State of Alaska

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DIVISION OF WATER

Guidance for the Implementation of
Natural Condition-Based Water Quality Standards

Public Notice Draft – August 16, 2006

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ACRONYMS

AAC	Alaska Administrative Code
AML	Average Monthly Load
AML-A	Average Monthly Load (alternate calculation)
CV	Coefficient of Variation
DEC	Alaska Department of Environmental Conservation
DQOs	Data Quality Objectives
LTA	Long-term Average Load
LTA_A	Long-term Average (Acute)
LTA_C	Long-term Average (Chronic)
MDL	Maximum Daily Load
MDL-A	Maximum Daily Load (alternate calculation)
MQOs	Measurement Quality Objectives
NPDES	National Pollutant Discharge Elimination System
PCBs	Polychlorinated Biphenyls
POTW	Publicly Owned Treatment Works
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAC	Reference Ambient Concentration
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
WLA	Wasteload Allocation
WLA_A	Wasteload Allocation (Acute)
WLA_C	Wasteload Allocation (Chronic)
WLA_H	Wasteload Allocation (human health)

1 PURPOSE AND SCOPE

The State of Alaska water quality standard regulations establish water quality standards primarily through a combination of designated uses and associated water quality criteria. In certain instances, the natural condition of a waterbody may include pollutant levels that exceed criteria-based standards. In those cases, the state water quality standards regulation provides that the natural condition becomes the water quality standard for the waterbody.

The purpose of this document is to specify the procedures that the Alaska Department of Environmental Conservation (DEC) will use to implement natural condition-based water quality standards.

1.1 Regulatory Provision

The natural condition-based water quality standard provision is found at 18 AAC 70.010(c):

> (c) Where the department determines that the natural condition of a water of the state is of lower quality than the water quality criteria set out in 18 AAC 70.020(b), the natural condition supersedes the criteria and becomes the standard for that water. In implementing water quality standards based on the natural conditions in a permit, certification or other written decision, the department will follow the procedures set out in the *Guidance for the Implementation of Natural Condition-Based Water Quality Standards*, dated August 16, 2006 adopted by reference.

This document comprises the guidance referenced in the regulation.

1.2 Definitions

The following definitions apply to this guidance:

> "*Natural Condition*" is defined in the Water Quality Standard regulations (18 AAC 70.990(41)) as any physical, chemical, biological, or radiological condition existing in a waterbody before any human-caused influence on, discharge to, or addition of material to, the waterbody.
>
> "*Water,*" "*Waterbody,*" and "*Waters*" are defined in Alaska Statutes (46.03.900(37)) to include lakes, bays, sounds, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, marshes, inlets, straits, passages, canals, the Pacific Ocean, Gulf of Alaska, Bering Sea, and Arctic Ocean, in the territorial limits of the state, and all other bodies of surface or underground water, natural or artificial, public or private, inland or coastal, fresh or salt, which are wholly or partially in or bordering the state or under the jurisdiction of the state."

1.3 Applicable Water Quality Parameters

By definition, the natural character and constituents of a waterbody are those not attributable to human activities. Natural water quality is affected by local geophysical, hydrological and meteorological processes and wildlife. The natural condition standard provision applies to any parameter listed in 18 AAC 70.020(b), except as discussed below.

DEC anticipates that the natural condition provision would most frequently apply to parameters such as:

- *Bacteria* attributed to wildlife including waterfowl,
- *Metals* derived from natural mineral deposits,
- *Nutrients* attributed to background soil, vegetation or wildlife sources,
- *Sediments* from natural stream morphology processes or organic matter,
- *Temperature* due to seasonal shifts and other natural processes
- *Dissolved oxygen* due to seasonal shifts and other natural processes.

Natural condition-based standards are not appropriate for human created substances that do not naturally exist in the environment. For example natural condition-based standards would not be appropriate for synthetic compounds that do not occur naturally such as polychlorinated biphenyls (PCBs) or pesticides such as aldrin or dieldrin.

2 GENERAL PROCEDURES

The natural condition provision requires that DEC first determine that "the natural condition of a water of the state is of lower quality than the water quality criteria." With that determination then, "the natural condition supersedes the criteria and becomes the standard for that water."

In determining the first part of the provision, that the natural condition is of lower quality than the water quality criteria, DEC must find that (1) the quality is lower than the water quality criteria and (2) the quality of the waterbody (or some portion thereof) is a result of natural processes. This document provides guidance to DEC staff in making these two preliminary findings.

Once the two preliminary conditions have been established, the water quality standard becomes the natural condition. This document goes on to provide guidance as to methods to express the natural condition in terms that can be used in permits and other agency decisions and actions.

The general process for implementing natural condition-based water quality standards is shown in Figure 1 on the next page. Each step in the process is described in the following paragraphs.

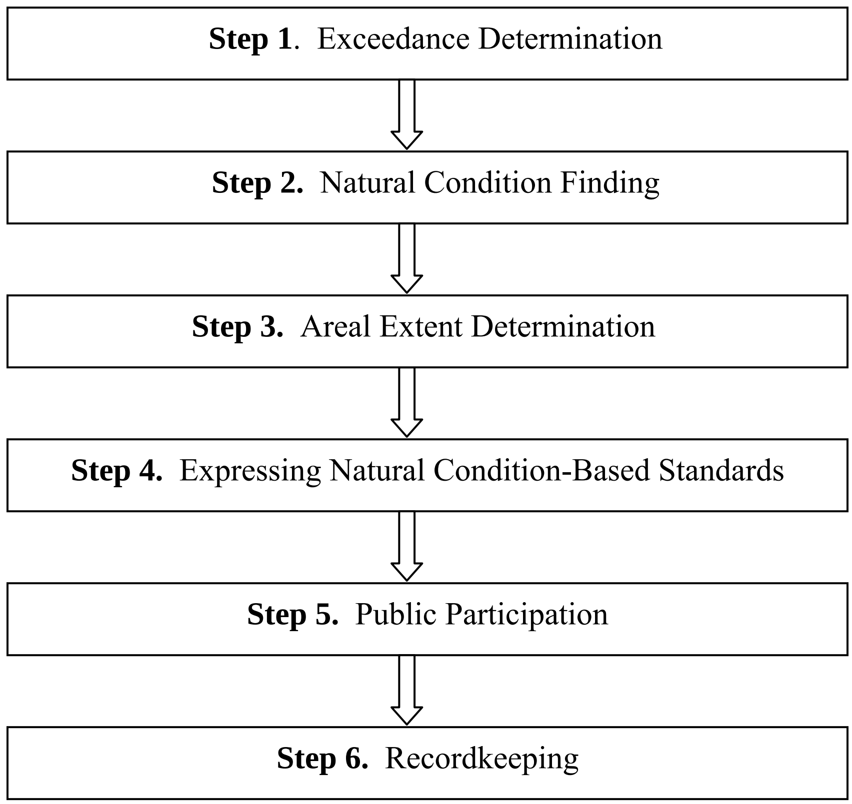


Figure 1. Establishing a Natural Condition-Based Water Quality Standard Process Overview

2.1 Procedural Steps

2.1.1 Exceedance Determination

The first step in implementing the natural condition-based water quality standard provision is determining whether one or more water quality criteria-based standards are exceeded. The clearest form of documentation for such a determination is a record of water quality monitoring in the water that includes actual water quality measurements that fall outside of the allowable range of the water quality criteria-based standards. For this type of documentation, only a few measurements that fall outside of the water quality criteria range may be needed.

While documentation in the form of a water quality monitoring record is preferred, in the event that such documentation is not available and cannot be obtained without unreasonable effort and expense, documentation for this initial step can take the form of monitoring records in nearby waterbodies that are believed to have similar water quality characteristics, or regional information suggesting that water quality over the region that includes the area of interest routinely falls outside of water quality criteria-based standards.

DEC staff are afforded significant flexibility in deciding what sort of documentation is sufficient for this threshold determination based on the availability of existing information and the difficulty of obtaining additional information. In any event, the record for a natural condition-based standard must include a compelling basis for a finding that the water quality criteria-based standards are being exceeded. In the event that an exceedance determination leads to the need to express a natural condition-based standard for use in a permit or other agency action or decision, site-specific water quality monitoring will be required.

2.1.2 Natural Condition Finding

The second step in implementing the natural condition-based standard provision is an analysis concluding in a finding that water quality criteria-based standard exceedances are the result of natural processes and not human activity in the watershed.

There remain in Alaska many watersheds that exist in a pristine state. In those cases, a natural condition finding is relatively easy to make based on the mere absence of human presence or development. A watershed need not be in a pristine state, however, to warrant a finding that water quality reflects the natural condition. In watersheds that are predominantly in a natural state, but include limited human activity, such as occasional personal or recreational use, or contain only minor human development, such as hiking trails or a small number of roads and road crossings that are not believed to contribute to the pollutant of concern, water quality may still reflect the natural condition. The "natural condition" is a relative concept that may include minor human activity or development but excludes watersheds with pervasive hydrologic or riparian changes.

In determining whether the quality of a waterbody reflects its natural condition, DEC staff will consider:

- The nature extent, and intensity of any human use and development within the watershed
- Whether human use and development is historic or continuing
- Whether the types of human use and development are generally known to affect the specific water quality parameters that fall outside of the water quality criteria-based standards
- Whether the quality of the subject waterbody is similar to that of other waterbodies known or believed to reflect a natural condition

A finding that the quality of a waterbody reflects its natural condition must include:

- An explanation of why human activities in a watershed are not directly or indirectly the cause of the exceedances of a water quality criteria for the pollutant of concern
- Evidence that there has been minimal human activity in the watershed that would affect the water quality parameter in question

- An explanation as to how natural processes are adequate to explain the observed exceedances of the water quality criteria for the pollutant of concern

2.1.3 Areal Extent Determination

With a determination that water quality criteria-based standards are being exceeded due to natural processes, the natural condition of a water becomes the water quality standard. The question then becomes, to what "water" does the standard apply?

The basis for the exceedance determination and natural condition finding may include information on only a single point in a waterbody, or on a number of points over an entire waterbody or within some portion of a waterbody. The essence of an areal extent determination is often a matter of integrating water quality information at one or more points with hydrologic information to reach a decision as to the area where natural conditions do not meet water quality criteria-based standards.

In some cases, it may be sufficient to determine that the natural condition-based standard only applies to a single point. For example, when a natural condition-based standard is established in conjunction with a discharge permit, it may be sufficient to establish that the standard applies at the point of discharge even if there is reason to believe that the standard extends to waters beyond that point.

In other cases, and for other purposes, DEC may determine that the natural condition-based standard applies to an entire waterbody or some portion of a surface waterbody or groundwater aquifer. In those cases, determining the water to which the standard applies may rest on measurements taken at points within the water along with hydrologic information suggesting that the measured water quality is likely to be indicative of the water quality over a greater area. In deciding the areal extent of a natural condition-based water quality standard, DEC staff will consider:

- Water quality information
- Groundwater and surface water influences including confluences of main stems and tributaries
- Other natural processes that affect water quality with distance

In deciding on the areal extent of a natural condition-based water quality standard, DEC staff should exercise care to limit the extent to those waters that are known or can clearly be expected to be of lesser quality than criteria-based standards. Care should also be taken to confine the areal extent of the natural condition-based standard to the watershed or other area where water quality has been found to be a product of natural processes.

In defining the extent of a natural condition-based water quality standard, DEC staff must include in the determination:

- A description of monitoring locations and available water quality data from each location considered in determining the areal extent of the standard
- An explanation of why the natural water quality is expected to be relatively consistent over the areal extent of the standard
- A clear description of the boundaries of the waters to which the natural condition-based standard applies

2.1.4 Expressing Natural Condition-Based Standards

It is often necessary to express the natural condition in terms that can be used in permits and in other agency decisions and actions. There are two approaches to establishing a natural condition-based water quality standard level: concurrent measurement and statistical characterization of a historic record.

The concurrent measurement approach is based on using a reference station such that the standard is equated to the measure of a parameter at the reference station at any given time. This approach does not demand a historic monitoring record. If feasible, the concurrent measurement approach is preferred to an approach based on statistical characterization of a historic record.

Statistical characterization of a historic record is used only when a concurrent monitoring approach is not practicable. This is most often the case where planned development or use of a watershed will mean that there is no reference point that can be relied on to reflect continuing natural conditions.

The two methods for expressing natural condition-based water quality standards are detailed in Sections 3.3 and 3.4.

2.1.5 Public Participation

Any time DEC finds that the natural condition comprises the water quality standard for a water, the public will be notified and afforded an opportunity to comment. It is important that DEC staff solicit and inform the agency's water quality standard decision with information held and provided by outside experts, persons with local knowledge, and the public at large.

Public notification, review and opportunity for comment may be conducted independently or as part of the public notice and comment process of an associated action, such as a permitting decision, a water quality standards triennial review, a 303(d) listing or a Total Maximum Daily Load (TMDL) development action.

When conducted as an independent action, proposed findings that a natural condition comprises the water quality standard for a water will be subject to public notice, comment and opportunity for hearing in substantial conformance with 18 AAC 15.050(a) and (b) and 18 AAC 15.060(b)-(h). A minimum of 30 days will be allowed for public comment.

When conducted as part of an associated action, proposed findings that a natural condition comprises the water quality standard for a water will be subject to the public notice and comment process of the associated action as long as the process affords the public notice and opportunity for comment at least as great as that called for by 18 AAC 15.050(a) and (b) and 18 AAC 15.060(b)-(h).

The public notice will include information on the waters to which the natural condition-based standard applies, a summary of the information supporting that the natural condition is the water quality standard, a summary of any information on how the standard will be expressed in narrative or numerical terms; and a description of how members of the public can obtain a copy of the detailed record.

2.1.6 Recordkeeping

DEC will establish a record for every finding that the natural condition is the water quality standard that includes the supporting documentation for the determinations and findings identified in parts 2.1.1 to 2.1.4 of this chapter, along with the technical analysis conducted in Chapters 3 and 4. DEC will maintain an official list of the waterbodies where natural condition-based standards have been found to apply, post the list on its website, and make the information available to the public upon request.

2.2 Appeals

DEC decisions that the natural condition comprises the water quality standard for a water are subject to both informal review under 18 AAC 15.185 as well as the provisions for adjudicatory hearing under 18 AAC 15.195 – 18 AAC 15.340.

2.3 Information Burden

The process to examine whether the natural condition represents the water quality standard for a waterbody or portion thereof may be initiated by DEC or requested by an applicant for a department authorization. When an applicant is seeking approval of a natural condition-based standard, it is incumbent on the applicant to provide all information that DEC requires to conduct the analysis and make the associated determinations and findings. DEC will process requests submitted by applicants in a timely manner.

2.4 Antidegradation Policy

The state water quality standard regulations include an "antidegradation policy" providing, in effect, that existing uses and the water quality to protect those uses must be maintained and protected, and that in cases where the natural water quality is better than that required by water quality criteria-based standards, the higher natural quality must be maintained and protected unless certain conditions are met.

Since the natural condition provision in the state water quality standards regulation and this implementation guidance do not allow degradation of natural water quality, decisions made in accordance with the regulation and guidance satisfy the antidegradation policy. DEC staff need not make a separate antidegradation finding.

3 CALCULATING NATURAL CONDITION-BASED STANDARDS

This chapter covers the methods that may be used to express a natural condition-based standard in terms that can be used in departmental authorizations and other decisions. Two methods may be used: *concurrent measurement* and *statistical characterization*. For either the concurrent measurement or the statistical characterization approach, correct interpretations concerning the natural condition-based standard at a site depend on several factors including:

- Proper selection of reference sites that represent natural background conditions
- Proper sample collection and accurate pollutant analyses, including adequate quality control documentation
- Appropriate statistical procedures to translate natural condition measurements to a water quality standard
- Use of Water Quality Data Elements to provide the definition and structure of data and metadata used to describe the results that characterize natural conditions (Methods and Data Comparability Board, 2006)

The following sections discuss recommended procedures for addressing the above factors.

3.1 Selection of Reference Sites

Both methods for expressing a natural condition-based standard rely on establishing reference water quality monitoring sites. In the context of this Guidance, a reference site is a site at which the concentration of a given analyte or pollutant is due solely to non-anthropogenic sources. These sites establish benchmark conditions within a particular region (Hughes et al., 1986; Hughes, 1995), representing the highest quality streams in which there has been little or no human activity of any kind since historic records have been kept. In both approaches in this Guidance, reference sites must be located upstream of the test site or within the same watershed.

There are a number of factors that should be considered in identifying reference sites for this Guidance, including similarity of aquatic life habitats, geomorphology, hydrology, elevation, and geology. It is critical that the reference site conditions are comparable to those at the test site of interest so that comparisons of pollutant concentrations are valid. In particular, it is helpful to understand the ultimate source of natural background levels of the pollutant of concern. For example, background levels of many metals in streams are often a function of the type of

geology and soils present, as well as flow regime and type of natural vegetation (e.g., Church et al., 1997). To the extent such information is known and documented, it is then easier to ensure that the reference site is comparable to the test site for purposes of identifying a natural background condition-based standard.
While Geospatial Information Systems (GIS) and remote sensing landscape tools are useful to help identify potential reference sites, a site reconnaissance may be conducted to help ensure that a proposed reference site meets minimum acceptability criteria. Those criteria are:

1. No channel or habitat modification
2. No logging, mining, intensive recreational uses (e.g., ski resort), farming, or livestock grazing
3. Few, if any, roads or bridges are present upstream of the site
4. No evidence of sources of sediment delivery that are associated with human disturbance
5. No water withdrawal structures, impoundments, or water return outfalls

In cases where historic monitoring data from a site are proposed for expressing a natural condition-based standard, and the site is no longer accessible or able to meet reference site acceptability criteria, then there must be documentation that the site did meet reference site criteria during the time data collection took place. This may be accomplished through the use of historic land use maps or other materials indicating the absence of human activity upstream of the site at the time. In some cases, it may be appropriate to compare data from proposed historical reference sites with data from known acceptable reference sites in the same region (preferably the same watershed) to help determine whether the historic data are likely to reflect natural, non-human-influenced conditions. In addition, it is important that the quality of historic data meets data quality objectives (DQOs) as discussed below.

Some variability in pollutant concentration is likely to be naturally present, even among similar sites on the same stream at the same time. Therefore, for either the concurrent measurement or the statistical characterization approach, it is desirable to collect data for more than one reference site, if available. Concentrations of contaminants as a function of water depth should also be considered in waterbodies such as lakes, estuaries, or large rivers. Each reference site must be comparable in geology, hydrology, and elevation to each other and to the test site, and each site must meet the acceptability criteria as outlined above. It is essential to fully characterize each reference site so that the variability in analyte concentration, and therefore, natural background conditions, can be determined accurately.

3.1.1 Required Documentation

Any site proposed as a reference site under this Guidance should have the following documentation:

- A map showing reference site(s) locations in relation to test site of interest, along with available land cover information
- Reference site and test site elevation
- Available geology and soil information for reference and test sites
- Photographs showing reference site riparian vegetation, waterbody size and channel morphology
- Site reconnaissance survey data regarding presence of roads, any channel modifications, outfalls, or other human-made structures
- Records from relevant state or federal agencies indicating no known mining, forestry, or other human activities upstream of the proposed reference site

DEC will review the documentation to determine if the proposed site can be used as a reference site for determining a natural condition water quality standard.

3.2 Data Quality

3.2.1 Data Quality Objectives

DQOs are the quantitative and qualitative terms used to describe how good the data needs to be in order to meet the project's objectives. In this Guidance, critical DQOs include assurance that: (1) samples collected are representative of true natural conditions, and (2) data are an accurate reflection of the samples collected. DQOs for measurement data (also known as data quality indicators) are precision, accuracy, representativeness, completeness, and comparability. The overall quality assurance objective for analytical data is to ensure that data of known and acceptable quality are provided, thereby assuring that the data are comparable.

For quantitative projects, such as determining natural conditions of water quality parameters, DQOs must address uncertainty in results due to unknown environmental characteristics that will be estimated from collecting the data, as well as analytical method sources of variability. This Guidance presumes that all sites should meet DEC water quality standards under natural conditions unless the need for site-specific natural condition-based standards is proven. Therefore, DQOs for determining the natural condition with respect to a chemical or other constituents are predicated on documenting the natural variability in concentration based on observed data (whether a historical record or newly collected data).

Organizations collecting data to assess natural conditions must operate in a manner that is consistent with the requirements of the Water Programs Quality Assurance Management Plan and the Generic Quality Assurance Project Plan for Water Program Staff, Sampling and Analysis Activities developed by the Alaska DEC, Division of Water. They can be located at:
http://www.dec.state.ak.us/water/wqapp/Water%20Program%20Quality%20Management%20Plan2Rev.4Feb%2004.pdf and
http://www.dec.state.ak.us/water/wqsar/pdfs/qualityassproplan-generic.pdf

DQOs and data quality indicators for proposed natural condition standards must comply with these documents. After DQOs are established, Measurement Quality Objectives (MQOs) are established that must be met in order for the data to be useable in determining natural conditions, whether based on historical or newly collected data. MQOs are statements that contain specific units of measure such as percent recovery, percent relative standard deviation, and detection levels or quantification limits (minimum reporting limits).

Details of the required analytical methods, MQOs, and sample collection methods (sampling containers, preservation, volumes, and holding times) are specified in Table 1 of the Generic Quality Assurance Project Plan cited above. For parameters not listed in this table, see 40 CFR 136.3 for United States Environmental Protection Agency (USEPA) approved methods, minimum detection levels, and other analyte-specific requirements. Appendix A discusses other methodological and data quality issues that should also be considered. All natural condition-based standards determinations that rely on new data collection must use a Quality Assurance Project Plan (QAPP), approved by DEC, to ensure that proper data are collected.

3.2.2 Detection and Quantitation Limits

Any measurement method has an inherent limit of detection that is based on the sampling and analytical methods used and the parameters of interest. Methods applied to determining natural conditions must have detection and quantitation limits low enough so that the applicable state water quality standard can be reported with a high level of confidence for any given analyte. Detection limits allow the determination of the presence of an analyte with a high level of confidence, whereas the quantitation limit allows one to report both the presence and concentration of the analyte with confidence (see Appendix A).

3.2.3 Treatment of Outliers

Environmental data sets frequently contain outliers, which are observations that appear not to conform to the pattern established by other observations. Some outliers may represent valid data, while others may reflect data errors. High outliers are of concern in both approaches, therefore, initial screening should examine data for the potential presence of high outliers. This can be done visually or through use of a more formal test such as that of Rosner (1983; see also Gilbert, 1987). It is important to note that outliers are not deleted at this stage; they are merely flagged and reported as potential outliers.

If data are flagged as high outliers, those observations should be reviewed for obvious errors, such as transcription or data coding errors, instrument malfunction, and calibration problems. Where evidence is available to document such errors, the outlier should be replaced with the correct value and the change documented. Observations for which the quality control record indicates equipment failure, sample contamination, or inadequate calibration (as defined in the QAPP) should be eliminated from the dataset. All such modifications must be documented.

Apparent outliers that are not eliminated because of obvious data errors may or may not represent valid data and should be retained. In cases where apparent high outliers are retained in the statistical characterization approach, and are believed to unduly influence results, DEC may, at its discretion, require re-analysis with the questionable observation(s) deleted.

3.3 Concurrent Measurement Approach

The concurrent measurement approach relies on using a reference station such that the water quality standards for one or more parameters for a waterbody or some portion of a waterbody are equated to actual measurements of those parameters at a reference station at any given time. When practicable, this approach is preferred to an approach based on statistical characterization of a historic record. It has particular applicability in establishing discharge permit limits. When concurrent measurements are used, water quality-based effluent limits incorporating the standard as measured at the reference station work together with monitoring requirements calling for concurrent measurement at both the reference point and the discharge point.

A simple scenario would be a proposed discharge to a stream. Assuming that water quality above the discharge point is found to represent a natural condition, an upstream reference station is established (using the criteria described in Section 3.1) to serve as the basis for a natural condition-based standard for a uniform reach of the stream that includes the proposed discharge point. The permit for the discharge is drafted such that the water quality-based effluent limit for the parameter(s) of concern is the level of that parameter at the reference station (the natural condition-based water quality standard) measured concurrently with a measurement at the discharge point. Concurrent measurement is specified as a permit monitoring condition.

The concurrent measurement approach can also be used in marine waters and lakes. In those situations, multiple reference stations may be needed to establish the natural condition with sufficient certainty.

When the effluent concentration is less than or equal to the concurrent reference site measurement (and data quality requirements have been met), the discharge will be deemed to be in compliance with the natural condition-based water quality standard.

In applying the concurrent measurement approach, all data quality requirements discussed in Section 3.2 apply. Specifically, it is critical that the discharger document accurate and representative sample collection and adequate quality control concerning measurements. It is particularly important to obtain representative samples at the reference and effluent sites (see Section 3.1).

In some cases, effluent concentrations may be close to natural conditions but exceed concentrations measured at the concurrent reference site. This may or may not constitute an actual excursion of natural conditions. Natural short-term variability in concentrations, variability in sampling, and uncertainty in analytical results may all contribute to such differences even when the effluent is of the same quality as the upstream reference water. To address this issue, all applications of the concurrent measurement approach should include duplicate analyses to establish method precision. Replicate samples from both the reference site and effluent are used to establish levels of uncertainty associated with sampling (see Appendix B for statistical analyses for the Concurrent Measurement Approach and Appendix E for an example). The average of the replicates is used to determine the concurrent upstream and effluent concentrations.

The objective of effluent discharge permit conditions is to ensure that water quality standards are met with a reasonable degree of assurance. Therefore, any situations in which the effluent concentration is persistently above the concurrent reference site measurement by any amount can also be deemed a violation of the natural condition-based water quality standard. Definition of a persistent excursion will be determined on a site-specific basis by DEC and incorporated into permit conditions. In general, the following situations would constitute persistent excursions:

- The effluent concentration is greater than the target concurrent reference concentration (where the target concentration is the larger of the concurrent reference concentration and the water quality criteria-based water quality standard) by any amount on three consecutive measurements or
- The average difference between the effluent concentration and the target concentration (where the target concentration is the larger of the concurrent reference concentration and the water quality criteria-based water quality standard) is greater than zero when evaluated over the previous 12 months or other appropriate time basis.

3.4 Statistical Characterization Approach

It is anticipated that natural condition-based water quality standards will be used most frequently to supersede water quality criteria for aquatic life uses. Accordingly, this section is focused on statistical characterization that will provide estimates of the chronic and acute exposure of aquatic life under the natural condition of a waterbody that can be implemented in place of aquatic life criteria. Use of the statistical characterization approach to develop permit limits in these cases is presented in Section 4.3.2. All of the statistical procedures described in this section are also applicable to the characterization of natural background conditions for pollutants that are of concern for the protection of human health. Application of the resulting natural condition-based water quality standard to permitting does, however, differ when setting permit limits to minimize the risk of the natural condition to human health and is described separately in Section 4.3.3.

A water quality standard based on natural conditions differs from typical toxicologically based aquatic life criteria in that the natural conditions are not constant. They tend to vary in time, and their magnitude may have a systematic relationship to other natural factors, such as flow, temperature, or time of year. The fact that the site-specific standard is variable in time, means that the analysis proceeds on a statistical basis rather than through comparison to a fixed number. Two of the essential characteristics of the natural conditions at a site are, in statistical terms, a measure of the central tendency of the natural concentrations (for example, the average concentration) and a measure of the natural variability in the concentration (for example, upper and lower 90th percentiles of the distribution). The statistical characterization approach makes use of these statistical properties of the data to derive both a natural condition-based standard and effluent limits, using an approach similar to that discussed in EPA's *Technical Support Document for Water Quality-Based Toxics Control* (EPA, 1991).

Statistical characterization of natural conditions may be based either on historical data or on data obtained from a suitable reference site (see Section 3.1). Most of the statistical characterization approach discussed below is applicable to both types of data. The primary difference is that collection of new reference site data allows use of a DQOs process to plan for efficient data collection.

The following two sections summarize the statistical characterization requirements. The characterization is broken into two major sequential parts. The first is data assembly and review, and the second is statistical analysis. Details of this approach are included in Appendix C.

3.4.1 Data Assembly

> **Data Needs for Statistical Characterization**
>
> A minimum of 20 quality-assured samples collected over at least two years with a limited number of non-detect values.

The data assembly step involves collection and review of the data, to determine whether the data are of sufficient quantity and quality to justify a natural conditions analysis. Certain minimum data requirements are specified to ensure that the statistical characterization approach to natural condition-based water quality standards is appropriate. Not only must the number of data points meet a minimum threshold, the quality of the data must also be assured.

The general steps in the data assembly task are summarized in Figure 2. This applies to both calculation from historical data and calculation from new data, with minor differences.

3.4.2 Data Quantity

Data sets to be used for the statistical characterization approach must include at least 20 valid data points (see Section 3.4.3), preferably obtained over at least a three-year period. Data from multiple years is recommended to help guard against anomalous environmental conditions (extremely wet or dry years), as well as ensuring that unidentified anthropogenic impacts are likely to be detected. Two years of data may be acceptable if there are at least 20 valid samples and the variability appears to be well-characterized; less than two years of data are unacceptable using this approach. For determinations that include the collection of new data, the sample size should be optimized to meet DQOs based on the expected degree of variability in measurements. See Appendix C for statistical methods to calculate sample size in these cases.

3.4.3 Data Quality

Valid data includes only those data that meet MQOs (see Section 3.2 and Appendix A), and any data points that lack adequate quality control are not included in the analysis. In addition, acceptable datasets should have 20% or less frequency of non-detects (as determined from the complete data set after removing any samples flagged as potentially contaminated). Large numbers of non-detects would indicate that the standard is often met and also make it impossible to evaluate the true mean with precision. For that reason, data sets that contain large numbers of non-detects are inappropriate for natural conditions determinations using the statistical characterization approach. It may be possible to assemble a dataset that is acceptable for a seasonal determination if the non-detects are clustered in one season; however, such a determination would only be applicable to that season. If method detection limits

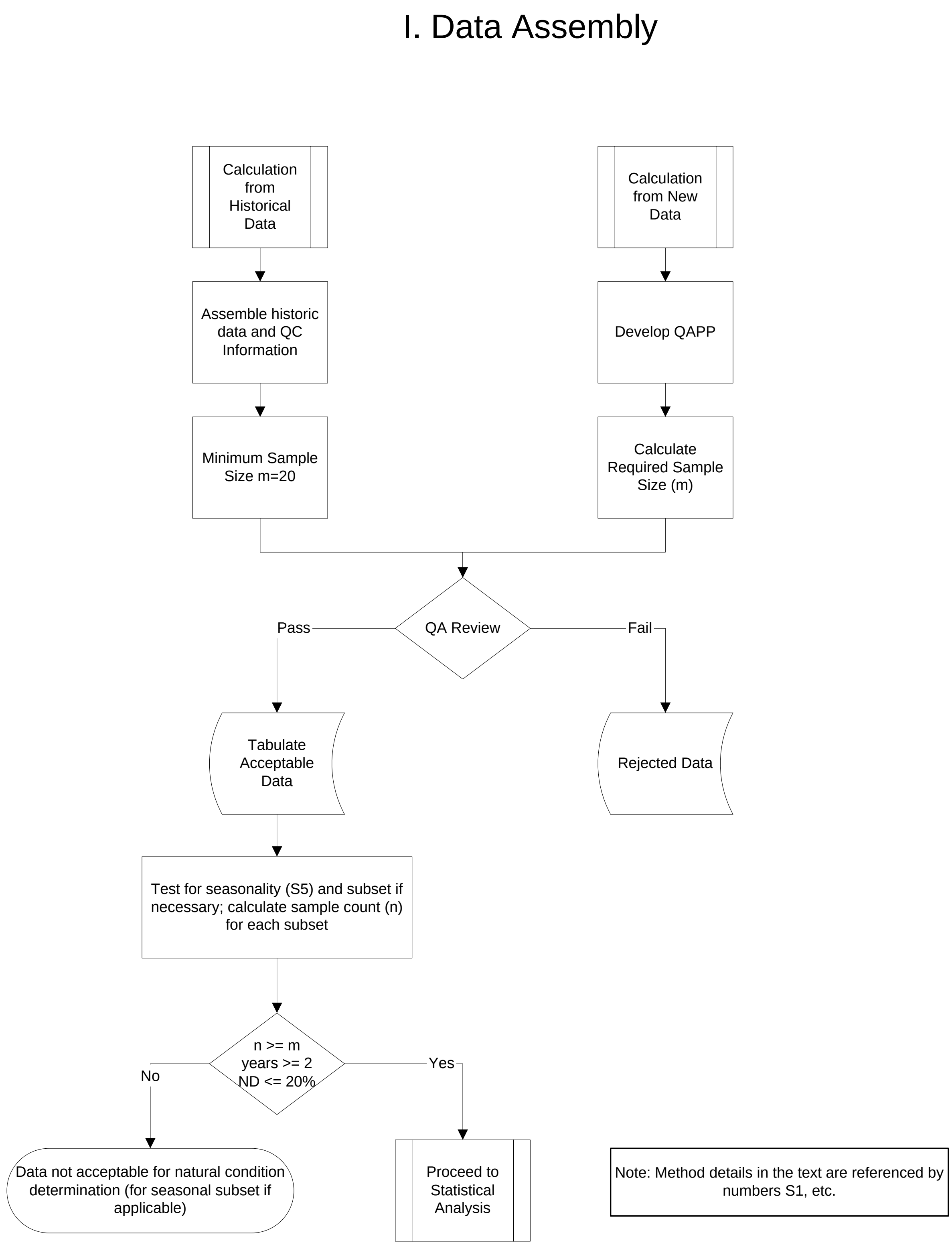


Figure 2. Data Assembly Step

changed during the course of monitoring, a subset of the data may be created by eliminating *all* monitoring data obtained at higher detection limits; however, the subset data must still meet minimum sample size requirements as discussed in the next section.

Once the data are assembled, a test should be undertaken to determine if separate analyses by season are warranted (as described in Section 3.4.5). If separate seasonal determinations are indicated, the sample size requirements apply to each individual season for which a natural conditions determination is sought.

At the bottom of Figure 2, a test is applied for adequate sample size. If the sample size *n* is greater than the minimum requirement *m*, at least two years of sampling are included, and the fraction of non-detects is less than or equal to 20 percent, it is permissible to proceed to statistical analysis to determine a natural condition-based water quality standard. (This determination is made on a seasonal basis if seasonal analysis is indicated – see Section 3.4.5.) If any of the three conditions are not met (either in general, or for specific seasons where seasonal analysis is indicated by the analysis described in Section 3.4.5), then a natural background condition standard cannot be developed.

3.4.4 Statistical Analysis

Where data are sufficient for a natural background determination (either in general or by season), statistical analyses are undertaken to estimate confidence limits on the average and upper quantile of the natural background concentration distribution. Lower confidence limits are used to help ensure that the analysis is protective.

Statistical Analyses

Measures of central tendency (such as the mean) and the spread of concentrations are used to define natural conditions. Statistical lower-bound confidence limits are applied to ensure that results are appropriate. The specific statistical tests required vary according to the characteristics of the data.

The general outline of tasks for statistical analysis is shown in Figure 3. The left hand side of the figure addresses determination of the central tendency of the data, while the right hand side addresses determination of the upper range. Details of specific statistical methods are presented in Appendix C.

3.4.4.1 Estimation of Central Tendency

In applying a potential site-specific standard based on natural conditions to effluent permitting, one relevant estimate is the long-term central tendency or average concentration (annual or seasonal, as appropriate). While confidence limits on the mean are relatively robust against small deviations from normal distribution assumptions, estimation of confidence limits is sensitive to non-normal distribution of the data and the presence of non-detects. Therefore, confidence limits are estimated only after steps are taken to address non-detects and potential data transformations.

II. Statistical Analysis

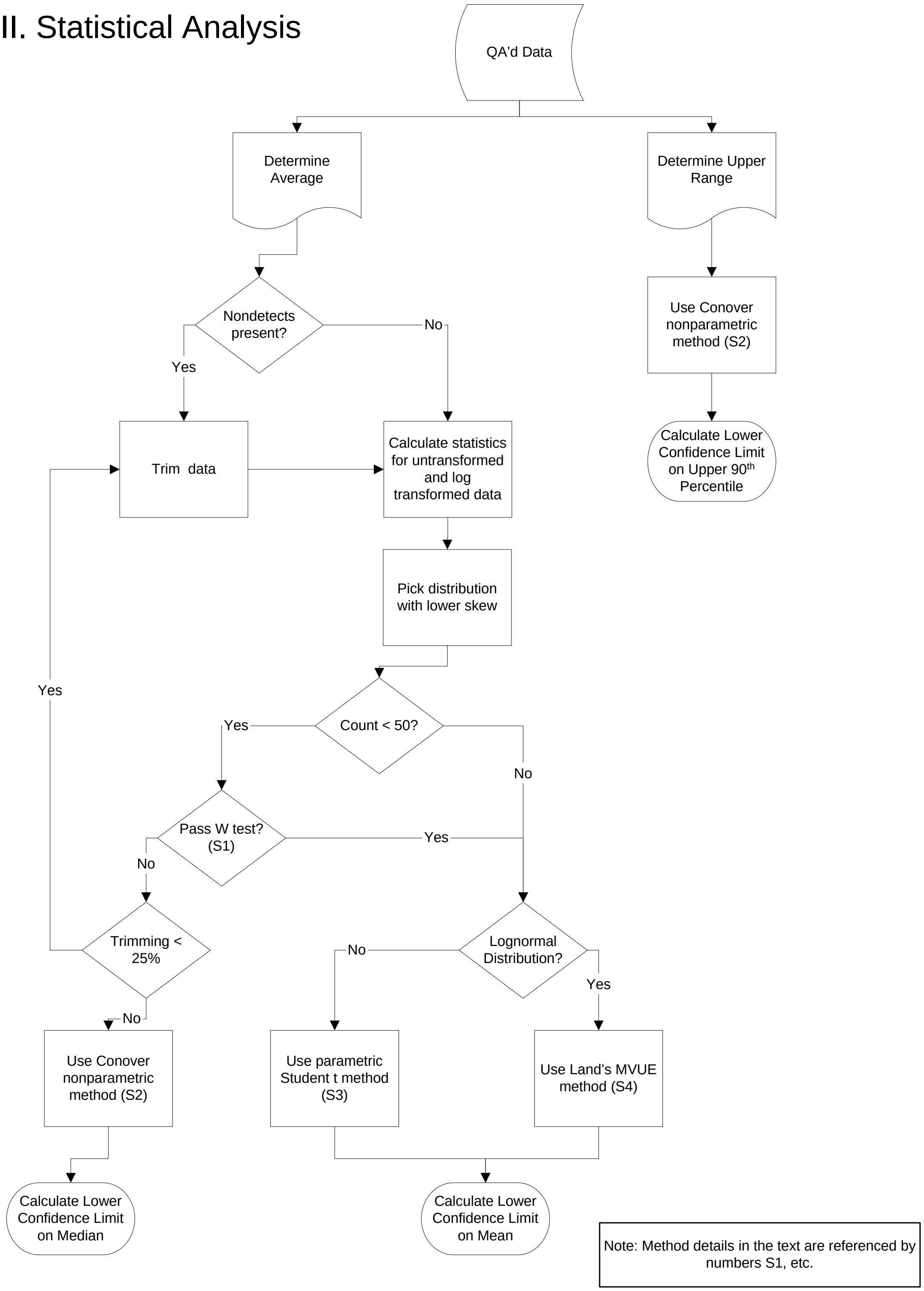


Figure 3. **Statistical Analyses for Natural Background Determination. Note that discussion of methods related to S1, S2, S3, and S4 are in Appendix C.**

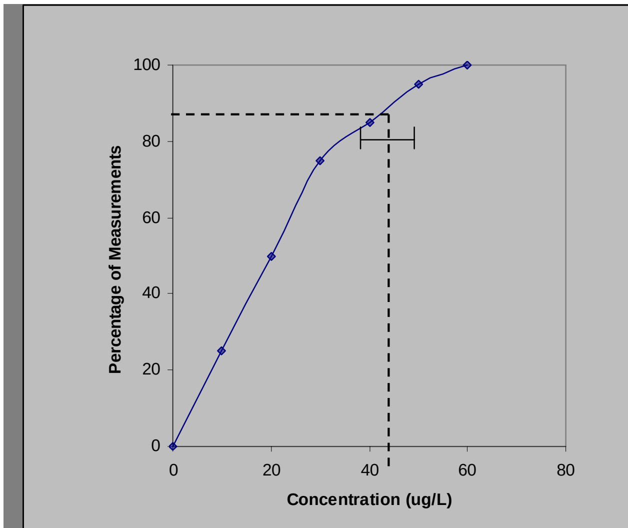
The first step addresses non-detects and infrequent measurements of an unusually high concentration (i.e., outliers) that are not representative of the natural background condition. To deal with non-detects and guard against undue influence from outliers, this approach creates a "trimmed" dataset in which the non-detects and an equal number of high values are removed (with the proviso, given above, that only up to 20 percent of observations may be non-detects in a dataset suitable for natural conditions determination). While methods exist to create values for non-detects, these should not be used for statistical characterization of natural conditions because (1) results will differ depending on the method used to impute values, (2) methods depend on the assumption of the form of the distribution of the data, which will rarely be exactly met, and (3) some observations reported as non-detects may actually be invalid data that result from failure of analytical methods that has not been flagged by data quality control activities. A major objective of the statistical characterization is to obtain a reliable estimate of the central tendency of the natural conditions data and its uncertainty bounds. Therefore, it is preferable to use the trimmed dataset approach, which helps guard against these problems.

The trimmed dataset is used to calculate the mean, standard deviation, and skew (departure from a normal distribution) for both the raw data and log-transformed data. Many environmental data series will follow approximately lognormal distributions. The strategy taken is therefore to initially choose between the normal and log-transformed normal distribution, selecting the option that has the lower coefficient of skew (and thus better approximates a symmetric, normal distribution). If an acceptable fit to a normal or lognormal distribution is not attained, the method uses a more conservative estimate of central tendency based on the median or 50th percentile. Appendix C discusses detailed procedures to determine confidence limits for the measure of central tendency used in the statistical characterization approach.

3.4.4.2 Estimation of Upper Range

An estimate of the upper range of the natural condition concentration is needed to assess the maximum concentration that is consistent with natural conditions. This is used in two ways: first, to help define acceptable daily maximum effluent loads (comparable to the use of an acute criterion for toxics), and second to provide a point of comparison for water quality assessments. This approach determines the upper range based on calculations of a high percentile of the data (i.e., a reasonably high value that occurs with some frequency) for use in connection with effluent limit determinations. Specifically, this approach recommends setting the upper range estimate at the 95-percent *lower* confidence interval on the estimated 90th percentile of the natural conditions distribution.

The upper range estimate should not be construed as a never-to-exceed value. Indeed, the method is designed to ensure that at least 10 percent of observations will be greater than the upper range estimate (at a 95-percent probability value). This upper range estimate provides a checkpoint for flagging observations that may warrant further investigation. Individual observations that fall below the conservative upper range estimate can be considered as consistent with the natural conditions distribution and are thus not, on an individual basis, indicators of persistent exceedances.



Percentiles

The statistical approach makes use of percentile data and confidence limits around a given percentile. Percentiles are calculated from measurements observed over time for a given site. The graph shows the cumulative percentage of measurements in relation to concentration. The dashed line shows that 90 percent of the data (i.e., the 90th percentile) had less than or equal to about 45 µg/L of the pollutant. The bracket around the dashed line represents 95 percent confidence intervals around the 90th percentile value.

3.4.4.3 The Natural Condition-Based Water Quality Standard

The natural condition is not a single, constant number; rather it is a distribution of concentrations that naturally varies over time. Therefore, the natural condition-based water quality standard is defined in terms of a statistical distribution characterized by a measure of central tendency and a measure of upper range (i.e., 90th percentile). These values are selected as lower confidence intervals, which acknowledges the uncertainty inherent in monitoring data and ensures that decisions based on the natural condition-based water quality standard are consistent with the maintenance and protection of natural water quality. Methods of estimating the central tendency and upper range measures are described in detail to ensure that determinations are both accurate and reproducible. Appendix D provides examples for calculating the natural condition standard using the approach discussed above.

3.4.5 Seasonal Expressions

Natural condition-based water quality standards may be expressed on a full year basis or on a separate basis for different seasons. In many cases, full-year (annual) expressions will be preferable because they: (1) are easier to develop and implement, and (2) allow use of the maximum number of available samples in calculations, which will tend to reduce the uncertainty. Nonetheless, there are situations in which seasonal expressions are necessary and appropriate. One situation is when the natural conditions differ significantly between seasons. In such cases, assigning a single, annual value may not be protective of existing aquatic life in the waterbody during the period in which natural conditions represent a lower concentration. Another situation is when data are available from only one season. In such a case, it is appropriate to assume that the water quality criteria set out in 18 AAC 70.020(b) apply to unmonitored seasons by default.

If a natural condition varies substantially and predictably with time, the natural condition should be expressed differently for annual, seasonal, or shorter time periods to protect water quality. Temporal shifts in water quality that should be considered include:

- High and low flows
- Seasonal variations in gaining or losing flow
- Seasonal variation in current patterns
- Seasonal thermal stratification in lakes and estuaries
- Winter and summer conditions
- Ice coverage
- Storm events

Many Alaskan waterbodies may be expected to exhibit differences in natural conditions between two seasons, loosely defined as the "winter" period of colder weather, characterized by lower flows and lower sediment loads, and the "summer" period of warmer weather, characterized by higher flows and higher sediment loads.

Deciding whether seasonal characterization of natural conditions is appropriate involves both statistical evidence and best professional judgment that takes into account both observed or predicted variability in concentrations and the seasonal sensitivity of aquatic life. In most cases in which the analysis is based on historical data, it is anticipated that the number of data will not be sufficient to examine more than a few seasonal divisions. Where new data are collected from a reference site, the DQOs should address the potential need to evaluate specific seasons that are expected to differ in quality or have more sensitive conditions, such as spawning, juvenile aquatic life stages or the presence of sensitive species.

If natural condition-based water quality standards are to be expressed for individual seasons, sample size requirements must be met for each season, as discussed below. The statistical characterization approach prescribes one general test for seasonal differences that will be applied to all data sets. Additional tests may be required by the DEC based on site-specific conditions. The general test for seasonality to be conducted during seasonal characterization is indicated on the data assembly flowchart (Figure 2) in Section 3.4.1 and in Appendix C.

4 USING NATURAL CONDITION-BASED STANDARDS IN AGENCY DECISION MAKING

Natural condition-based water quality standards serve the same purposes as criteria-based standards. Whether criteria-based or natural condition-based, water quality standards are often used by DEC as the basis for making decisions on whether the quality of surface waterbodies has been impaired to the point that corrective action is needed, allowable pollutant loads, and pollutant levels allowed by permits and other authorizations. This chapter explores the use of natural condition-based standards for three of the more common water quality-based decisions the agency makes.

4.1 303(d) Listing and Delisting

Under Section 303(d) of the Clean Water Act, states are required to develop lists of impaired waters. These impaired waters are surface waterbodies that do not meet the water quality standards.

Natural condition-based water quality standards can be used to support adding waterbodies to the state 303(d) list or removing waterbodies from the list. In instances where waterbodies have been included on the 303(d) list due to exceedances of criteria-based standards and there is evidence that their inclusion may be a result of natural conditions, DEC may initiate the analysis set out in the previous chapter to determine whether a natural condition-based standard applies. If the analysis finds that the natural condition provision does apply, that may be a basis for revising a decision as to whether the waterbody should be included on the list.

4.2 Total Maximum Daily Loads

A Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDLs are required for waterbodies that do not meet state water quality standards for a specific pollutant. Usually these waterbodies have been identified on the state's 303(d) list of impaired waterbodies.

TMDLs identify the links between water quality impairment, the causes of the impairment, and the pollutant reduction measures needed to achieve the state's water quality standards. TMDLs include a margin of safety to ensure that the waterbody can be used for the purposes the state has designated.

There are several instances where natural condition based-standards can play a role in TMDL development and implementation:

- Calculating site-specific waterbody recovery goals and TMDL targets
- Calculating that portion of a pollutant load derived from naturally occurring conditions
- Establishing natural conditions when the applicable state water quality criterion allows for a specified increase over natural background

- Establishing natural conditions when the natural background is used in determining the TMDL target for other parameters

4.3 Discharge Authorizations

4.3.1 Authorizations Based on Concurrent Monitoring

The basis for using a natural condition-based standard based on concurrent monitoring in a discharge authorization is establishing an effluent limit for one or more parameters as the measured level of the parameter(s) at a reference point. The effluent limit is expressed as the concurrent measurement of the parameter at the reference point. Compliance is determined by comparing the measured parameter in the discharge with the measurement at the reference point.

> **Permit Limits**
>
> Permit limits are established to ensure compliance with the natural condition-based water quality standard. These will consist of an Average Monthly Load (AML) and a Maximum Daily Load (MDL). The AML is established based on the lower confidence limit on the mean (or other measure of central tendency) and range of natural conditions developed in the statistical analyses. Procedures for developing and implementing the AML and MDL include a standard option and an alternative option. The alternative option is based on the distribution of natural condition concentrations rather than a fixed load.

The authorization's monitoring requirements will call for concurrent measurement of the parameter(s) at the reference location and in the discharge. Ideally concurrent measurements are not necessarily taken at exactly the same time. In dealing with flowing water, the aim should be to sample the same volume of water at the reference point and at the discharge point taking into account travel time. In water that is not moving, true concurrent sampling may be the objective. In both cases, however, these ideal sample timing objectives will often need to be tempered with practical considerations including the logistics involved in monitoring or sample collection. As a general rule, the timing of "concurrent" monitoring of parameters that vary slowly with time can deviate more from the ideal than for parameters that vary sharply with time. Decisions as to what is a protective yet practicable protocol for collection of concurrent samples will often necessarily involve site-specific considerations.

4.3.2 Authorizations Based on Statistical Characterization: Ambient Aquatic Life

Statistical characterization of natural condition-based water quality standards is fully consistent with a statistically based approach to discharge authorizations and effluent limitations. In typical water quality-based permitting, the wasteload allocation (WLA) is derived to ensure compliance with a toxicologically based aquatic life water quality criterion (EPA, 1991). Next, a long-term average effluent load (LTA) is calculated that is consistent with achieving the WLA at an acceptably low frequency of excursion. For design and compliance purposes, upper limits are then calculated for observed effluent quality: specifically an effluent maximum daily load

(MDL) and an average monthly load (AML) (both lower than the WLA and typically greater than the LTA) to ensure that the WLA is met with a high degree of assurance.

The statistical values that characterize the distribution of ambient water quality in a natural condition (i.e. the central tendency and the lower confidence limit of the 90^{th} percentile) are used in place of water quality criteria to derive the permit limits. However, the natural condition statistics are not toxicologically based water quality criteria since they are derived using a different methodology. Nevertheless, these natural condition statistics estimate the chronic and acute exposure levels found in the natural condition of the waterbody and so are appropriate substitutes for acute and chronic aquatic life criteria when deriving permit limits.

For natural condition-based permits, the standard is not a fixed value. As summarized in Section 3.4 and detailed in Appendix C the natural condition is characterized statistically, including a measure of central tendency and confidence limits. The confidence limits on this central tendency reflect uncertainty in the characterization of natural conditions, rather than effluent variability. It is still a not-to-exceed value, but one that is not explicitly based in a criterion averaging period (which results in some differences in permit calculation procedures). Further, even though this value is not to be exceeded as an average, it is still permissible that it be exceeded in individual samples.

This type of approach is conceptually similar to that described in USEPA (1991) in the section for "Permit Limit Derivation from Dynamic Model Outputs" (p. 101), with observations of natural condition substituted for model output. In deriving permits from dynamic models, "The WLA is first developed by iteratively running the dynamic model with successively lower LTAs until the model shows compliance with the water quality standards." In the natural conditions case, the natural condition is the default condition of compliance with (site-specific) water quality standards. The WLA is the amount of loading that does not change the natural condition - because the effluent concentration is the same or less than expected under natural conditions. That is, if we maintain natural conditions then the standard is, by definition, met.

In contrast to a modeling approach, it is not possible to work directly with 1-day and 4-day averages and their recurrence frequency for natural conditions analysis because only limited sampling will be available. However, it is conservative to assume that the overall average implied by the confidence limit on the central tendency of natural conditions should be met as a 4-day (chronic) average, in which case the chronic LTA or LTA_C is calculated from the lower confidence limit on the mean (incorporated as the WLA_C) as described in USEPA (1991; p. 102). Similarly, an acute WLA (WLA_A) is developed from the lower confidence limit on an upper percentile of the natural conditions data. In essence, the lower confidence limits on the mean and upper percentile of natural conditions become the natural condition-based water quality standard for the site (if they are higher than the applicable published water quality criteria-based water quality standard). Such an approach is protective of the natural water quality because lower confidence limits are used. Details of the calculations used to derive effluent limits based on a statistical approach natural background standard are included in Appendix D.

The AML and MDL, calculated using the method in USEPA (1991) are most appropriate for authorization of controlled process discharges from industrial facilities and wastewater treatment plants. For some types of discharges, there is little process control, leading to greater variability and occasional extreme values that are not consistent with the lognormal assumptions for effluent concentrations used in USEPA (1991). In such cases, the discharge may still be consistent with natural conditions, but an alternative method to the lognormal basis AML and MDL for assessing compliance may be needed.

An alternative for assessing compliance with the daily maximum, applicable at the discretion of DEC, is to not exceed the percentiles of the natural condition distribution (estimated at the lower confidence limits). In this approach, the alternative MDL (MDL-A) is assigned based on the concentration estimate for the lower 95 percent confidence limit on the upper 95^{th} percentile of the natural conditions distribution (using method S2 in Appendix C). Because this is a less restrictive limit than the MDL recommended by USEPA (1991), an additional test for compliance monitoring is added. This specifies that compliance will be assessed on a rolling average or control chart basis by requiring that the maximum effluent concentration (or its associated load) should not exceed the lower confidence limit on the 90^{th} percentile of the natural condition distribution (calculated using method S2 in Appendix C) more than 10 percent of the time (as evaluated over data from a preceding time period to be determined by DEC). The analysis would still be protective because a lower confidence limit is used, ensuring that the effluent discharge remains less than the natural condition. Application of the alternate method for the MDL is shown in several examples in Appendix D.

To establish permit effluent limitations, calculations proceed in the manner specified in USEPA (1991), using the coefficient of variation (CV) of the effluent itself as a basis for evaluating the not-to-exceed values. However, an alternative method is provided for evaluating the MDL in certain cases.

Standard calculations for permit limits will proceed as follows, consistent with USEPA (1991):

1. Use the lower confidence limit on the mean concentration of the natural condition (or the statewide chronic aquatic life criterion if higher) and the permitted effluent flow to establish the chronic WLA (WLA_C) in lb/d unit or other appropriate units for the pollutant of concern (e.g., thermal load).

2. Use the lower confidence limit on the 90th percentile of the natural condition concentration distribution (or the statewide acute aquatic life criterion if higher) and the permitted effluent flow to establish the acute WLA (WLA_A) in lb/d units.

3. Calculate the acute LTA (LTA_A) at the 99^{th} percentile level from WLA_A using Table 5-1 in USEPA (1991), where
$LTA_A = WLA_A \cdot \exp\left[\sigma^2/2 - 2.326\,\sigma\right]$ and $\sigma^2 = \ln\left[CV^2 + 1\right]$.

4. Calculate the chronic LTA (LTA_C) at the 99th percentile level from WLA_C using Table 5-1 in USEPA (1991), where
$$LTA_C = WLA_C \cdot \exp\left[{\sigma_4}^2/2 - 2.326\sigma_4\right] \text{ and } {\sigma_4}^2 = \ln\left[CV^2/4 + 1\right].$$

5. Set the LTA to the more restrictive of LTA_A and LTA_C from steps 3 and 4.

6. Use the LTA value established in step 5 and the appropriate multiplier (EPA, 1991, Table 5-2) to calculate the AML (lb/d) at the 95th percentile on the basis of *n* samples per month:
$$AML = LTA \cdot \exp\left[1.645 \cdot \sigma_n - {\sigma_n}^2/2\right] \text{ and } {\sigma_n}^2 = \ln\left[CV^2/n + 1\right].$$

7. Calculate the LTA value established in step 5 to calculate the standard MDL (lb/d) at the 99th percentile (EPA, 1991, Table 5-2):
$$MDL = LTA \cdot \exp\left[2.326 \cdot \sigma - \sigma^2/2\right] \text{ and } \sigma^2 = \ln\left[CV^2 + 1\right].$$

An alternative is also allowed for the AML. For the average load, the procedures for calculation of the LTA given above remain valid and the AML calculated above will still be used as a basis for evaluating design specifications; however, an alternative for assessing compliance with the AML may be adopted at the discretion of DEC. This alternative approach to compliance is evaluated on a rolling average or control chart basis by requiring that the rolling average effluent concentration (or its associated load) should not exceed the lower confidence limit on the mean of the natural condition data (as calculated using method S3 or S4 in Appendix C as appropriate) more than 50 percent of the time (as evaluated over a preceding time period to be determined by DEC). In addition, no individual monitored monthly average load should exceed the value of an alternative AML (AML-A) calculated with the best estimate of the mean concentration and 90th percentile (rather than the lower confidence limits) in Steps 1 through 6 in Appendix C. Compliance with the MDL (or its alternative given above) would also need to be maintained. This alternative approach to the AML would still be protective of the LTA because a lower confidence limit is used as the target for the rolling average.

4.3.3 Authorizations Based on Statistical Characterization: Human Health

In certain cases, DEC may use a statistical characterization of natural condition to establish discharge authorizations for the protection of human health. Permitting for human health protection can use as input the same type of statistical characterization of natural conditions as is used for authorizations based on natural condition that protect existing aquatic life. The permit limits calculated using this method will pose no greater risk to human health than the pre-existing natural condition of the waterbody. However, the application of natural condition statistics to the permitting process will differ from the methods used to derive aquatic life based permit limits.

As noted in Section 1.3, a natural condition-based standard is not appropriate for human-created (non-natural) substances such as PCBs or pesticides. Other naturally occurring pollutants regulated for the protection of human health encompass a variety of situations and exposure routes, including naturally occurring toxins ingested in drinking water (e.g., metals), pathogens in drinking water or shellfish (e.g., fecal coliform bacteria), and naturally occurring toxins that bioaccumulate in fish and shellfish (e.g., mercury).

Where natural conditions are documented to exceed the water quality criteria established for the protection of human health, DEC may implement a natural conditions-based water quality standard to ensure that further degradation of the human health use does not occur. Methods for calculating effluent limits for human health protection are detailed in Appendix C.

In the case of a pollutant for which a natural condition-based standard (or a combination of natural condition-based standard and water quality criteria) for both the protection of human health and the protection of aquatic life apply, permit limits will be calculated by both the aquatic life and human health procedures. The more stringent limits calculated by the two procedures will then apply.

4.3.4 Mixing Zones

A mixing zone associated with an authorized discharge is an area within a waterbody where state water quality standards can be exceeded while constituents are mixed with and diluted by receiving waters provided certain conditions are met. In the case of a natural condition-based water quality standard, there is no dilution potential. For this reason, mixing zones are generally not appropriate for natural condition-based water quality standards. The sole exception is when a water quality standard allows for an increase above background or natural conditions. In those cases, a mixing zone may be allowed so long as all mixing zone requirements are met.

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6 AUTHORITY

Authority for this action is granted under 18 AAC 70.010 and AS 46.03.020, AS 46.03.050, and AS 46.03.070.

7 IMPLEMENTATION AUTHORITY

Implementation of this guidance is under the authority of the Commissioner of the Department Environmental Conservation under AS 46.03.020.

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APPENDIX A. DATA QUALITY INFORMATION

Information in this section has been drawn from EPA's "Guidance on Systematic Planning Using the DQOs Process – EPA QA/G4, February 2006. It can be found at the following website: http://www.epa.gov/QUALITY/qs-docs/g4-final.pdf

Data Quality Objectives (DQOs) are generated using a widely accepted systematic planning process and include such concepts as objectivity of approach and acceptability of results. DQOs must be developed to determine the natural conditions of water quality parameters. In quantitative and qualitative terms, they describe how good the data need to be in order to meet the stated objectives. DQOs for measurement data (also known as data quality indicators) include a statement of precision, accuracy, representativeness, completeness, and comparability.

For quantitative projects that involve estimation studies, such as determining natural conditions of water quality parameters, the study question should include a statement of the unknown environmental characteristics that will be estimated from collecting the data. Where possible, a well defined parameter of interest such as mean and median concentrations should be selected. Additionally, a comparison of concentration over time is often necessary.

The elements of systematic planning as part of the DQO Process include:

- Organizational description of the unit conducting the project
- Project goal, objectives, and study questions and issues
- Schedule – identification of a project schedule, resources, milestones, and other applicable requirements, such as regulatory requirements
- Data Needs – identification of the type of data needed and how the data will be used to support project objectives
- Criteria – a description of the quantity of data needed and specification of performance criteria for measuring quality
- Data Collection – a description of how and where the data will be obtained and identification of any constraints on data collection
- Quality Assurance (QA) – specification of needed QA and quality control (QC) activities to assess the stated performance criteria – for example, QC samples for field and laboratory, technical assessments, performance evaluation, and audits
- Analysis – how the collected data are analyzed and assessed against their intended use and specified performance criteria

A principal goal in developing and using DQOs along with QA and QC procedures is to generate data of known quality and comparability. This is essential if one is to be able to ascertain whether a pollutant is found in a waterbody naturally or as a result of anthropogenic activities. Measurement of data comparability will allow such judgments to be made, whether by direct measurement or statistical approaches.

Measurement Considerations

Methods

Each laboratory or its parent organization performing sampling and analysis must have an approved Quality Assurance Management Plan. Each laboratory must have an approved Quality Assurance Project Plan.

In assessing natural conditions, methods should be used that are specified by the State of Alaska or equivalent.

Measurement methods included in the State of Alaska Quality Assurance Plan are shown in Table 1 of the Plan. These methods are approved by the USEPA for monitoring of drinking water and wastewater. However, there are other methods that can be used as well. Standard Methods has published a 21^{st} Edition in book form as well as having the same methods available online (http://www.standardmethods.org). Available methods can also be accessed online using the National Environmental Methods Index (www.nemi.gov). Methods that are publicly available can be downloaded, whereas methods that are copyright protected are available from sources such as Standard Methods. USEPA web sites are also sources of methods.

Methods that are used must be able to meet the MQOs that are established for assessing natural conditions. These MQOs will vary, depending on the particular situation, for example water quality standard and waterbody. Depending on the particular method and its requirements, the following types of quality control (QC) checks should used.

- Laboratory performance check standard
- A reporting level that describes the concentration of a given analyte with a high degree of certainty
- Internal standards and surrogate standards
- Blanks: field, method, frequency of use
- Replicate analyses: frequency of use
- QC samples: source, frequency of use
- Proficiency Testing (PT) samples
- Fortified sample analyses: type, frequency of use
- Initial demonstration of precision and accuracy and control charts

Detection and Quantitation

This following discussion applies to chemical analytes such as metals and nutrients, where specific analytes are detected and their concentrations determined.

Any measuring method has an inherent limit of detection that is based on the instrument and the parameter of interest. Analytical methods applied to determining natural conditions must have detection limits that meet the applicable state water quality standard, or are lower than the applicable state water quality standard. A reporting level must be used that provides a high level of confidence in the concentration of any given analyte. For each situation when natural conditions are assessed, the analytical method used must have suitable detection and quantitation levels that permit a high level of confidence in the data obtained.

There are a number of approaches to measuring detection and quantitation. Detection allows one to determine whether an analyte is present or absent. It is not an accurate measure of quantitation – the concentration of the analyte that is present. Due to the uncertainty of concentration at the detection limit, a concentration above the detection limit is set as the quantitation level. Note that a variety of terms are used to represent detection and quantitation. Terms such as level of detection, instrument detection level, lower level of detection, and minimum detection level are used. Depending on how and who uses the terms, they can have the same or different meanings. Terms related to quantitation include minimum level, quantitation level, level of quantitation, and reporting limit, as well as others. Once again, these terms can have various meaning and applications.

The USEPA minimum detection level (MDL) is used in many method applications. It is defined as "the minimum concentration of an analyte (substance) that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero as determined by the procedure set forth at Appendix C of this part" (Glaser et al.). A multiple of the MDL is used to set the quantitation level and is dependent on the application and the approach taken.

A newer approach that has been developed recently is the Lowest Concentration Minimum Reporting Level (LCMRL) and the Minimum Reporting Level (MRL) (EPA, 2004) (ref 5). "The LCMRL is the lowest true analyte concentration for which the future recovery is predicted to fall, with a high confidence (99%), between 50 and 150% recovery." The MRL is the lowest analyte concentration that demonstrates known quantitative quality. A result below the MRL is considered to be an estimated value that does not satisfy quality control objectives.

APPENDIX B. STATISTICAL ANALYSES FOR CONCURRENT MEASUREMENT APPROACH

The acceptable amount of difference in measurement between the reference site and effluent samples in the Concurrent Measurement Approach is based on the analytical and sampling variability, which is expressed through a tolerance coefficient of variation (CV_T). The coefficient of variation is the standard deviation calculated from the difference between replicate upstream reference samples divided by the mean of the replicate upstream reference measurements;

$$CV_T = \frac{\left[\sum_{i=1}^{n} \left(X_{i,1} - X_{i,2} \right)^2 \Big/ n-1 \right]^{0.5}}{\sum_{i=1}^{n} \left(X_{i,1} + X_{i,1} \right) \Big/ 2 \cdot n}$$

where $X_{i,1}$ and $X_{i,2}$ are the first and second replicate upstream reference concentrations for monitoring event *i* and *n* is the total number of upstream reference replicate monitoring events. The denominator of this equation contains the factor 2 · n because the average is calculated from 2 replicates at each of *n* monitoring events.

In general, the CV_T will be recalculated on an annual basis, using the full set of replicated upstream measurements collected up to that time. During the first year of operation, site-specific information to calculate CV_T may not be available unless a pre-permitting study with replicate samples has been undertaken. For this first year, DEC may assign a value of CV_T based on experience with similar sites. Alternatively, where documentation on analytical method variability and sampling variability is provided, the coefficients of variation attributable to each of these sources may be combined to establish the first-year tolerance coefficient of variation through an assumption of additive variance as:

$$CV_T = \sqrt{CV_M^{\ 2} + CV_S^{\ 2}} \ ,$$

where CV_M is the coefficient of variation due to measurement variance and CV_S is the coefficient of variation due to sampling and time of day. If only the analytical method variability is provided, DEC, at its discretion, may estimate a value of CV_S based on data from similar sites or assume that CV_S is equal to zero, minimizing the allowable amount that the effluent can exceed the reference site measurement. If information on analytical method variability is not provided in the form established in the QAPP, then the tolerance variance will be assumed to be zero and any instance in which the effluent concentration is greater than the concurrent reference site concentration would constitute an excursion.

The tolerance coefficient of variation, as defined above, is used in a statistical test to determine whether the effluent concentration is equal to or lower than the reference site concentration. This test is a one-sided upper 95 percent confidence limit on the difference between effluent concentration and concurrent reference site concentration as evaluated by the equation:

$$T = t_{95\%,\, n-1} \cdot CV_T \cdot R$$

where Ris the observed concentration at the reference site, where *T* is the tolerance limit, and $t_{95\%,\, n-1}$ is the table value that represents the upper 5 percent of the Student's *t* distribution at n-1 degrees of freedom, where *n* is the number of replicate upstream monitoring events used to calculate CV_T (refer to Table C-2) in Appendix C).

For a single pair of observations, when the effluent concentration is greater than *T*, and the effluent concentration is also greater than the published criterion, the effluent is noncompliant with the natural condition-based water quality standard.

APPENDIX C. STATISTICAL METHODS FOR STATISTICAL CHARACTERIZATION APPROACH

Background

In some cases, it may be possible to describe the distribution of natural conditions through a statistical distribution of known form (such as the normal distribution) and known parameters – but this is not always the case. Natural conditions are typically based on the interpretation of limited amounts of monitoring data. In many cases, the data will not exactly follow a normal statistical distribution; in all cases, there will be uncertainty in the estimation of parameters, whether or not the distribution is known. As the statistical characterization approach is intended to be protective of true natural conditions, while still providing a realistic estimate of a natural background concentration, a confidence limit approach is used. Confidence limits are statistical boundaries of a given value (e.g., a mean or the 90th percentile value) as determined by the variability observed among measurements. Higher variability means wider (bigger) confidence limits, signifying more uncertainty in the true value. By relying on confidence limits in this approach, the estimates of natural conditions (both in terms of averages and potential natural high values) are adjusted to reflect the reasonable range of uncertainty in the estimation of the true distribution. In addition, since the data are frequently not normally distributed, it is appropriate to use robust non-parametric statistical methods to estimate confidence limits to address uncertainty in the true distribution of data.

Determining true distribution of environmental data at a site is affected by including erroneous high values, which could result in a high bias in the estimate of natural conditions. As a result it is preferable to err on the side of caution by eliminating or limiting the influence of high outliers on the analysis. Outliers are generally of somewhat less concern for the concurrent measurements approach, as their greatest impact would be in the interpretation of compliance at a single point in time. However, the presence of such outliers can lead to an overestimate of the tolerance for the difference between reference site and effluent concentrations, while an extreme outlier in effluent monitoring could lead to a false determination of persistent excursions, so data used in the concurrent measurement approach should also be checked.

The potential influence of outliers on natural conditions analysis is controlled in three ways in the statistical characterization approach. First, if non-detects are present, a trimmed data set is created that eliminates both the non-detects and an equal number of high values. Second, additional trimming is pursued (up to 25 percent of the data) until the trimmed data set (with appropriate transformations, if applicable) passes a normality test and can be used to develop a parametric confidence limit on the central tendency. Third, for data that do not pass a test of normality after trimming, a more conservative estimate of central tendency based on the median (50th percentile), rather than the mean, is employed in the statistical characterization. Parametric analysis with trimmed data and analysis based on the median will both reduce the influence of outliers.

Calculating Minimum Sample Size for New Data Collection

The minimum required sample size is estimated based on a sample power calculation for a pre-specified acceptable error on the estimation of the mean (Δ) expressed as a percentage of the ambient water quality criterion. We recommend 90 percent confidence that the sample mean is within a distance of 10 percent of the true mean. The necessary sample size can then be determined iteratively from (Gilbert, 1987):

$$n = \left[t_{\alpha/2,n-1} \cdot s / \Delta\right]^2 = \left[t_{\alpha/2,n-1} \cdot CV / f\right]^2,$$

where *CV* is the coefficient of variation (standard deviation divided by the mean) estimated from the available data at the historic or reference site, *t* is the critical value of Student's *t* distribution, and *f* is the desired tolerance as a fraction of the mean (e.g., 10 percent).

Calculating Central Tendency

If there are valid measurements for ≥ 50 samples, the normal approximation to the distribution of the mean is assumed to be appropriate (see Gilbert, 1987). For smaller datasets, tests are undertaken to ensure that the approximation to normality is sufficiently close to render parametric confidence limits valid. For this test, apply the Shapiro and Wilk *W* test for normality. The null hypothesis is that the population of data (transformed, if appropriate) follows a normal distribution. This statistical test evaluates whether the null hypothesis is true at a 95 percent confidence level (see S1 in this Appendix for description of the Shapiro-Wilk test, which is also available in many statistical software packages).

If the null hypothesis is not true (i.e., it is rejected), and the sample size is less than 50, the selected distribution (transformed or untransformed) is not a satisfactory approximation of the normal distribution. In this case, a loop is entered in which additional pairs of high and low outliers are trimmed from the data (up to 25 percent of the original sample size including non-detects). Thus, if there were originally 20 valid data points (the minimum required), a "trimmed" dataset could have as few as 15 datapoints for this analysis. The *W* statistic is then recalculated on the trimmed data.

If the normality test is passed (or if the sample size is greater than or equal to 50), parametric confidence limits can be calculated. In the general case, the 95-percent lower confidence limit on the mean should be selected to provide a conservative estimate of the natural background central tendency. For an untransformed normal distribution, the confidence limit on the mean is calculated using the Student's *t* distribution (see S3 in this Appendix). If the data have been log transformed, back transformation may introduce an estimation bias for the mean. In this case, the method of Land (1971, 1975) is used to obtain an estimate of the lower confidence limit on the untransformed mean (see S4 in this Appendix).

In some cases (with sample count less than 50), neither transformation nor trimming up to the specified limit of 25 percent of the data will result in an approximation of normality that is acceptable for parametric confidence limits. If this occurs, more data collection is advised if feasible. Otherwise, use the non-parametric method of Conover (1980) to estimate a 95-percent lower confidence limit on the median or 50^{th} percentile (see S2 in this Appendix). As most environmental data are right-skewed (i.e., there is a greater number of low concentration values than expected based on a normal distribution), use of the median rather than the mean provides a more appropriate estimate of the average. Alternatively, it may be permissible (on a case-by-case basis) to propose and test an alternative parametric distribution (other than the normal or lognormal) for estimation of confidence limits on the mean.

Estimating Upper Range

Due to the uncertainties in using parametric distribution assumptions to estimate confidence intervals on quantiles from small samples, evaluation of the 95% confidence intervals is made using the robust nonparametric method of Conover (1980), which relies on direct evaluation of the order statistics of the observed data. Because sample size is required to be ≥ 20 data points for natural conditions determinations using the statistical characterization approach, the binomial approximation to this method can be used (Gilbert, 1987; see S2 in this Appendix).

Seasonal Determinations

If at least five observations are available for both summer and winter, a test is made to determine whether mean values are equal between seasons. If the means are significantly different, then the natural condition determinations may need to be made separately by season. Use the nonparametric Wilcoxon-Mann-Whitney rank sum test (see S5 in this Appendix) (which is robust against non-normality) at a probability value of 0.05 to complete the tests. If this test indicates that the means are different with season and the difference between the seasonal means is greater than 10 percent, then DEC will evaluate whether the natural condition analysis should be undertaken on a seasonal basis. The extra "10-percent" test is added to deal with situations in which large data sets have means that are very close to one another but are still significantly different due to a small level of variability in the available measurements. When the seasonal means differ by less than 10 percent, the apparent difference will generally be within the range of analytical precision.

Permit Limit Calculations for Human Health Protection

Reference ambient concentrations (RACs) for the protection of human health are generally calculated with exposure periods longer than 1 month, and up to 70 years in length. Further, the average exposure rather than the maximum exposure is generally of concern. Because of the long averaging period, the procedure used to calculate an AML and MDL for ambient criteria described in Section 4.3.2 is not appropriate to the protection of human health (USEPA, 1991). Nonetheless, USEPA regulations (40 CFR 122.45(d)) do require that both an AML and MDL (or weekly average limit for POTWs) be developed unless impracticable. Accordingly, USEPA

(1991) recommends in permitting for human health protection that the AML be set equal to the WLA, and that the MDL then be set based on the effluent variability and number of samples per month, using a procedure similar to that for ambient criteria for the protection of aquatic life.

For a natural condition-based water quality standard for the protection of human health, the following procedures will be used:

1. Determine the natural condition-based human health WLA_H as equal to the lower confidence limit on the mean of the natural condition concentration times the permitted effluent flow.

2. Set the AML equal to WLA_H.

3. Calculate the MDL from the AML using Table 5-3 in USEPA (1991), selecting the 99th percentile for the maximum and the 95th percentile for the average:

$$MDL = AML \cdot \frac{\exp\left[2.326 \cdot \sigma - \sigma^2 / 2\right]}{\exp\left[1.645 \cdot \sigma_n - \sigma_n^2 / 2\right]}, \text{ where}$$

$$\sigma^2 = \ln\left[CV^2 + 1\right] \text{ and } \sigma_n^2 = \ln\left[CV^2 / n + 1\right].$$

The alternative approaches allowed at the discretion of DEC for ensuring protection of aquatic life under a natural condition-based water quality standard in Section 4.3.2 are also applicable, at the discretion of DEC, to the protection of human health. Specifically:

- An alternative MDL-A may be specified based on the concentration estimate for the lower 95 percent confidence limit on the upper 95th percentile of the natural condition distribution (using method S2 in this Appendix). Use of this alternative requires an additional compliance test stating that the maximum effluent concentration (or its associated load) should not exceed the lower confidence limit on the 90th percentile of the natural condition distribution (calculated using method S2 in this Appendix) more than 10 percent of the time (as evaluated over a preceding time period to be determined by DEC).

- An alternative AML-A may be specified from the best estimate of the mean concentration and application of Steps 1-2 above. When the AML-A is used, an additional compliance test is added that requires that the rolling average should not exceed the lower confidence limit on the mean of the natural condition data (calculated using method S3 or S4 in this Appendix as appropriate) more than 50 percent of the time (as evaluated over a preceding time period to be determined by DEC).

S1. Shapiro-Wilk *W* Test for Normality

This test is tabulated for sample sizes up to 50 and has a null hypothesis that the population has a normal distribution (Gilbert, 1987, p.159; Helsel and Hirsch, 2002, p. 114). Rejecting the null hypothesis means that the data are not consistent with a normal distribution assumption. The test is somewhat cumbersome to implement by hand, but is available in many statistical software packages as well as numerical libraries. The following brief overview of implementation of the *W* test is adapted from Gilbert (1987).

1. Arrange the n data (x) in ascending order from x_1 to x_n.
2. Calculate $d = \sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2$
3. Compute $k = n/2$ (if n is even) or $k = (n-1)/2$ (if n is odd).
4. Obtain coefficients a_1 through a_k from the appropriate table (see attached Table C-1, Gilbert, 1987, Table A6, or Shapiro and Wilk, 1965).
5. Calculate $W = \left[\sum_{i=1}^{k} a_i \left(x_{[n-i+1]} - x_i\right)\right]^2 \Big/ d$
6. Compare the value of *W* to the tabled critical values (see Table C-1).
7. Reject the null hypothesis if *W* is less than the critical value for the sample size and significance level.

S2. Conover's Nonparametric Confidence Limit for Quantiles

Nonparametric upper and lower confidence limits on quantiles can be developed using a binomial approximation for sample size greater than 20 (Conover, 1980, p. 112; Gilbert, 1987, p. 141). As only samples of this size or greater are considered for natural condition determinations, the approximation may be used. The method estimates lower (*l*) and upper *(u)* order statistics for the true quantile given by the fraction *p* for a set of data of size *n* at the 1-α confidence level as:

$$l = p(n-1) - Z_{1-\alpha/2}\sqrt{np(1-p)} \text{ and}$$
$$u = p(n-1) + Z_{1-\alpha/2}\sqrt{np(1-p)},$$

where *Z* is the critical value of the standard normal distribution (Table C-5). The confidence limits are then obtained through interpolation on the available data. For instance, the lower confidence limit corresponds to the interpolated *l/n* percentile of the data.

S3. Confidence Limits for the Arithmetic Mean of Normal Distributions

The confidence limits on the mean of the normal distribution are calculated using Student's *t* distribution. The lower confidence limit at the 1 - α level is estimated by

$$LL_{\alpha} = \bar{x} - t_{1-\alpha,n-1}\frac{s}{\sqrt{n}},$$

where $\bar{x}$ is the sample average, *s* is the sample standard deviation, *n* is the sample size, and *t* is the critical value of the Student's *t* distribution (Table C-2).

S4. Confidence Limits for the Arithmetic Mean of Lognormal Distributions

Calculating confidence limits on means from lognormal distributions must avoid the bias that is introduced by back transformation. Land (1971, 1975; see also Gilbert, 1987) developed a method to address this issue. The lower confidence limit on the arithmetic mean at the α confidence level (LL_{α}) is given by

$$LL_{\alpha} = \exp\left(\bar{y} + 0.5s_y^2 + \frac{s_y H_{\alpha}}{\sqrt{n-1}}\right)$$

where $\bar{y}$ and s_y are the sample mean and standard deviation of the natural logarithms of the data, respectively, and H_{α} is obtained from tables developed by Land (1975), and reproduced in attached Table C-3. Note that the lower bound at the 95 percent confidence interval is obtained with α = 0.05. The method is contained in various statistical software packages and is also available online at http://conflimit.nci.nih.gov/RunOnline/frmInputs_Lognormal.html.

S5. Wilcoxon-Mann-Whitney Rank Sum Test

The rank-sum test is a non-parametric test of the relationship of central tendency between two independent (non-paired) data sets of sizes n_1 and n_2. The null hypothesis (H_0) is that the populations from which the two data sets derive are the same. Calculation procedures (Gilbert, 1987; Helsel and Hirsch, 2002) are as follows (adapted from Gilbert, 1987):

1. Form a joint data set containing all $m = n_1 + n_2$ data. Rank the *m* data in ascending order from 1 to *m*. If several data are tied, assign them the average of the ranks that would otherwise be assigned to those data.
2. Sum the ranks assigned to data set 1 as W_{rs}.
3. If n_1 or n_2 is less than or equal to 10, compare W_{rs} to the appropriate critical value derived by Hollander and Wolfe (1973) and shown in attached Table

C-4. Small sample probabilities are available in various statistical software packages and online at http://eatworms.swmed.edu/%7Eleon/stats/utest.html.

4. If n_1 and n_2 are both greater than 10, compute the large sample statistic

$$Z_{rs} = \frac{W_{rs} - n_1(m+1)/2}{\sqrt{\frac{n_1 n_2}{12} \cdot \left[m + 1 - \frac{\sum_{j=1}^{g} t_j \left(t_j^2 - 1\right)}{m(m-1)} \right]}}$$

where g is the number of tied groups and t_j is the number of tied data in the jth group.

5. Compare to tabulated critical values of the standard normal distribution (Table C-5). For a 1 - α level two-tailed test, reject H_0 if $Z_{rs} \leq -Z_{1-\alpha/2}$ or if $Z_{rs} \geq Z_{1-\alpha/2}$.

Table C-1. Shapiro-Wilk W Test (Part 1)

(Naval Facilities Engineering Command. 1999. Handbook for Statistical Analysis of Environmental Background Data; http://enviro.nfesc.navy.mil/erb/erb_a/restoration/analysis/hndbk-sw.pdf)

Table A.6 Coefficients a_k for the Shapiro-Wilk W Test for Normality

k\n	2	3	4	5	6	7	8	9	10	
1	0.7071	0.7071	0.6872	0.6646	0.6431	0.6233	0.6052	0.5868	0.5739	
2	-	0.0000	0.1677	0.2413	0.28D6	0.3031	0.3164	0.3244	0.3291	
3	-	-	-	0.0000	0.0875	0.1401	0.1743	0.1976	0.2141	
4	-	-	-	-	-	0.0000	0.0561	0.0947	0.1224	
5	-	-	-	-	-	-	-	0.0000	0.0399	

k\n	11	12	13	14	15	16	17	18	19	20
1	0.5601	0.5475	0.5359	0.5251	0.5150	0.5056	0.4968	0.4886	0.4808	0.4734
2	0.3315	0.3325	0.3325	0.3318	0.3306	0.3290	0.3273	0.3253	0.3232	0.3211
3	0.2260	0.2347	0.2412	0.2460	0.2495	0.2521	0,2540	0.2553	0.2561	0.2565
4	0.1429	0.1506	0.1707	0.1802	0.1876	0.1939	0.1988	0.2027	0.2059	0.2085
5	0.0695	0.0922	0.1099	0.1240	0.1353	0.1447	0.1524	0.1587	0.1641	0.1686
6	0.0000	0.0303	0 0539	0.0727	0.0880	0.1005	0.1109	0.1197	0.1271	0.1334
7	-	-	0.0000	0.0240	0.0433	0.0593	0.0725	0.0837	0.0932	0.1013
8	-	-	-	-	0.0000	0.0196	0.0359	0.0496	0.0612	0.0711
9	-	-	-	-	-	-		0.0163	0.0303	0.0422
10	-	-	-	-	-	-	-	-	0.0000	0.0140

k\n	21	22	23	24	25	26	27	28	29	30
1	0.4643	0.4590	0.4542	0.4493	0.4450	0.4407	0.4366	0.4328	0.4291	0.4254
2	0.3185	0.3156	0.3126	0.3098	0.3069	0.3043	0.3018	0.2992	0.2968	0.2944
3	0.2578	0.2571	0.2563	0.2554	0.2543	0.2533	0.2522	0.2510	0.2499	0.2487
4	0.2119	0.2131	0.2139	0.2145	0.2148	0.2151	0.2152	0.2151	0.2150	0.2148
5	0.1736	0.1764	0.1787	0.1007	0.1822	0.1836	0.1840	0.1857	0.1864	0.1870
6	0.1399	0.1443	0.1480	0.1512	0.1539	0.1563	0.1584	0.1601	0.1616	0.1630
7	0.1092	0.1150	0.1201	0.1245	0.1263	0.1316	0.1346	0.1372	0.1395	0.1415
8	0.0804	0.0878	0.0941	0.0997	0.1046	0.1089	0.1128	0.1162	0.1192	0.1219
9	0.0530	0.0618	0.0696	0.0764	0.0823	0.0876	0.0923	0.0965	0.1002	0.1036
10	0.0263	0.0368	0.0459	0.0539	0.0610	0.0672	0.0728	0.0778	0.0822	0.0862
11	0.0000	0.0122	0.0228	0.0321	0.0403	0.0476	0.0540	0.0598	0.0650	0.0697
12	-	-	0.0000	0.0107	0.0200	0.0284	0.0358	0.0424	0.0483	0.0537
13	-	-	-	-	0.0000	0.0094	0.0178	0.0253	0.0320	0.0381
14	-	-	-	-	-	-	0.0000	0.0084	0.0159	0.0227
15	-	-	-	-	-	-	-	-	0.0000	0.0076

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Table C-1. Shapiro-Wilk W Test (Part 2)

(Naval Facilities Engineering Command. 1999. Handbook for Statistical Analysis of Environmental Background Data; http://enviro.nfesc.navy.mil/erb/erb_a/restoration/analysis/hndbk-sw.pdf)

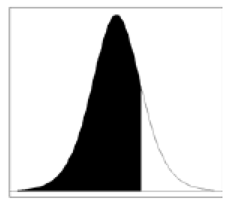
Table A.7. Quantiles of the Shapiro-Wilk W Test for Normality

n	$W_{0.01}$	$W_{0.02}$	$W_{0.05}$	$W_{0.10}$	$W_{0.50}$
3	0.753	0.756	0.767	0.789	0.859
4	0.687	0.707	0.748	0.792	0.935
5	0.686	0.715	0.762	0.806	0.927
6	0.713	0.743	0.788	0.826	0.927
7	0.730	0.760	0.803	0.838	0.928
8	0.749	0.778	0.818	0.851	0.932
9	0.764	0.791	0.829	0.859	0.935
10	0.781	0.806	0.842	0.869	0.938
11	0.792	0.817	0.850	0.876	0.940
12	0.805	0.828	0.859	0.883	0.943
13	0.814	0.837	0.866	0.889	0.945
14	0.825	0.846	0.874	0.895	0.947
15	0.835	0.855	0.881	0.901	0.950
16	0.844	0.863	0.887	0.906	0.952
17	0.851	0.869	0.892	0.910	0.954
18	0.858	0.874	0.897	0.914	0.956
19	0.863	0.879	0.901	0.917	0.957
20	0.868	0.886	0.905	0.920	0.969
21	0.873	0.884	0.908	0.923	0.960
22	0.878	0.892	0.911	0.926	0.961
23	0.881	0.895	0.914	0.928	0.962
24	0.884	0.898	0.916	0.930	0.963
25	0.886	0.901	0.918	0.931	0.964
26	0.891	0.904	0.920	0.933	0.965
27	0.894	0.906	0.923	0.935	0.965
28	0.896	0.908	0.924	0.936	0.966
29	0.898	0.910	0.926	0.937	0.966
30	0.900	0.912	0.927	0.939	0.967
31	0.902	0.914	0.929	0.940	0.967
32	0.904	0.915	0.930	0.941	0.968
33	0.906	0.917	0.931	0.942	0.968
34	0.908	0.919	0.933	0..943	0.969
35	0.910	0.920	0.934	0.944	0.969
36	0.912	0.922	0.935	0.945	0.970
37	0.914	0.924	0.936	0.946	0.970
38	0.916	0.925	0.938	0.947	0.971
39	0.917	0.927	0.939	0.948	0.971
40	0.919	0.928	0.940	0.949	0.972
41	0.920	0.929	0.941	0.950	0.972
42	0.922	0.930	0.942	0.951	0.972
43	0.923	0.932	0.943	0.951	0.973
44	0.924	0.933	0.944	0.952	0.973
45	0.926	0.934	0.945	0.953	0.973
46	0.927	0.935	0.945	0.953	0.974
47	0.928	0.936	0.946	0.954	0.974
48	0.929	0.937	0.947	0.954	0.974
49	0.929	0.937	0.947	0.955	0.974
50	0.930	0.938	0.947	0.955	0.974

Table C-2. Critical Values of Student's t Distribution

(USEPA. 2006. Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S. EPA/240/B-06/003, Office of Environmental Information, U.S. EPA, Washington, DC).

TABLE A-2. CRITICAL VALUES OF STUDENT'S-*t* DISTRIBUTION



$t_{1-\alpha}$

Degrees of Freedom	$1-\alpha$								
	0.70	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**	**0.975**	**0.99**	**0.995**
1	0.727	1.000	1.376	1.963	3.078	6.314	12.706	31.821	63.657
2	0.617	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925
3	0.584	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841
4	0.569	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604
5	0.559	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032
6	0.553	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707
7	0.549	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499
8	0.546	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355
9	0.543	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250
10	0.542	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169
11	0.540	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106
12	0.539	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055
13	0.538	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012
14	0.537	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977
15	0.536	0.691	0.866	1.074	1.34	1.753	2.131	2.602	2.947
16	0.535	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921
17	0.534	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898
18	0.534	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878
19	0.533	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861
20	0.533	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845
21	0.532	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831
22	0.532	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819
23	0.532	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807
24	0.531	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797
25	0.531	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787
26	0.531	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779
27	0.531	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771
28	0.530	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763
29	0.530	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756
30	0.530	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750
40	0.529	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704
60	0.527	0.679	0.848	1.046	1.296	1.671	2.000	2.390	2.660
120	0.526	0.677	0.845	1.041	1.289	1.658	1.980	2.358	2.617
∞	0.524	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576

Note: The last row of the table (∞ degrees of freedom) gives the critical values for a standard normal distribution (*Z*), e.g., $t_{\infty,\,0.95} = z_{0.95} = 1.645$.

Table C-3. Land's H for Calculating a One-Sided Confidence Limit on a Lognormal Mean

(USEPA. 2006. Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S. EPA/240/B-06/003, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, DC).

TABLE A-17. VALUES OF $H_{1-\alpha} = H_{0.95}$ FOR COMPUTING A ONE-SIDED UPPER 95% CONFIDENCE LIMIT ON A LOGNORMAL MEAN

s_y	*n*									
	3	5	7	10	12	15	21	31	51	101
0.10	2.750	2.035	1.886	1.802	1.775	1.749	1.722	1.701	1.684	1.670
0.20	3.295	2.198	1.992	1.881	1.843	1.809	1.771	1.742	1.718	1.697
0.30	4.109	2.402	2.125	1.977	1.927	1.882	1.833	1.793	1.761	1.733
0.40	5.220	2.651	2.282	2.089	2.026	1.968	1.905	1.856	1.813	1.777
0.50	6.495	2.947	2.465	2.220	2.141	2.068	1.989	1.928	1.876	1.830
0.60	7.807	3.287	2.673	2.368	2.271	2.181	2.085	2.010	1.946	1.891
0.70	9.120	3.662	2.904	2.532	2.414	2.306	2.191	2.102	2.025	1.960
0.80	10.43	4.062	3.155	2.710	2.570	2.443	2.307	2.202	2.112	2.035
0.90	11.74	4.478	3.420	2.902	2.738	2.589	2.432	2.310	2.206	2.117
1.00	13.05	4.905	3.698	3.103	2.915	2.744	2.564	2.423	2.306	2.205
1.25	16.33	6.001	4.426	3.639	3.389	3.163	2.923	2.737	2.580	2.447
1.50	19.60	7.120	5.184	4.207	3.896	3.612	3.311	3.077	2.881	2.713
1.75	22.87	8.250	5.960	4.795	4.422	4.081	3.719	3.437	3.200	2.997
2.00	26.14	9.387	6.747	5.396	4.962	4.564	4.141	3.812	3.533	3.295
2.50	32.69	11.67	8.339	6.621	6.067	5.557	5.013	4.588	4.228	3.920
3.00	39.23	13.97	9.945	7.864	7.191	6.570	5.907	5.388	4.947	4.569
3.50	45.77	16.27	11.56	9.118	8.326	7.596	6.815	6.201	5.681	5.233
4.00	52.31	18.58	13.18	10.38	9.469	8.630	7.731	7.024	6.424	5.908
4.50	58.85	20.88	14.80	11.64	10.62	9.669	8.652	7.854	7.174	6.590
5.00	65.39	23.19	16.43	12.91	11.77	10.71	9.579	8.688	7.929	7.277
6.00	78.47	27.81	19.68	15.45	14.08	12.81	11.44	10.36	9.449	8.661
7.00	91.55	32.43	22.94	18.00	16.39	14.90	13.31	12.05	10.98	10.05
8.00	104.6	37.06	26.20	20.55	18.71	17.01	15.18	13.74	12.51	11.45
9.00	117.7	41.68	29.64	23.10	21.03	19.11	17.05	15.43	14.05	12.85
10.00	130.8	46.31	32.73	25.66	23.35	21.22	18.93	17.13	15.59	14.26

TABLE A-17. VALUES OF $H_{\alpha} = H_{0.05}$ FOR COMPUTING A ONE-SIDED LOWER 5% CONFIDENCE LIMIT ON A LOGNORMAL MEAN

s_y	*n*									
	3	5	7	10	12	15	21	31	51	101
0.10	-2.130	-1.806	-1.731	-1.690	-1.677	-1.666	-1.655	-1.648	-1.644	-1.642
0.20	-1.949	-1.729	-1.678	-1.653	-1.646	-1.640	-1.636	-1.636	-1.637	-1.641
0.30	-1.816	-1.669	-1.639	-1.627	-1.625	-1.625	-1.627	-1.632	-1.638	-1.648
0.40	-1.717	-1.625	-1.611	-1.611	-1.613	-1.617	-1.625	-1.635	-1.647	-1.662
0.50	-1.644	-1.594	-1.594	-1.603	-1.609	-1.618	-1.631	-1.646	-1.663	-1.683
0.60	-1.589	-1.573	-1.584	-1.602	-1.612	-1.625	-1.643	-1.662	-1.685	-1.711
0.70	-1.549	-1.560	-1.582	-1.608	-1.622	-1.638	-1.661	-1.686	-1.713	-1.744
0.80	-1.521	-1.555	-1.586	-1.620	-1.636	-1.656	-1.685	-1.714	-1.747	-1.783
0.90	-1.502	-1.556	-1.595	-1.637	-1.656	-1.680	-1.713	-1.747	-1.785	-1.826
1.00	-1.490	-1.562	-1.610	-1.658	-1.681	-1.707	-1.745	-1.784	-1.827	-1.874
1.25	-1.486	-1.596	-1.662	-1.727	-1.758	-1.793	-1.842	-1.893	-1.949	-2.012
1.50	-1.508	-1.650	-1.733	-1.814	-1.853	-1.896	-1.958	-2.020	-2.091	-2.169
1.75	-1.547	-1.719	-1.819	-1.916	-1.962	-2.015	-2.088	-2.164	-2.247	-2.341
2.00	-1.598	-1.799	-1.917	-2.029	-2.083	-2.144	-2.230	-2.318	-2.416	-2.526
2.50	-1.727	-1.986	-2.138	-2.283	-2.351	-2.430	-2.540	-2.654	-2.780	-2.921
3.00	-1.880	-2.199	-2.384	-2.560	-2.644	-2.740	-2.874	-3.014	-3.169	-3.342
3.50	-2.051	-2.429	-2.647	-2.855	-2.953	-3.067	-3.226	-3.391	-3.574	-3.780
4.00	-2.237	-2.672	-2.922	-3.161	-3.275	-3.406	-3.589	-3.779	-3.990	-4.228
4.50	-2.434	-2.924	-3.206	-3.476	-3.605	-3.753	-3.960	-4.176	-4.416	-4.685
5.00	-2.638	-3.183	-3.497	-3.798	-3.941	-4.107	-4.338	-4.579	-4.847	-5.148
6.00	-3.062	-3.715	-4.092	-4.455	-4.627	-4.827	-5.106	-5.397	-5.721	-6.086
7.00	-3.499	-4.260	-4.699	-5.123	-5.325	-5.559	-5.886	-6.227	-6.608	-7.036
8.00	-3.945	-4.812	-5.315	-5.800	-6.031	-6.300	-6.674	-7.066	-7.502	-7.992
9.00	-4.397	-5.371	-5.936	-6.482	-6.742	-7.045	-7.468	-7.909	-8.401	-8.953
10.00	-4.852	-5.933	-6.560	-7.168	-7.458	-7.794	-8.264	-8.755	-9.302	-9.918

Table C-4. Wilcoxon-Mann-Whitney Rank Sum Test, Small Sample Critical Values for W_{rs}

(USEPA. 2006. Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S. EPA/240/B-06/003, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, DC).

TABLE A-8. CRITICAL VALUES FOR THE WILCOXON RANK-SUM TEST

Table values are the largest x values such that $P(W_{rs} \leq x) \leq \alpha$. Therefore, significance levels, α, are approximate. If there are ties, then the test is approximate.

min(*m*, *n*)	α	max(*m*, *n*)								
		2	3	4	5	6	7	8	9	10
2	0.010	-	-	-	-	-	-	-	-	-
	0.025	-	-	-	-	-	-	0	0	0
	0.050	-	-	-	0	0	0	1	1	1
	0.100	-	0	0	1	1	1	2	2	3
3	0.010		-	-	-	0	0	0	1	1
	0.025		-	-	0	1	1	2	2	3
	0.050		0	0	1	2	2	3	4	4
	0.100		1	1	2	3	4	5	5	6
4	0.010			-	0	1	1	2	3	3
	0.025			0	0	2	3	4	4	5
	0.050			1	2	3	4	5	6	7
	0.100			3	4	5	6	7	9	10
5	0.010				1	2	3	4	5	6
	0.025				2	3	5	6	7	8
	0.050				4	5	6	8	9	11
	0.100				5	7	8	10	12	13
6	0.010					3	4	6	7	8
	0.025					5	6	8	10	11
	0.050					7	8	10	12	14
	0.100					9	11	13	15	17
7	0.010						6	7	9	11
	0.025						8	10	12	14
	0.050						11	13	15	17
	0.100						13	16	18	21
8	0.010							9	11	13
	0.025							13	15	17
	0.050							15	18	20
	0.100							19	22	25
9	0.010								14	16
	0.025								17	20
	0.050								21	24
	0.100								25	28
10	0.010									13
	0.025									23
	0.050									27
	0.100									32

Table C-5. Cumulative Normal Distribution

(USEPA. 2006. Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S. EPA/240/B-06/003, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, DC).

TABLE A-1. STANDARD NORMAL DISTRIBUTION (CONT.)

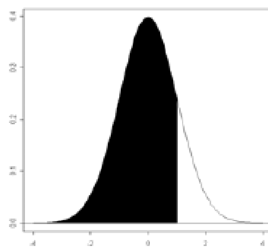


Table values are $P(Z \le z_p) = p$.

z_p	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6247	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8897	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9889	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9137	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

APPENDIX D. EXAMPLES USING THE CONCURRENT MEASUREMENT AND STATISTICAL CHARACTERIZATION APPROACHES

This appendix presents four examples of application of the concurrent measurement and statistical characterization approaches. For the purposes of the statistical examples, actual sets of monitoring data from locations outside Alaska were assembled Examples 2 and 3 are drawn from USGS monitoring in Montana, while Example 4 is from Helsel and Hirsch (2002, Appendix D6). These data are assumed to be from appropriate sites that represent natural conditions for the purpose of method demonstration.

Example 1 Example of the Concurrent Measurement Approach

This example shows how the concurrent measurement approach is used in permitting in a situation where the effluent discharge is highly correlated to the upstream concentration. The example focuses on iron, for which Alaska specifies a chronic criterion for the protection of aquatic life of 1,000 µg/L. No acute criterion is specified.

Monitoring of natural conditions in the waterbody at an upstream reference site established that the average concentration in the waterbody was 1,050 µg/L, with concentrations as high as 1,400 µg/L observed on occasion. DEC determined that the quality is lower than the published criterion, that the watershed was in a predominantly natural state, and that the lowered water quality is a result of natural processes. As a result, DEC issued a natural conditions finding.

A discharge is proposed for the watershed. The discharge consists primarily of ambient water obtained from the receiving stream and thus closely follows natural concentrations. The watershed above the discharge point remains in a predominantly natural state, and the concurrent measurement approach can thus be used to assess compliance with standards. The permittee was required to obtain and submit concurrent replicate samples of upstream concentrations and effluent concentrations on a monthly basis.

The first two years of monitoring are summarized graphically in Figure D-1, along with the Tolerance Limit (described further below). The raw data are shown in Table D-1.

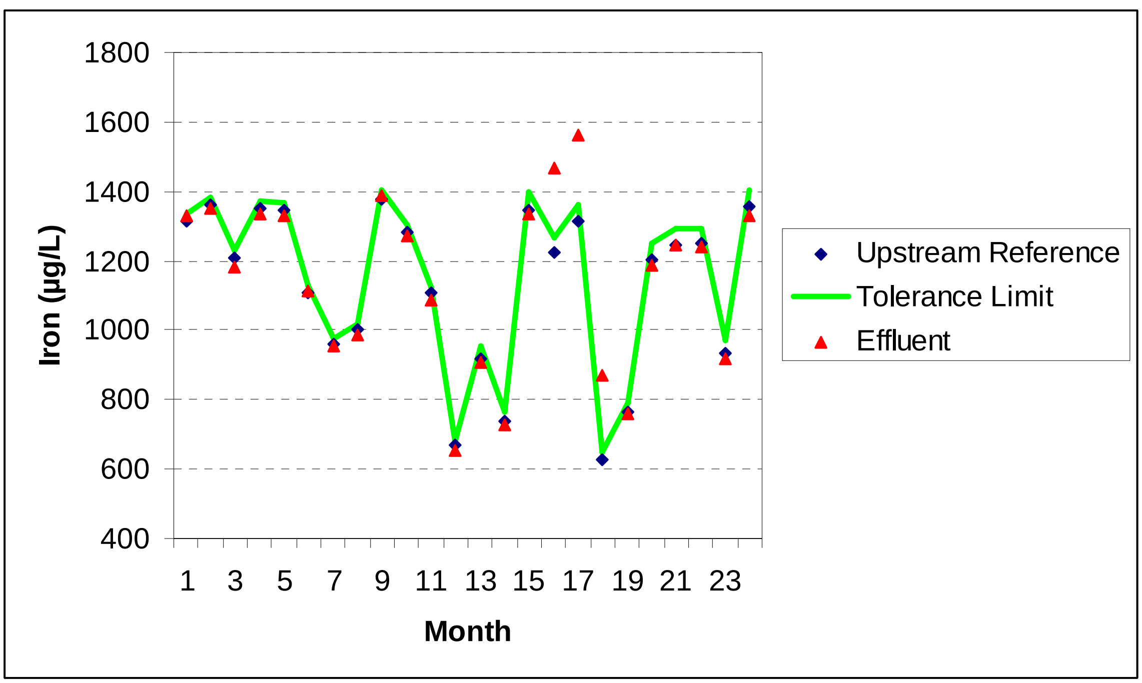


Figure D-1 Iron Observations for Concurrent Measurement Approach Example

Table D-1 Iron Data (µg/L) for Concurrent Measurement Approach Example 1

Month	Upstream Replicate 1	Upstream Replicate 2	Effluent Replicate 1	Effluent Replicate 2	Upstream Average	Effluent Average	Tolerance Limit
1	1307.1	1322.0	1327.5	1333.8	1314.5	1330.6	1337.2
2	1379.7	1341.8	1348.2	1351.5	1360.7	1349.9	1384.2
3	1209.8	1204.8	1173.9	1189.4	1207.3	1181.7	1228.1
4	1372.3	1330.2	1330.3	1342.0	1351.2	1336.1	1374.6
5	1364.3	1325.9	1336.9	1322.6	1345.1	1329.8	1368.3
6	1106.9	1111.2	1106.4	1122.9	1109.1	1114.7	1128.2
7	964.1	957.1	949.6	957.3	960.6	953.4	977.2
8	998.7	1002.6	994.7	979.7	1000.7	987.2	1017.9
9	1390.7	1365.9	1400.7	1374.5	1378.3	1387.6	1402.1
10	1276.6	1283.8	1275.5	1271.5	1280.2	1273.5	1302.3
11	1113.3	1097.5	1088.1	1088.8	1105.4	1088.4	1124.5
12	664.9	675.4	658.0	653.6	670.2	655.8	681.7
13	913.1	926.3	902.0	912.4	919.7	907.2	953.4
14	740.6	739.4	732.0	727.6	740.0	729.8	767.1
15	1346.4	1348.0	1344.9	1330.4	1347.2	1337.7	1396.5
16	1216.2	1227.8	1465.1	1470.6	1222.0	1467.8	1266.7
17	1309.7	1319.0	1571.2	1553.3	1314.3	1562.3	1362.4
18	623.0	626.7	869.2	870.0	624.8	869.6	647.7
19	769.0	759.5	760.4	757.8	764.3	759.1	792.3
20	1206.2	1203.5	1191.7	1182.2	1204.8	1186.9	1248.9
21	1240.2	1251.0	1249.6	1242.8	1245.6	1246.2	1291.2
22	1233.6	1264.2	1245.4	1230.0	1248.9	1237.7	1294.6
23	939.4	930.7	920.1	919.5	935.1	919.8	969.3
24	1357.0	1355.2	1324.5	1330.9	1356.1	1327.7	1405.8

For each month, the averages of the replicates of the upstream and effluent concentrations provide the basis for comparison. Tolerance limits were established as follows. For the first year, replicate sampling of natural conditions at the site was not available. Therefore, DEC specified, based on experience with a similar site, a value of $CV_T = 0.01$ to account for analytical and sampling variability. The tolerance limit is then calculated for each concurrent measurement pair as described in Appendix B:

$$T = R + t_{95\%,\, n-1} \cdot CV_T \cdot R\,,$$

in which the critical value of t was determined from tables to be 1.725 based on a sample size of 21 for monitoring at the similar site.

After the first year, the value of CV_T was recalculated for the site based on the difference between replicates of the upstream measurements. This yields $CV_T = 0.020$ and a critical value of t of 1.833, based on 12 samples. These are used to estimate tolerance limits for the second year of data. After the conclusion of the second year the values would again be recalculated, yielding $CV_T = 0.016$ and a critical t value of 1.729 based on 24 samples.

In the example data, seven out of 24 months yielded concurrent measurements in which the effluent concentration was greater than the upstream concentration. The process generating the discharge operated as intended through month 15 and from month 19 on. That is, the effluent concentrations closely replicated upstream concentrations. In months 16 through 18, effluent concentrations were substantially higher than concurrent upstream concentrations.

Referring to Table D-1, effluent concentrations were greater than concurrent upstream measurements in months 1, 6, 9, 16, 17, 18, and 21 – but in only two of these months did the effluent concentration exceed the tolerance level. Except for months 16-18, the deviations of effluent concentration above effluent concentration were small, and within the range of tolerance and can therefore be interpreted as resulting from sampling and analytical variability. These observations thus are consistent with natural conditions and in compliance with permit conditions. In months 16 and 17, the effluent concentration was greater than the upstream concentration by a statistically significant amount, indicating non-compliance with permit conditions. In month 18, the effluent concentration was well above the concurrent upstream concentration, but was still less than the published ambient water quality criterion. Therefore, the discharge was in compliance with permit conditions during this month.

The concurrent measurement approach also includes additional tracking of consecutive occurrences of effluent concentrations greater than target concentrations, and rolling averages on the difference. In this case, there are no periods in which three consecutive effluent measurements exceed target concentrations. (This occurs despite a three month period in which effluent concentrations were substantially greater than upstream concentrations because, in the third month, the resulting concentrations were below the published criterion). The rolling average difference between the effluent concentration and the target concentration (where the target concentration is the larger of the concurrent reference concentration and the published criterion), starting at month 12, remains less than zero. Therefore, the site monitoring is not judged to indicate a persistent excursion.

Example 2. Determining Natural Conditions and Associated Permit Limits – Simple Example

The second example addresses a rather simple case in which the monitored natural conditions concentrations for copper are valid and clearly above the ambient water quality criterion. Alaska specifies water quality criteria for copper based on dissolved concentration but provides a translator to total recoverable copper. The total recoverable criteria are hardness dependent. For this example, we assume that site hardness is a constant 50 mg/L. The relevant published acute and chronic aquatic life criteria for total recoverable copper are then 7.29 and 5.15 μg/L, respectively.

Natural conditions monitoring data for this example are available for three years, as shown in Table D-2. Data are assigned to two seasons ("winter" and "summer," where summer is defined as May-September) for the purposes of testing for seasonal effects.

All of the data are quality assured and the dataset contains no non-detects. The sample size of 28 and number of years are greater than the minimum requirement, so analysis for natural conditions may proceed. The complete natural condition data set has a mean of 9.86 μg/L (well in excess of the acute and chronic aquatic life criteria). There are 21 summer observations of the natural condition (with a mean of 11 μg/L) and 7 winter observations (with a mean of 6.43 μg/L).

Table D-2. Total Recoverable Copper Data for Example 2

Date	Season	Concentration (µg/L)	Natural Log of Concentration
3/8/1993	W	7	1.946
4/12/1993	S	28	3.332
4/26/1993	S	52	3.951
5/14/1993	S	6	1.792
5/24/1993	S	6	1.792
6/6/1993	S	7	1.946
7/12/1993	S	4	1.386
8/16/1993	S	7	1.946
10/28/1993	W	10	2.303
2/15/1994	W	2	0.693
3/8/1994	W	6	1.792
4/11/1994	S	5	1.609
4/25/1994	S	13	2.565
5/12/1994	S	7	1.946
5/20/1994	S	11	2.398
6/13/1994	S	9	2.197
7/11/1994	S	5	1.609
8/17/1994	S	3	1.099
11/28/1994	W	5	1.609
2/6/1995	W	8	2.079
3/9/1995	W	7	1.946
4/10/1995	S	9	2.197
4/28/1995	S	8	2.079
5/8/1995	S	14	2.639
5/22/1995	S	10	2.303
6/5/1995	S	18	2.890
7/11/1995	S	5	1.609
8/7/1995	S	4	1.386

Note: Data for copper concentrations taken from USGS site 12323230, Blacktail Creek at Harrison Avenue at Butte, MT

The Wilcoxon rank sum test (S5 in Appendix C) is applied to check for significant differences in distribution between seasons. This yields a large-sample approximation result of $Z_{rs} = 0.909$, which falls within the 95 percent confidence bounds of $-1.96 \leq Z_{rs} \leq 1.96$, and the lack of significance is confirmed by the small-sample tables. Therefore, the null hypothesis that the two samples are drawn from the same distribution is not rejected, and it is not necessary to undertake separate seasonal analyses. Working with the full data set, basic statistics for the raw and log-transformed data are shown in Table D-3.

Table D-3. Statistics for the Complete Data Set, Example 2

	Raw Data	Log Transformed Data
Count	28	28
Mean	9.857	2.037
Median	7.000	1.946
Standard Deviation	9.748	0.653
Skew	3.423	0.872

The natural log transformation considerably reduces the estimated skew, so we work with the log transformed data. The number of data points is less than 50, so test normality of the transformed data using the *W* test (S1). When applied to the full data set, $W = 0.944$, which is greater than the critical value of 0.924 at the $\alpha = 5\%$ level. Therefore, do not reject the null hypothesis that the transformed data are normal and proceed to calculation of parametric confidence limits.

Because the data are log transformed, use the method of Land (S4) to derive the lower confidence limit on the arithmetic mean. The appropriate value of H_a for a 5 percent lower confidence limit is -1.67. The lower confidence limit on the untransformed (arithmetic) mean concentration is then 7.70 µg/L, which falls between the raw mean and median of the data.

To calculate the nonparametric 95 percent lower confidence limit on the 90th percentile value, calculate the order statistic $l = 22.99$ (S2). Interpolating into the table of ordered values gives a concentration of 11.34 µg/L. Future observations in excess of this value should be flagged for further assessment as potentially incompatible with achieving natural background conditions. Persistent observations in this range would indicate that the site had become impaired relative to natural conditions.

The confidence limits on concentrations established in the preceding two paragraphs constitute the natural condition-based water quality standards for the site. The lower confidence limit on the mean (7.70 µg/L) of the natural condition is an expression of the chronic exposure level for aquatic life in the waterbody. This central tendency of the natural condition is greater than the published chronic aquatic life criterion criterion (5.15 µg/L total recoverable copper at 50 mg/L hardness). The lower confidence limit on the 90th percentile (11.34 µg/L) is an expression of the natural condition acute exposure level and is likewise greater than the published acute aquatic life criterion (7.29 µg/L total recoverable copper at 50 mg/L hardness).

For a permitted discharge, effluent limits should be set in accordance with the TSD for Toxics (USEPA, 1991) to include an average monthly and maximum daily load to ensure that there is a low risk of the actual discharge exceeding the natural condition.

The first step in the procedure for setting effluent limits is determination of the LTA, based on the coefficient of variation (CV) of the effluent. We assume a CV of 0.5 and an average discharge of 5 MGD. The chronic wasteload allocation (WLA) is evaluated at the confidence limit on the mean of 7.70 µg/L, while the acute WLA is estimated at the confidence limit on the upper percentile of 11.34 µg/L. These correspond to loads of 0.321 and 0.473 lb/d, respectively. Using Table 5-1 in USEPA (1991) and 99th percentile factors, the multipliers and resulting LTAs are shown in Table D-4. The acute LTA is more restrictive, and so it is used as the basis for effluent limits.

Table D-4. Calculation of LTA, Example 2

	WLA (lb/d)	WLA Multiplier[1]	LTA (lb/d)
Acute	0.473	0.373	0.176
Chronic	0.321	0.581	0.187

[1] See USEPA (1991), Table 5-1.

The AML and MDL are set as the actual compliance limits in the permit and are scaled up from the LTA (see Table 5-2 in USEPA, 1991) to assign maximum values that are consistent with achieving the LTA. The AML is first calculated. Using four compliance samples per month at the 95th percentile level (as recommended by USEPA, 1991), the multiplier for the AML is 1.45. Thus, the AML for the permit is 1.45 x 0.176 = 0.255 lb/d. In contrast, the AML calculated from the default ambient water quality criterion would be 0.165 lb/d – about one-third less than the site-specific value.

A standard MDL for controlled process wastewater would be calculated from the LTA using the TSD method. At CV of 0.5, the multiplier at the 99 percent level is 2.68, leading to an MDL of 2.68 x 0.176 = 0.472 lb/d.

For sites where the discharge is not controlled and treated but still believed to reflect background conditions, the alternative procedure can be used to establish the MDL and evaluate compliance. First, the MDL is set equivalent to the lower 95 percent confidence interval on the 95th quantile of the concentration data. This yields a concentration of 15.55 µg/L and an MDL of 0.649 lb/d. An additional compliance condition is set to ensure that no more than 10 percent of the monitored effluent discharges exceed the lower confidence limit on the 90th percentile of the natural condition concentration data of 11.3 µg/L.

An alternative approach can also be used to evaluate compliance with the average load. The AML-A (alternative not-to-exceed value for the average monthly load) is calculated in the same manner as the AML, but using the best estimates of the mean concentration and 90th percentile. Because the distribution has been determined to be approximately lognormal, the arithmetic mean of natural conditions is estimated from the log-transformed statistics as $\exp\left(\bar{y} + 0.5 s_y^2\right) =$ 9.49, while the 90th percentile of the data is 15.2 µg/L. Using these values, the chronic LTA is more restrictive (0.230 lb/d), and the AML-A is 0.334 lb/d (again assuming a CV of 0.5 and 99 percent level multiplier of 2.68). When the AML-A is used, an additional requirement is made that the rolling average of the effluent concentration not exceed the lower confidence limit on the mean (7.70 µg/L) more than 50 percent of the time.

Table D-5 summarizes the concentrations limits calculated using state-wide water quality standards, the natural condition standards, and the alternative natural condition standards.

Table D-5. Comparison of Permit Limits for Example 2

	State-wide Std (µg/L)	Natural Condition Std (µg/L)	Alternative Limits (µg/L)
AML	3.94	6.13	8.00
MDL	7.29	11.33	15.55

Example 3. Determining Natural Conditions and Associated Permit Limits – Data near the Criterion Level

This example examines a more complex case in which data are near the criterion level. Some other aspects of the statistical analyses are also addressed, such as treatment of outliers and non-normality. Although the natural conditions data are near the criterion level, the analyses result in some relaxation of effluent limits in recognition of the natural conditions – but at a level much more conservative than shown in Example 2.

A site is believed to have natural conditions for an arbitrary metal that are in excess of the acute water quality criterion of 0.5 mg/L and chronic water quality criterion of 0.3 mg/L (at the appropriate site-specific hardness concentration). A total of 38 observations are available for the natural conditions analysis, collected over a three-year period. The data are shown in Table D-6 (dates are not shown, but an assignment to summer and winter seasons is indicated). Many of the observations are greater than the water quality criterion concentration.

All of the data are quality assured and the dataset contains no non-detects. However, there appears to be one high outlier (36 mg/L). The valid sample size of 38 is greater than the minimum requirement of 20 for historical data, so analysis may proceed.

The complete data set has a mean of 1.37 mg/L. There are 25 summer observations (with mean of 0.50) and 13 winter observations (with mean of 3.05 mg/L).

Table D-6. Data for Example 3

Count	Season	Concentration (mg/L)	Natural Log of Concentration
1	S	0.48	-0.73397
2	S	0.4	-0.91629
3	W	0.52	-0.65393
4	W	0.38	-0.96758
5	S	4.5	1.504077
6	S	1.2	0.182322
7	W	0.16	-1.83258
8	W	0.06	-2.81341
9	S	0.56	-0.57982
10	S	0.11	-2.20727
11	S	0.25	-1.38629
12	S	0.44	-0.82098
13	S	0.16	-1.83258
14	S	0.2	-1.60944
15	W	0.35	-1.04982
16	S	0.06	-2.81341
17	S	0.27	-1.30933
18	S	0.12	-2.12026
19	S	1.2	0.182322
20	W	0.04	-3.21888
21	W	0.2	-1.60944
22	S	0.04	-3.21888
23	S	0.68	-0.38566
24	S	0.06	-2.81341
25	S	0.05	-2.99573
26	W	0.49	-0.71335
27	S	0.2	-1.60944
28	W	0.32	-1.13943
29	S	36	3.583519
30	W	0.05	-2.99573
31	W	0.29	-1.23787
32	S	0.08	-2.52573
33	S	0.43	-0.84397
34	W	0.51	-0.67334
35	S	0.47	-0.75502
36	S	0.23	-1.46968
37	S	0.41	-0.8916
38	W	0.21	-1.56065

Note: The data in this table are taken from iron concentrations reported for an unmined site in Helsel and Hirsch (2002, Appendix D6); however, for the purposes of this example they are assumed to represent an arbitrary metal.

Before proceeding, apply the Wilcoxon Rank Sum test (see S5 in Appendix C) to check for significant differences in distribution between seasons. This yields a large sample approximation statistic of $Z_{rs} = -0.385$. The statistic does not fall outside the critical value at the 95 percent confidence level ($-1.96 < Z_{rs} < 1.96$), and the result is confirmed by small sample tables. Therefore, the null hypothesis that the two samples are drawn from the same distribution is not rejected, and it is not necessary to undertake separate seasonal analyses. Working with the full data set, basic statistics for the raw and transformed data are shown in Table D-7.

Table D-7. Statistics for the Complete Data Set, Example 3

	Raw Data	Log Transformed Data
Count	38	38
Mean	1.373	-1.286
Median	0.280	-1.274
Standard Deviation	5.815	1.316
Skew	6.021	1.338

The natural log transformation considerably reduces skew (although it is still large due to the outlier), so we work with the log transformed data. The number of data points is less than 50, so test normality of the transformed data using the W test (S1). When applied to the full data set, $W = 0.893$, which is less than the critical value of 0.938 at the $\alpha = 5\%$ level. Therefore, reject the null hypothesis that the transformed data are normal.

Trim the highest and lowest data point and retest. This results in $W = 0.957$, which exceeds the critical value of 0.935 for $n = 36$. Therefore, work with this trimmed data set. The transformed, trimmed data set has a mean of -1.367 and standard deviation of 1.020 on sample size of 36. Because the data are log transformed, use the method of Land to derive the lower confidence limit on the arithmetic mean (S4). The appropriate value of H_a for a 5 percent lower confidence limit is -1.8. The lower confidence limit on the untransformed (arithmetic) mean concentration is thus 0.314 mg/L – which is much less than the arithmetic mean, but slightly greater than the arithmetic median.

To calculate the nonparametric lower bound on the upper confidence limit for assessment purposes, return to the full data set and calculate the order statistic $l = 31.48$ (based on 95 percent confidence on 90th percentile) (S2). Interpolating into the table of ordered values gives a concentration of 0.516 mg/L.

The lower confidence limits on the mean and 90th percentile (0.314 and 0.516 mg/L) become, respectively, the expressions of the natural condition-based chronic and acute exposure levels for the site and are slightly greater than the published chronic and acute aquatic life criteria (0.3 and 0.5 mg/L, respectively).

The first step in the procedure for setting effluent limits is determination of the LTA, based on the coefficient of variation (CV) of the effluent. We again assume a CV of 0.5 and an average discharge of 5 MGD. The chronic wasteload allocation is evaluated at the lower confidence limit on the mean concentration of 0.314 mg/L determined above, while the acute wasteload allocation is estimated at the lower confidence limit on the 90th percentile of 0.516, which corresponds to loads of 13.12 and 21.55 lb/d, respectively. Using Table 5-1 in USEPA (1991) and 99th percentile factors, the multipliers and resulting LTAs are shown in Table D-8. The chronic LTA is more restrictive in this case, and so is used as the basis for effluent limits.

Table D-8. Calculation of LTA, Example 3

	WLA (lb/d)	WLA Multiplier[1]	LTA (lb/d)
Acute	21.55	0.373	8.04
Chronic	13.12	0.581	7.62

[1]USEPA (1991), Table 5-1

The AML and MDL are set as the actual compliance limits in the permit and are scaled up from the LTA (see Table 5-2 in USEPA, 1991) to assign maximum values that are consistent with achieving the LTA. The AML is first calculated from the more restrictive LTA given in Table D-8. Using four compliance samples per month at the 95th percentile level (as recommended by USEPA, 1991), the multiplier for the AML is 1.45. Thus, the AML for the permit is 7.62 x 1.45 = 11.05 lb/d.

A standard MDL for controlled process wastewater would be calculated from the LTA using the USEPA (1991) method. At CV of 0.5, the multiplier at the 99 percent level is 2.68, leading to an MDL of 7.62 x 2.68 = 20.42 lb/d.

Note that if the published chronic aquatic life criterion had been 0.35 mg/L, the lower confidence limit on the mean of the natural condition would be less than the published aquatic life criterion. In that case, the chronic LTA would have been calculated using the published chronic aquatic life criterion, rather than the natural condition data, yielding an acute LTA of 8.48 lb/d. The acute LTA would then have been more restrictive than the chronic LTA and would have been used to establish effluent limits.

As in Example 2, an alternative procedure can be used to establish the MDL and AML to evaluate compliance in conditions where the discharge is not controlled and treated but is believed to reflect natural background variability. First, the MDL-A is set equivalent to the lower 95 percent confidence interval on the 95th quantile of the concentration data. This yields a concentration of 0.946 mg/L, and an MDL-A of 39.46 lb/d. An additional compliance condition is set to ensure that no more than 10 percent of the monitored effluent discharges exceed the lower confidence limit on the 90th percentile of the natural condition concentration data of 0.516 mg/L.

The AML-A is calculated using the best estimate of the arithmetic mean calculated from log-transformed statistics (0.429 mg/L) and the 90th percentile of the data (0.836 mg/L). The resulting chronic LTA of 10.40 lb/d is more restrictive and yields an AML-A of 27.86 lb/d. When the AML-A is used, an additional requirement is made that the rolling average of the effluent concentration not exceed the lower confidence limit on the mean (0.314 mg/L) more than 50 percent of the time.

Because the optional AML-A procedure is based on replicating the quantiles of the natural condition data, the rolling average criterion would be set at the lower confidence limit on the mean (0.314 mg/L) even if the published criterion was greater than this value.

Table D-9 summarizes the concentrations limits calculated using state-wide water quality standards, the natural condition standards, and the alternative natural condition standards.

Table D-9. Comparison of Permit Limits for Example 3

	State-wide Std (mg/L)	Natural Condition Std (mg/L)	Alternative Limits (mg/L)
AML	0.253	0.265	0.361
MDL	0.467	0.490	0.946

Example 4. Natural Conditions Not Proven to Exceed Water Quality Criteria

The fourth example highlights a case in which data for a site initially suggest that a site-specific standard based on natural conditions determination is warranted, but such a finding is not supported by the data analysis (see Table D-10).

The example again focuses on an arbitrary metal, which is assumed to have an acute aquatic life criterion of 10 µg/L and a chronic aquatic life criterion of 5 µg/L. A total of 83 observations have been collected over a 9-year period, yielding reported values as high as 130 µg/L. However, there are also plentiful non-detects (“less than” values) and one estimated value. Data from the early years was collected at a much higher detection limit (10 µg/L or greater), which leads to imprecision in the earlier results.

Over the whole period of record, 64 percent of the results are non-detect or estimated. This exceeds the limit of 20 percent valid records, so the full data set cannot be used for a natural condition determination.

For data starting with 2000 the detection limit is lower, and there are no nondetects. For 2000-2003, there are 31 data points over a four-year period. Therefore, the 2000-2003 data can be used to evaluate natural conditions.

Table D-10. Data for Example 4

Date	Value (µg/L)	Date	Value (µg/L)	Date	Value (µg/L)
3/8/1993	20	12/9/1996	10	6/4/2000	2
4/12/1993	80	3/3/1997	< 10	7/21/2000	6
4/26/1993	130	3/20/1997	40	9/1/2000	6
5/14/1993	20	4/21/1997	< 10	10/30/2000	11
5/24/1993	< 10	5/5/1997	< 10	1/6/2001	9
6/6/1993	10	6/4/1997	< 10	3/28/2001	8
7/12/1993	10	6/25/1997	< 10	5/2/2001	4
8/16/1993	< 10	8/4/1997	< 10	5/22/2001	3
10/28/1993	30	11/3/1997	< 10	6/4/2001	9
2/15/1994	10	3/11/1998	< 10	7/23/2001	5
3/8/1994	< 10	4/14/1998	< 10	9/4/2001	3
4/11/1994	< 10	5/1/1998	< 10	11/6/2001	7
4/25/1994	20	5/12/1998	< 10	3/14/2002	6
5/12/1994	< 10	5/29/1998	< 10	4/8/2002	8
5/20/1994	10	6/26/1998	10	5/6/2002	9
6/13/1994	10	8/21/1998	< 10	5/29/2002	3
7/11/1994	< 10	11/17/1998	< 10	6/3/2002	9
8/17/1994	< 10	2/22/1999	< 10	6/24/2002	3
11/28/1994	< 10	4/27/1999	E 21	8/20/2002	2
2/6/1995	20	5/12/1999	< 40	3/17/2003	15
3/9/1995	10	5/30/1999	< 40	4/2/2003	27
4/10/1995	20	6/22/1999	< 40	4/28/2003	6
4/28/1995	< 10	8/12/1999	< 40	5/26/2003	4
5/8/1995	20	11/15/1999	< 31	6/3/2003	3
5/22/1995	< 10	3/6/2000	5	6/16/2003	3
6/5/1995	10	4/4/2000	3	7/28/2003	3
7/11/1995	< 10	5/9/2000	5	8/25/2003	3
8/7/1995	< 10	5/22/2000	4		

For 2000-2003, there are 7 winter observations and 24 summer observations. There are more than five observations in each season, so a test of equality between seasons is applied. The summer data have a mean of 5.5 and the winter data have a mean of 8.7 µg/L. Application of the Wilcoxon Rank Sum test (S5 in Appendix C) rejects the null hypothesis that the populations are the same at the 95 percent confidence level. This implies that the data from the two seasons cannot be combined. However, there are not enough data (n=7) for the winter season to make a determination of natural conditions. Therefore, a natural conditions analysis can be conducted only for the summer data.

Statistics for the 2000-2003 summer data are shown in Table D-11. Log transformation reduces skew, so work with the log-transformed data.

Table D-11. Statistics for the Summer Data, Example 4

	Raw Data	Log Transformed Data
Count	24	24
Mean	5.542	1.500
Median	4.000	1.386
Standard Deviation	5.082	0.593
Skew	3.532	1.239

The full data fail the *W* test for normality (S1). The initial sample size is 24, so up to three trimming steps can be tried (the trimming must yield a minimum data set of 20 samples). Even after three trimming steps, the data do not pass the *W* test. Therefore, nonparametric confidence limits (see S2 in Appendix C) are developed for the median (rather than the mean) and the 90th percentile. These confidence limits are developed on the initial data set (n=24), rather than the trimmed data and yield a lower confidence limit on the median of 3 µg/L and a lower confidence limit on the 90th percentile of 7.6 µg/L. The central tendency measure (in this case the lower confidence limit on the median) is less than the published chronic aquatic life criterion of 5 µg/L and the lower confidence limit on the 90th percentile is less than the published acute aquatic life criterion of 10 µg/L. As a result, no natural condition-based water quality standard will be pursued.