(2.2046)(1000)}$

Figure D.9