# Exhibit 15

## American Samoa Water Quality Standards Implementation Guidance Manual

AMERICAN SAMOA

# WATER QUALITY STANDARDS IMPLEMENTATION GUIDANCE MANUAL

MARCH 2014

## AS-EPA Implementation Guidance Manual for
## ASWQS Numeric Criteria
## Administrative Rule No. 001-2013

---

### 1.0    Introduction

This manual provides guidance on mathematical applications for water quality data to determine if results comply with numerical criteria listed in the 2013 ASWQS (Administrative Rule No. 001-2013).   Compliance determination shall be used for 303(d) listing, NPDES permit compliance, and enforcement actions against non-permitted discharges, as applicable.

Analytical results for Toxicants (Section 2.0), Bacteria (Section 3.0), and Conventional Non-Statistical Parameters (Section 4.0) are evaluated against the ASWQS by single sample analytical results, geometric mean, or median.

For Conventional Statistical Parameters (Section 5.0) compliance determination is based on a two-tiered percentile rank approach.  The two-tiered approach first uses an expedient screening level method, and then a more detailed method by graphing or calculations if the screening level indicates non-compliance at one or more of the specified percentiles ($50^{th}$, $90^{th}$ or $98^{th}$).  Section 5.0 presents guidance on mathematical applications and compliance determination for the screening level, graphing, and calculations methods.

### 2.0    Toxicants

Compliance for toxic substances shall be determined using the value of the analytical result for any single sample.  The list of regulated toxic substances and respective action levels are provided in the National Recommended Water Quality Criteria 2002, EPA-822-R-02-047 (November 2002 or current version), as referenced in the ASWQS.

For toxic substance use support evaluation methodology, including Impaired Waterbody (§303d) listing, refer to the current edition (as amended) of the Territory of American Samoa Integrated Water Quality Monitoring and Assessment Report.

### 3.0    Bacteria

Compliance for maximum allowable bacteria levels for public health protection (e.g., beach advisories) shall be based on any single sample exceedance of the statistical threshold value (CFU/100 ml) of specified bacteria for fresh and marine waters.

For NPDES permittees, permit compliance for marine receiving waters shall be determined utilizing the geometric mean of all discrete measurements (all depths, all stations, as required in the permit) over a 30 day period.

For bacteria use support evaluation methodology, including Impaired Waterbody (§303d) listing, refer to the current edition (as amended) of the Territory of American Samoa Integrated Water Quality Monitoring and Assessment Report.

## 4.0    Conventional Non-Statistical Parameters:    Ammonia
Dissolved Oxygen
pH

Compliance for conventional non-statistical parameters shall be determined by comparing the median of the data set to the appropriate ASWQS numeric criteria.  The median is a measure of central tendency for the overall range of the data (lowest to highest value), and is the middle value for an ordered data set.  Thus, an equal number of data values are greater than and less than the median.

For purposes of this manual, analytical results for ammonia, dissolved oxygen, and pH are assumed to follow a normal distribution, and standard methods for determining the median are applied.  These parameters are expected to have relatively low variability in the natural systems of streams and marine waters if no pollution is present, although out-liers are expected to occur.  The median is therefore considered to be the appropriate measure of central tendency to evaluate analytical results, to detect elevated levels of these parameters as a result of a pollution input.

The first step to determine the median is to arrange the data in order, from lowest to highest value.  Once the data is ordered there are several possible scenarios when determining the median.  The most frequently encountered scenarios are presented below:

(a) Odd number of data points, no ties for mid-range values.
    In this case, the median is the middle value.  If there are 25 data points, the median is the 13th value of the ordered data set.

(b) Even number of data points, no ties for mid-range values.
    In this case, the median is the mid-point (average) of the two middle values.  If there are 24 data points, the median is the average of the 12th and 13th data points.

(c) Even number of data points, tied mid-range values.

In this case, the median is the two middle values. If there are 24 data points, the median is either the 12th or 13th data points, which are the same value.

The median can also be calculated using Excel[®]. The Excel[®] formula for the median of a column of numbers is "=MEDIAN(cell:cell)", where the first "cell" reference is the top cell of the column of numbers, and the second "cell" reference is the bottom cell of the column.

Compliance for conventional non-statistical parameters shall be determined utilizing not less than 12 measurements taken over a consecutive 12-24 month period to account for seasonality of prevailing trade wind and non-trade wind conditions, localized weather conditions, and various tidal stages. Although the minimum required number of samples is 12, 24 or more samples are recommended to improve the representativeness of analytical results.

For stream waters, samples are to be taken at lower, middle, and upper stream sites, and above the tidal influence (lower and upper only for very short streams; length criteria is to be determined by the AS-EPA Water Program manager).

For marine waters, samples are to be taken at mid-depth for waters of depth 30 ft or less, and at two depths (3 ft below surface and near bottom, 60 ft maximum) for waters of depth greater than 30 ft. The analytical result for each water sample from each depth at each sampling station shall be considered as a discrete data point for the purposes of compliance determination.

For localized non-permitted discharges that occur as a result of an activity on a specific parcel of land or specific contiguous parcels of land, the period of sampling is not required to account for the natural variability of the system (i.e., seasonality, weather, and tidal stage). Compliance for localized non-permitted discharges shall be determined utilizing at least 12 measurements taken during periods of discharge. Water samples are to be taken within the area of the influence of discharge on the waterbody. Although the minimum required number of samples is 12, 24 or more samples are recommended to improve the representativeness of analytical results.

For NPDES permittees, permit compliance for marine receiving waters shall be determined utilizing all measurements (all depths, all sampling stations, as required in the permit) over a running 12 month period.

For conventional non-statistical parameter use support evaluation methodology, including Impaired Waterbody (§303d) listing, refer to the current edition (as amended) of the Territory of American Samoa Integrated Water Quality Monitoring and Assessment Report.

**5.0    Conventional Statistical Parameters:   Turbidity**
**Total Phosphorus**
**Total Nitrogen**
**Chlorophyll-a**
**Light Penetration**
**Total Suspended Solids**

For purposes of this manual, analytical results for Turbidity, Total Phosphorus, Total Nitrogen, Chlorophyll-a, Light Penetration, and Total Suspended Solids are assumed to follow a log-normal distribution.  These parameters are potentially highly variable in the natural systems of streams and marine waters, even if pollution is not present.  Therefore, these parameters must be evaluated based on statistical probability in order to determine if the levels detected in the water column are within the limits of natural variability or are due to a pollution input.

Compliance determination for conventional statistical parameters shall be based on a two-tiered percentile rank approach.  First, field data is evaluated at a screening level, as described in Section 5.1.  The screening level determination is made from ordered numerical data that is evaluated at the $50^{th}$, $90^{th}$ and $98^{th}$ percentile rank.  If the analytical result at each percentile rank is equal to or less than the applicable ASWQS criteria, then compliance is indicated.  If the screening level analysis shows that one or more of the $50^{th}$, $90^{th}$ and $98^{th}$ percentile rank exceeds the ASWQS numerical criteria, then a detailed evaluation of data by graphing or calculations is required for a more robust validation of non-compliance.

The method for analysis by graphing is presented in Section 5.2.  The analysis by graphing uses a calculated "best-fit" graph of the analytical results, plotted on the same axes with the ASWQS numerical criteria graph, to accurately determine the percentile value of non-compliance, i.e., at what percentile between the $50^{th}$, $90^{th}$ or $98^{th}$ percentile levels.

The method for analysis by calculations is presented in Section 5.3.  This method directly calculates the value of the data set "best-fit" graph for each selected percentile rank.  The value at each percentile rank is then compared directly to the ASWQS numerical criteria to determine compliance.

Compliance for conventional statistical parameters shall be determined utilizing not less than 12 measurements taken over a consecutive 12 - 24 month period to account for seasonality of prevailing trade wind and non-trade wind conditions, localized weather conditions, and various tidal stages.  Although the minimum required number of samples is 12, 24 or more samples are recommended to improve the representativeness of analytical results.

For stream waters, samples are to be taken at lower, middle, and upper stream sites, and above the tidal influence (lower and upper only for very short streams; length criteria is to be determined by the AS-EPA Water Program manager).

For marine waters, samples are to be taken at mid-depth for waters of depth 30 ft or less, and at two depths (3 ft below surface and near bottom, 60 ft maximum) for waters of depth greater than 30 ft. The analytical result for each water sample from each depth at each sampling station shall be considered as a discrete data point for the purposes of compliance determination.

For localized non-permitted discharges that occur as a result of an activity on a specific parcel of land or specific contiguous parcels of land, the period of sampling is not required to account for the natural variability of the system (i.e., seasonality, weather, and tidal stage). Compliance for localized non-permitted discharges shall be determined utilizing at least 12 measurements taken during periods of discharge. Water samples are to be taken within the area of the influence of discharge on the waterbody. Although the minimum required number of samples is 12, 24 or more samples are recommended to improve the representativeness of analytical results.

For NPDES permittees, permit compliance for marine receiving waters shall be determined utilizing all measurements (all depths, all sampling stations, as required in the permit) over a running 12 month period.

For NPDES receiving waters, or other waterbodies sampled on a regular basis for 3 or more years as directed by the AS-EPA Water Program manager, numerical criteria for conventional statistical parameters shall not be exceeded more than once in any consecutive 3-year period.

For conventional statistical parameter use support evaluation methodology, including Impaired Waterbody (§303d) listing, refer to the current edition (as amended) of the Territory of American Samoa Integrated Water Quality Monitoring and Assessment Report.

## 5.1   Screening Level Analysis for Determination of Compliance

This screening level analysis was proposed by US EPA Region 9 (San Francisco) Water Program staff as an expedient first-tier method to determine compliance, with the intent to avoid more complicated mathematical analyses if possible.

This screening level analysis assumes a normal distribution of analytical results, and only approximates the 50th (median), 90th and 98th percentile values for the data set. The accuracy of the approximation will vary according to the characteristics of any particular data set, and will be influenced primarily by the range, variance, and number of samples (n) for each data set.

To determine compliance at the screening level, calculate the approximate 50th (median), 90th and 98th percentile values from the ordered data and compare these values to the ASWQS numerical criteria. For compliance, all calculated percentile data values shall be equal to or less than the ASWQS numerical criteria.

## Preparation of Table and Calculations - Screening Level Analysis

1. **Prepare an Excel® spreadsheet** with headings as shown in example below (Table 1). Enter analytical results in Column A in order from lowest value to highest value. All values must be in the same units (e.g. µg L$^{-1}$) as indicated in the ASWQS numerical criteria for each respective parameter. List the number of the successive cumulative data points in Column B.

2. **Determine the data point to represent the 50th percentile (median) of the analytical results** by multiplying the number of samples (n) by (0.50). If the calculated data point lies between two cumulative data points, use the higher data point. For this example (0.50) x 24 = 12. In this case use data point 12. The approximate analytical result for the **50th percentile = 9.7 µg L$^{-1}$** for the example data set (Table 1).

3. **Determine the data point to represent the 90th percentile of the analytical results** by multiplying the number of samples (n) by (0.90). If the calculated data point lies between two cumulative data points, use the higher data point. For this example (0.90) x 24 = 21.6. In this case use data point 22. The approximate analytical result for the **90th percentile = 16.9 µg L$^{-1}$** for the example data set (Table 1).

4. **Determine the data point to represent the 98th percentile of the analytical results** by multiplying the number of samples (n) by (0.98). If the calculated data point lies between two cumulative data points, use the higher data point. For this example (0.98) x 24 = 23.5. In this case use data point 24. The analytical result for the **98th percentile = 37.0 µg L$^{-1}$** for the example data set (Table 1).

## Determination of Compliance - Screening Level Analysis

Compare calculated percentile data values to ASWQS numerical criteria. If the 50th (median), 90th and 98th screening level percentile data values are equal to or less than the ASWQS criteria, compliance is indicated (Table 2).

If any of the screening level percentile values are greater than the ASWQS criteria, proceed to the detailed analysis by graphing or calculations as presented in Section 5.2 and Section 5.3.

**Table 1.     Example - Screening Level Analysis;
               Total Phosphorus (Open Coastal)**

| Column A | Column B | |
|---|---|---|
| **Ordered analytical results (µg $L^{-1}$)** | **Cumulative data points (1 to n)[1]** | |
| 6.7 | 1 | |
| 7.5 | 2 | |
| 7.8 | 3 | |
| 8.0 | 4 | |
| 8.1 | 5 | |
| 8.2 | 6 | |
| 8.3 | 7 | |
| 8.8 | 8 | |
| 9.1 | 9 | |
| 9.2 | 10 | |
| 9.7 | 11 | |
| 9.7 | 12 | (50th percentile) |
| 10.1 | 13 | |
| 10.9 | 14 | |
| 11.0 | 15 | |
| 11.6 | 16 | |
| 11.9 | 17 | |
| 14.0 | 18 | |
| 14.4 | 19 | |
| 15.8 | 20 | |
| 16.5 | 21 | |
| 16.9 | 22 | (90th percentile) |
| 21.6 | 23 | |
| 37.0 | 24 | (98th percentile) |

[1]n =number of samples in data set (24 this example).

**Table 2.     Example - Screening Level Analysis;
               Compliance for Total Phosphorus (Open Coastal)**

| ASWQS (percentile) | ASWQS numerical criteria (µg $L^{-1}$) | Data set percentile value (µg $L^{-1}$) | Compliance with ASWQS (?) |
|---|---|---|---|
| 50th (median) | 15 | 9.7 | Yes |
| 90th | 30 | 16.9 | Yes |
| 98th | 50 | 37.0 | Yes |

## 5.2    Analysis by Graphing for Determination of Compliance

This analysis by graphing follows the method developed by Krock (*c*. 1979-1985) which is described in documents on file with the AS-EPA Water Program.  This analysis assumes a log-normal distribution of analytical results, and uses mathematical applications for log-transformed data in the calculations.

Mathematical explanations for calculations are not provided, but readers are encouraged to investigate the mathematical applications in order to assure themselves of the veracity of the calculations and results.

For each ASWQS parameter, plot the analytical results, the calculated best-fit graph of the analytical results, and the corresponding ASWQS numerical criteria graph, on log-probability axes.

### **Preparation of Table and Calculations - Analysis by Graphing**

1.  **Prepare an Excel® spreadsheet** table with headings as shown in Table 3 below.

In Column A, enter analytical results in order from lowest value to highest value.  All values must be in the same units (e.g. $\mu g\ L^{-1}$) as indicated in the ASWQS numerical criteria for each respective parameter.

In Column B, calculate the $Log_{10}$ of each analytical result.  The $Log_{10}$ can be calculated in the Excel® spreadsheet by entering the cell formula "=LOG(cell)".  The "cell" reference is the corresponding analytical value cell in Column A.

In Column C, list the number of the successive cumulative data points (i).

In Column D, enter the formula in the Excel® spreadsheet to calculate relative cumulative frequency of values ($F_{(i)}$) for each successive data point (i).  The formula for  $F_{(i)}$ is "=((cell)-0.5)/n)*100".  The "cell" reference is the corresponding cumulative data point cell in Column C. The "n" in this formula is the total number of samples, i.e. 24 in this example.

Once Table 3 is completed, calculations to prepare for graphing the best-fit line of the analytical results can proceed.

**Table 3.     Example - Analysis by Graphing;
         Total Phosphorus (Open Coastal)**

| Column A | Column B | Column C | Column D |
|---|---|---|---|
| **Ordered analytical results ($\mu g\ L^{-1}$)** | **Log$_{10}$ of analytical results ($\mu g\ L^{-1}$)** | **Cumulative data points (i) (1 to n)[1]** | **Relative cumulative frequency $F_{(i)} = [(i-0.5)/n]100$** |
| 6.7 | 0.8228 | 1 | 2.1 |
| 7.5 | 0.8777 | 2 | 6.3 |
| 7.8 | 0.8944 | 3 | 10.4 |
| 8.0 | 0.9053 | 4 | 14.6 |
| 8.1 | 0.9060 | 5 | 18.8 |
| 8.2 | 0.9147 | 6 | 22.9 |
| 8.3 | 0.9177 | 7 | 27.1 |
| 8.8 | 0.9445 | 8 | 31.3 |
| 9.1 | 0.9614 | 9 | 35.4 |
| 9.2 | 0.9615 | 10 | 39.6 |
| 9.7 | 0.9857 | 11 | 43.8 |
| 9.7 | 0.9875 | 12 | 47.9 |
| 10.1 | 1.0044 | 13 | 52.1 |
| 10.9 | 1.0374 | 14 | 56.3 |
| 11.0 | 1.0411 | 15 | 60.4 |
| 11.6 | 1.0637 | 16 | 64.6 |
| 11.9 | 1.0745 | 17 | 68.8 |
| 14.0 | 1.1452 | 18 | 72.9 |
| 14.4 | 1.1573 | 19 | 77.1 |
| 15.8 | 1.1976 | 20 | 81.3 |
| 16.5 | 1.2176 | 21 | 85.4 |
| 16.9 | 1.2291 | 22 | 89.6 |
| 21.6 | 1.3354 | 23 | 93.8 |
| 37.0 | 1.5687 | 24 | 97.9 |

[1]n =number of samples in data set (24 this example).

Graphing the best-fit line for analytical results requires 3 (x,y) coordinate points:

    (1) Geometric mean (50% frequency);

    (2) 1 standard deviation left of the geometric mean;

    (3) 1 standard deviation right of the geometric mean.

Steps 2-5 below are calculations that determine the coordinates for these 3 points that represent a straight line that best expresses the general relationship between the analytical results and the frequency of occurrence. Final coordinates for the best-fit line for the analytical results are shown in Table 4.

2. **Calculate the geometric mean of analytical results in Column A.** For a log-normal distribution, the geometric mean is equivalent to the median (50th percentile), which is the 50% frequency on a cumulative frequency graph.

For analytical results in Column A, the Excel® formula for the geometric mean of a column of numbers is "=GEOMEAN(cell:cell)", where the first "cell" reference is the top cell of the column of numbers, and the second "cell" reference is the bottom cell of the column.

For this data set, the **geometric mean = 11.17 µg L$^{-1}$**.

Coordinates for the geometric mean of the best-fit line of the analytical results are therefore, x = 50%, y = 11.17 µg L$^{-1}$, as shown in Table 4.

3. **Calculate the standard deviation of the geometric mean**. To calculate the standard deviation of the geometric mean, first calculate the standard deviation of the log-transformed data in Column B of Table 3. The Excel® formula for the standard deviation of a column of numbers is "=STDEV(cell:cell), where the first "cell" reference is the top cell of the column of numbers, and the second "cell" reference is the bottom cell of the column.

Since the standard deviation is calculated for log-transformed data, the result must be back-transformed to obtain the standard deviation of the geometric mean.

For this data set, the s**tandard deviation for the log-transformed data = 0.1712 µg L$^{-1}$**.

Therefore, the **standard deviation of the geometric mean = 10$^{(0.1712)}$ = 1.48 µg L$^{-1}$**.

4. **Calculate the <u>best-fit y-axis coordinate</u> for 1 standard deviation left of the geometric mean, and 1 standard deviation right of the geometric mean**.

The corresponding y-axis coordinates are:

1 standard deviation <u>left</u> of the geometric mean = (geometric mean) ÷ (standard deviation) = 11.17 ÷ 1.48 = **7.53 µg L$^{-1}$** (Table 4);

1 standard deviation <u>right</u> of the geometric mean = (geometric mean) x (standard deviation) = 11.17 x 1.48 = **16.56 µg L$^{-1}$** (Table 4).

5. **Calculate the <u>best-fit x-axis coordinate</u> for 1 standard deviation left of the geometric mean, and 1 standard deviation right of the geometric mean**.

Statistical probability shows that approximately 68.2% of measurements lay between ± 1

standard deviation from the geometric mean (50% frequency) of a log-normal distribution.

Therefore, half of 68.2%, or 34.1% of measurements, lay 1 standard deviation left and right of the geometric mean.  The corresponding x-axis coordinates are:

1 standard deviation <u>left</u> of the geometric mean = 50% - 34.1% = **15.9%** (Table 4);

1 standard deviation <u>right</u> of the geometric mean = 50% + 34.1% = **84.1%** (Table 4).

**Table 4.** **Example - Analysis by Graphing;**
**Coordinates for best-fit line for Total Phosphorus (Open Coastal)**

| | coordinates | |
| --- | --- | --- |
| **Point** | **X-axis**<br>**(frequency, %)** | **Y-axis**<br>**(µg L$^{-1}$)** |
| 1 standard deviation left | 15.9 | 7.53 |
| Geometric mean | 50.0 | 11.17 |
| 1 standard deviation right | 84.1 | 16.56 |

**<u>Preparation of Log-probability Graph - Analysis by Graphing</u>**

Using graphing software such as Grapher 9® (Golden Software) plot the analytical results, the best-fit line, and the ASWQS numerical criteria line, on a log-probability graph.  The graph can also be prepared manually using log-probability paper, a fine-point pencil, and a straight-edge.

Coordinates for the <u>analytical results</u> are the data values in Column A (y-axis) and the corresponding cumulative frequency in Column D (x-axis), as shown in Table 3.

Coordinates for the <u>best-fit line for the analytical results</u> are shown in Table 4.

Coordinates for the <u>ASWQS numerical criteria</u> are specified in the ASWQS.

The completed log-probability graph is shown in Figure 1.

## Determination of Compliance - Analysis by Graphing

If the calculated best-fit line of the analytical results <u>does not cross</u> the ASWQS numerical criteria line at any point beyond the 50% cumulative frequency on the x-axis, then <u>compliance</u> with the ASWQS numerical criteria is indicated.

If the calculated best-fit line of the analytical results <u>does cross</u> the ASWQS numerical criteria line at any point beyond the 50% cumulative frequency on the x-axis, then <u>non-compliance</u> with the ASWQS numerical criteria is indicated.

Note that if the best-fit line and the ASWQS criteria line are extended to the left in the graph, the lines will cross at approximately 10% frequency for this example. This does not affect the compliance determination, because the ASWQS numerical criteria are for greater than 50% cumulative frequency only.

**Figure 1.    Example - Analysis by Graphing;
              Compliance for Total Phosphorus (Open Coastal)**
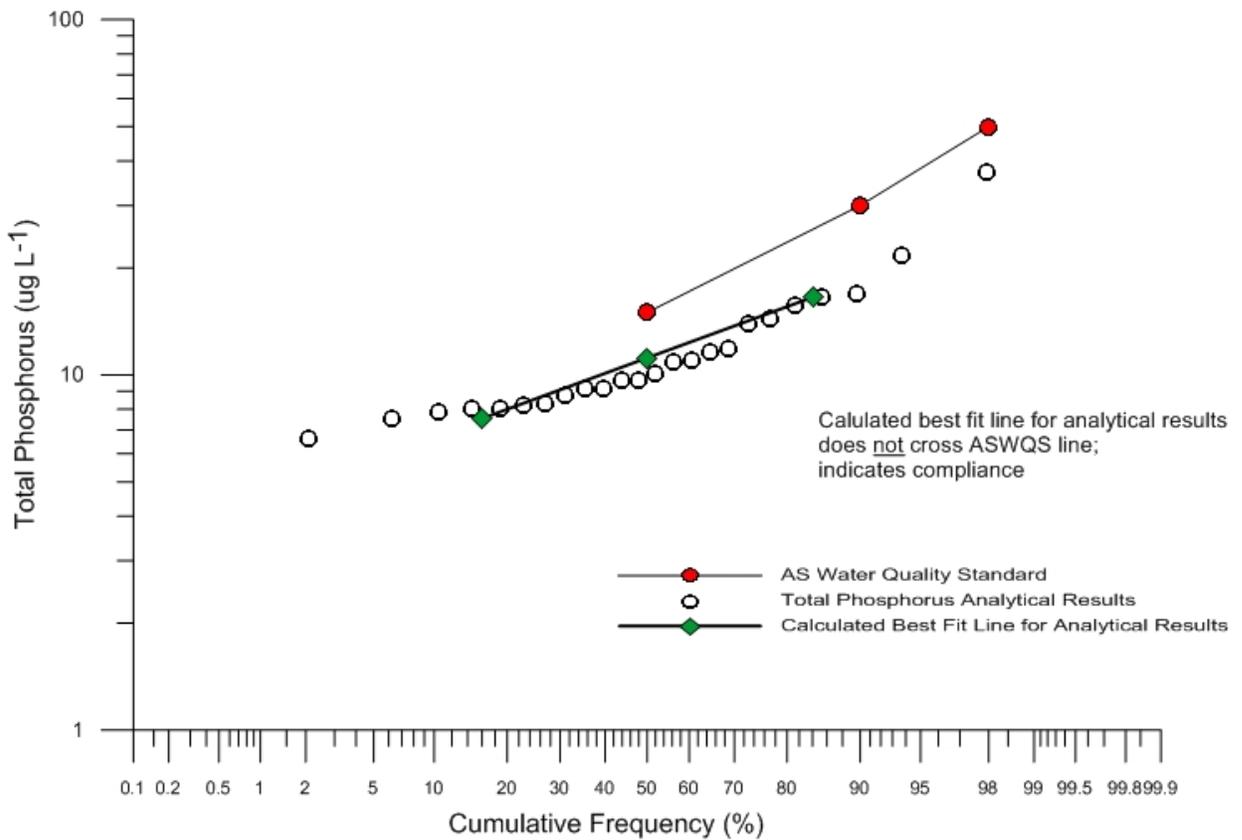
## 5.3    Analysis by Calculations for Determination of Compliance

The analysis by calculations adapts the method developed by Krock (*c*. 1979-1985) which is described in documents on file with the AS-EPA Water Program.  This analysis assumes a log-normal distribution of analytical results, and uses mathematical applications for log-transformed data in the calculations.

Mathematical explanations for calculations are not provided, but readers are encouraged to investigate the mathematical applications in order to assure themselves of the veracity of the calculations and results.

To determine compliance by the calculations method, calculate the geometric mean (50% frequency), $90^{th}$, and $98^{th}$ percentile values from the ordered data and compare these values to the ASWQS numerical criteria.  For compliance, all calculated percentile data values shall be equal to or less than the ASWQS criteria.

### Preparation of Table and Calculations – Analysis by Calculations

1. **Prepare an Excel® spreadsheet** table with headings as shown in Table 5 below.

In Column A, place analytical results in order from lowest value to highest value.  All values must be in the same units (e.g. µg $L^{-1}$) as indicated in the ASWQS numerical criteria for each respective parameter.

In Column B, calculate the $Log_{10}$ of each analytical result.   The $Log_{10}$ can be calculated in the Excel® spreadsheet by entering the cell formula "=LOG(cell)".  The "cell" reference is the corresponding analytical results cell in Column A.

2. **Calculate the geometric mean of analytical results in Column A of Table 5.**  For a log-normal distribution, the geometric mean is equivalent to the median ($50^{th}$ percentile), which is the 50% frequency on a cumulative frequency graph.

For analytical results in Column A, the Excel® formula for the geometric mean of a column of numbers is "=GEOMEAN(cell:cell)", where the first "cell" reference is the top cell of the column of numbers, and the second "cell" reference is the bottom cell of the column.

For this data set, the **geometric mean = 11.17 µg $L^{-1}$**.

**Table 5.      Example - Analysis by Calculations;**
**Total Phosphorus (Open Coastal)**

| Column A | Column B | |
| --- | --- | --- |
| **Ordered analytical results ($\mu g\ L^{-1}$)** | **$Log_{10}$ of analytical results ($\mu g\ L^{-1}$)** | **Calculated descriptive statistic** |
| 6.7 | 0.8228 | |
| 7.5 | 0.8777 | |
| 7.8 | 0.8944 | |
| 8.0 | 0.9053 | |
| 8.1 | 0.9060 | |
| 8.2 | 0.9147 | |
| 8.3 | 0.9177 | |
| 8.8 | 0.9445 | |
| 9.1 | 0.9614 | |
| 9.2 | 0.9615 | |
| 9.7 | 0.9857 | |
| 9.7 | 0.9875 | |
| 10.1 | 1.0044 | |
| 10.9 | 1.0374 | |
| 11.0 | 1.0411 | |
| 11.6 | 1.0637 | |
| 11.9 | 1.0745 | |
| 14.0 | 1.1452 | |
| 14.4 | 1.1573 | |
| 15.8 | 1.1976 | |
| 16.5 | 1.2176 | |
| 16.9 | 1.2291 | |
| 21.6 | 1.3354 | |
| 37.0 | 1.5687 | |
| 11.17 | | Geometric Mean |
| | 0.1712 | Standard Deviation |
| | 18.50 | 90th Percentile |
| | 25.05 | 98th Percentile |

3. **Calculate the standard deviation of the log-transformed data in Column B of Table 5.**
For analytical results in Column B, the Excel® formula for the standard deviation of a column of numbers is "=STDEV(cell:cell), where the first "cell" reference is the top cell of the column of numbers, and the second "cell" reference is the bottom cell of the column.

For this data set, the s**tandard deviation for the log-transformed data = 0.1712 μg L$^{-1}$**.

4. **Calculate the 90$^{th}$ percentile value.** The Excel$^{®}$ formula for the 90$^{th}$ percentile of a log-normal distribution of data is "=10^(log(cell)+1.28*cell)", where the first "cell" reference is the geometric mean of analytical results calculated above, and the second "cell" reference is the standard deviation of log-transformed data calculated above. The coefficient "1.28" is the number of standard deviations that corresponds with the 90$^{th}$ percentile value for a log-normal distribution.

For this data set, the **90$^{th}$ percentile = 18.50 μg L$^{-1}$**.

5. **Calculate the 98$^{th}$ percentile value.** The Excel$^{®}$ formula for the 98$^{th}$ percentile of a column of numbers is "=10^(log(cell)+2.05*cell), where the first "cell" reference is the geometric mean of analytical results calculated above, and the second "cell" reference is the standard deviation of log-transformed data calculated above. The coefficient "2.05" is the number of standard deviations that corresponds with the 98$^{th}$ percentile value for a log-normal distribution.

For this data set, the **98$^{th}$ percentile = 25.05 μg L$^{-1}$.**

## Determination of Compliance – Analysis by Calculations

Compare calculated percentile data values to ASWQS numerical criteria. If the geometric mean (median), 90$^{th}$ and 98$^{th}$ screening level percentile data values are equal to or less than the ASWQS criteria, compliance is indicated (Table 6).

**Table 6.** **Example - Analysis by Calculations; Compliance for Total Phosphorus (Open Coastal)**

| ASWQS (percentile) | ASWQS numerical criteria (μg L$^{-1}$) | Data set percentile value (μg L$^{-1}$) | Compliance with ASWQS (?)[1] |
|---|---|---|---|
| 50$^{th}$ (median) | 15 | 11.17 | Yes |
| 90$^{th}$ | 30 | 18.50 | Yes |
| 98$^{th}$ | 50 | 25.05 | Yes |

[1]Note that although Table 6 agrees with Table 2 in the final determination, the limitations of the screening level analysis are obvious.